Synthesising multi-level perspective and multi-criteria analysis: comparing energy systems transition in Australia and Germany

A Dissertation Presented

By

Grace Cheung

to

Faculty of Science and Engineering

of

Macquarie University

and

Faculty of Business, Economics and Social Sciences

of

Universität Hamburg

In Fulfillment of the Requirements for the Joint Degree of

Doctor of Philosophy

(Doktor der Wirtschaftswissenschaften)

Specializing in Energy Transition (Energiewende)

Supervisors

Assoc. Prof. Peter Davies – Dept. of Environmental Sciences, Macquarie University

Prof. Dr Alexander Bassen – Dept. of Socioeconomics, Universität Hamburg

Date of Submission: 21 September 2018

Statement of Candidate

I certify that the work in this thesis entitled "**Synthesising multi-level perspective and multi-criteria analysis: comparing energy systems transition in Australia and Germany**" has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree to any other university or institution other than Macquarie University and Universität Hamburg.

I also certify that the thesis is an original piece of research and it has been written by me. Any help and assistance that I have received in my research work and the preparation of the thesis itself have been appropriately acknowledged.

In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature:

Full Name: Grace May Yung Cheung Student ID**:**

21st September 2018

Acknowledgement

The remarkable journey of this dissertation commenced five years ago when I enrolled into the blank-new Master of Research (MRES) program at Macquarie University. I graduated the MRES with distinction and the research nature of the program has aroused my interest and passion for knowledge through research. Thus, I accepted an offer for doctorate degree from Macquarie University and embarked on another three years of my investigative research journey with a flavour of a joint-PhD degree with Universität Hamburg. The three-year journey was marked with many ebbs and flows of advances and setbacks, that the idea of quitting often emerges whenever going gets tough. Especially, when I wasted so much time beating down the wrong paths. As a result, the last fourteen months was very challenging, within which I have to produce two publishable papers as well as putting everything together into this thesis. The time pressure and the associated stresses were indescribable. I could not have been able to pull it off without the great uncompromising support from my principle academic supervisor Assoc. Professor Dr. Peter Davies.

At the conclusion of this journey, I like to express my heartfelt gratitude to many people who have along the way supported me academically and morally by cheering me on. Academically, I like to thank my two academic supervisors Assoc. Professor Dr. Peter Davies and Professor Dr. Alexander Bassen for their professional guidance and support, insightful advices and constructive critique throughout the course of this research project and to the completion of my thesis. I would like to thank Franziska Sump and Prof. Bassen for translating the abstract of this thesis into German. I would also like to thank the Professional editor, Dr Gaye Wilson. She provided copyediting and proofreading services, according to the guidelines laid out in the university-endorsed national guidelines, 'The editing of research theses by professional editors', revised 2010. All remaining errors are my own.

Privately, first and upmost, I like to express my appreciation to my children Alexander and Stephanie who have freed me from any motherly duties and worries that I can fully focus on the challenges at hand. I am also thankful to all my best friends and good neighbours Irmi Buys, Sally Carlson, Monique Jablonski, Janet and Richard Elmes, Pauline and Frances Boey, and Leonie and Peter Schouten for their morale, emotional and material supports.

List of publications in the course of this thesis

Peer-Reviewed Journal Articles included in this thesis

1) Cheung, G. & Davies, P. J. 2017. In the transformation of energy systems: what is holding Australia back? *Energy Policy*, 109, 96-108.
Co-authors contribution: G. Cheung 85%; P.J. Davies 15%.

2) Cheung, G., Davies, P.J. and Bassen, A. 2018. In the transition of energy systems: what lesson can be learnt from the German achievement? *Energy Policy*. (Peer-reviewed pending publication).
Co-authors contribution: G. Cheung 84%; P.J. Davies 11%; A. Bassen 5%.

3) Cheung, G. & Davies, P. J. From a multi-level perspective, what is underlying the contrasting performance of energy transition in Australia and Germany? *Energy Policy*. (submitted).
Co-authors contribution: G. Cheung 87%; P.J. Davies 13%.

Peer-Reviewed Journal Articles not included in this thesis

4) Cheung, G., Davies, P. J. & Trück, S. 2016. Financing alternative energy projects: An examination of challenges and opportunities for local government. *Energy Policy*, 97, 354-364.

5) Cheung, G., Davies, P. J. & Trück, S. 2019. Transforming urban energy systems: The role of local governments' regional energy master plan. *Journal of Cleaner Production*, 220, 655-667.

Abstract

This thesis investigates the contemporary energy transitions and greenhouse gas reduction strategies of Australia and Germany. The thesis provides a comparative study to gain insights into the drivers of change within and between these two developed nations and contributes new perspectives which could support other countries decarbonising their economies to address the wicked problem of climate change.

The thesis applied a multi-disciplinary (social, economic and political) and multi-dimensional (policies, actors, technology and comparative) approach. Research strategies were based on mixed-methods, *Grounded Theory*, longitudinal nested case-study strategies and the development of a multi-criteria analysis model. A combined multi-level perspective (MLP) and multi-criteria analysis tool was developed for the comparative analysis to explore the socio-technical transition processes in Australia and Germany. This applied mainstream *Transition Theory* and multi-level perspective concepts of the landscape, regime and niche as actors enacting through interwoven forces that shape transition outcomes in these two countries.

The focus of the analysis covers the tenure of four Australian Prime Ministers and their governments between 1996 and 2017 and three German Chancellors and their governments between 1990 and 2017. Through a nested case study of each leader's term, a comparative analysis of assessment results uncovered four new perspectives. *First*, static landscape including fossil-energy endowment and economic structures, such as resources-based vs industry-based economy, of a country are foremost drivers of national energy decision-making. *Second*, these static landscape aspects can explain the motivation for delayed decarbonisation in Australia when compared to early action in Germany and therein the willingness to invest in new and decarbonised energy systems. *Third*, consistent economic growth is not a precursor to energy-transition achievement. *Fourth*, as renewable energy approaches grid parity with traditional and incumbent energy generation, economic investment will expedite socio-technical energy transitions beyond the more cumbersome political policy frameworks.

Zusammenfassung

Diese Arbeit untersucht die gegenwärtigen Strategien von Australien und Deutschland im Bereich der Energiewende und Treibhausgasreduzierungen. Die Arbeit besteht aus einer Vergleichsstudie, um Einsichten in die Triebkräfte des Wandels innerhalb und zwischen beiden Industriestaaten zu gewinnen. Weiterhin werden neue Perspektiven geboten, die andere Länder bei der Dekarbonisierung der Wirtschaft unterstützen könnten, um das Problem des Klimawandels anzugehen.

Die Arbeit verwendete einen multidisziplinären (sozialen, wirtschaftlichen und politischen) und mehrdimensionalen Ansatz (Politik, Akteure, Technologie und Zeit). Die Forschungsstrategie basiert auf gemischten Methoden, *Grounded Theory*, longitudinalen Fallstudien und der Entwicklung eines multikriteriellen Analysemodells. Für die vergleichende Analyse wurde ein kombiniertes Multi-Level-Perspektive (MLP) - und Multikriterien-Analyse-Tool zur Untersuchung der sozio-technischen Transformationsprozesse entwickelt. Diese nutzt die *Transition Theory* und eine Multi-Level-Perspektive von Landschaft, Regime und Nische als Akteure, die als in sich verflochtene Kräfte den Ausgang eines Wandels gestalten.

Der Fokus der Analyse liegt auf der Amtszeit von vier australischen Premierministern und ihren Regierungen zwischen 1996 und 2017 sowie von drei deutschen Bundeskanzlern und ihren Regierungen zwischen 1990 und 2017. Eine Fallstudie zu den einzelnen Amtszeiten und eine Vergleichsanalyse der Bewertungsergebnisse liefern vier neue Perspektiven. Erstens sind die Haupttreiber nationaler Energieentscheidungen statische Landschaften, in denen die Nutzung fossiler Energiequellen und gewisse wirtschaftliche Strukturen eines Landes (z.B. ressourcenbasierte versus industriebasierte Wirtschaft) etabliert sind. Zweitens können diese statischen Landschaftsaspekte die Motivation für eine verzögerte Dekarbonisierung in Australien im Vergleich zu früheren Maßnahmen in Deutschland und die Bereitschaft zu Investitionen in neue und entkarbonisierte Energiesysteme erklären. Drittens ist konsistentes Wirtschaftswachstum kein Vorbote der Energiewende. Viertens, da erneuerbare Energien die Netzparität mit traditioneller und etablierter Energieerzeugung erreichen, werden wirtschaftliche Investitionen die sozio-technischen Energieübergänge über die schwerfälligen politischen Rahmenbedingungen hinaus beschleunigen.

Table of Contents

List of figures

List of tables

Acronyms and Abbreviations

A$	Australian dollar
ABARE	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
AEMO	Australian Energy Market Operator
AGEB	Arbeitsgemeinschaft Energiebilanzen
ALP	Australian Labor Party
ARENA	Australian Renewable Energy Agency
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMWi	Federal Ministry for Economic Affairs and Energy
BNEF	Bloomberg New Energy Finance
BnetzA	Bundesnetzagentur (German Network Agency)
BRD	Bundesrepublik Deutschland (West Germany)
BREE	Bureau of Resources and Energy Economics
CCA	Climate Change Authority
CCS	Carbon Capture & Storage
CDM	Clean Development Mechanism
CDU	Christian Democratic Union Party
CEC	Clean Energy Council
CEFC	Clean Energy Finance Corporation
CLEW	Clean Energy Wire
CO2	carbon dioxide
CO2e	carbon dioxide equivalent
COP	Conferences of the Parties
CPRS	Carbon Pollution Reduction Scheme
CSU	Christian Social Union Party
Cth	Commonwealth
DAP	Direct Action Plan
DDR	Deutsche Demokratische Republik (East Germany)
DEE	Department of the Environment and Energy
DENA	Deutsche Energie-Agentur (German Energy Agency)
EEG	Erneuerbare-Energien-Gesetz

Energiewende	Energy Transition
ERF	Emissions Reduction Fund
EU	European Union
EU-ETS	European Union Emissions Trading Scheme
FDP	Free Democratic Party
FIT	Feed-in tariff
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GW	Gigawatt
IEA	International Energy Agency
IPART	Independent Pricing and Regulatory Tribunal of NSW
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
KW	Kilowatt
kWh	Kilowatt hour
LNG	Liquefied natural gas
LNP	Liberal and National Party
LRET	Large-scale Renewable Energy Target
MLP	Multi-level Perspective
MPCCC	Multi Party Climate Change Committee
MRET	Mandatory Renewable Energy Target.
Mt	Million tonnes
MW	Megawatt
NEM	National Electricity Market
NEMMCO	National Electricity Market Management Company
NGO	Non-government organisation
NIEIR	National Institute of Economic and Industry Research
NSW	New South Wales
PV	Photo-voltaic
OECD	Organisation for Economic Co-operation and Development
RE	Renewable energy
REN 21	Renewable Energy Network for the 21st Century
RET	Renewable Energy Target
R&D	Research and Development
SPD	Social Democrats Party

StrEG	Stromeinspeisungsgesetz (Electricity Feed-In Act)
TPES	Total Primary Energy Supply
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
US$	United State dollar

Chapter 1: Introduction

Climate change is defining our present. Our response to it will define our future. To limit global temperature-rise to two degrees Celsius we will need a substantial reduction of greenhouse gas emissions.
United Nations Secretary-General Ban Ki-Moon (UNEP-BNEF, 2015, p. 5).

1.1 Introduction

This thesis investigates the energy transition processes of Australia and Germany. It explores the socio-technical transition of energy through a social-economic-political lens at the multi-level perspective, enhanced by the application of multi-criteria analysis to uncover underlying factors that contribute to or hinder progress in energy transitions. Combining the discursive analysis of the MLP and multi-criteria analysis helps cross-cutting the complex interactive components while assessing and quantifying the factors and associated impacts for their merits on the transition trajectories and performance at the national level. A comparative analysis with multiple research strategies was applied to reveal new perspectives on how and why each country has performed differently with respect to its greenhouse-gas emissions reductions, being one of the drivers, and the decarbonisation of their energy systems. The two countries present an ideal case study as they have many similarities and differences within which there are insights on energy-transition processes that can benefit other nations travelling the energy-transition path. Before proceeding to the aims, research questions, approaches and contributions of the thesis, it is vital to understand in context the role and drivers of the current energy-transition discourses.

Transitioning towards renewable-energy sources is heralded and articulated globally as a key climate change mitigation strategy through the decarbonisation of energy systems. Transitions in a broader sense are defined as large-scale transformations within society or important subsystems, within which the structure of the societal system changes fundamentally (Geels, 2002). Typical examples include the transition from industrial to service economies, from wood heating to coal heating and electricity generation, and from horse carriage to car powered by petroleum. Historically, socio-technical transitions emerged autonomously with an opportunity to produce cheaper and/or better alternative societal services that were driven by entrepreneurs exploring emerging commercial opportunities of innovative technologies for niche advantages (van den Bergh and Bruinsma, 2008). Full transitions typically take a long time (ranging from 40 to 120 years[1]) for the new technologies to reach market maturity with a price/performance competitive edge to replace the incumbent technologies and dissolve the inertia of the socio-cultural practices (Allen, 2012; Elzen et al., 2004; Fouquet, 2010; 2015; Fouquet and Pearson, 2012; Kern and Markard, 2016).

The Anthropocene epoch and the concomitant urgency to address climate change have provided additional incentives and drivers for energy transition (Pearson and Foxon, 2012). Paradoxically, the fossil-energy transitions that drove the Industrial Revolution are now the drivers of the current climate change renewable-energy transitions. The cumulative and increasing use of fossil energy since the Industrial Revolution has contributed to global climate change risks. Fossil-based energies such as coal, oil and gas have established themselves as powerful and complex mainstream energy industries from upstream fuel-source supplies (coal miners, oil and gas companies) to downstream heavily-regulated power generation, distribution and retail businesses (utilities companies). The share of CO_2 emissions from fossil-fuel combustion accounted for 68% of the global greenhouse gas (GHG) emissions in 2014 and the electricity and heating sector contributed 42% in 2015 (IEA, 2017). Therefore, transition towards low-carbon sustainable energy systems is the key to effectively reduce GHG emissions and would require collectively coordinated efforts from governments around the world to adopt an integrated approach in managing the speed, direction and long-term transition objectives (van den Bergh and Bruinsma, 2008) through target setting and an effective renewable-energy policy (Groba and Breitschopf, 2013) in steering various technological-transition pathways (Elzen et al., 2004; Smith et al., 2005).

The first Earth Summit in Rio de Janeiro (1992)[2] saw the formation of the UN Framework Convention on Climate Change (UNFCCC), the Rio Declaration on Environment and Development (1992), and Agenda 21. Agenda 21 embraced the concept of sustainable development as an urgent global imperative that provided a consensus in setting an initial step forward toward sustainability and offered a common platform to mobilise local, national and global actions towards climate-change mitigation (Keating, 1994). The Conference of the Parties (COP) that convenes annually aims to facilitate an ongoing climate-change negotiation process and provide a mitigation governance framework for participating countries. Since the first

[1] Since the Industrial Revolution, it has taken, on average, nearly fifty years for sector-specific transitions, such as energy, to unfold (i.e. the diffusion of energy sources and technologies).
[2] The United Nations Conference on Environment and Development (UNCED), also referred to as Earth Summit, which took place in Rio de Janeiro in June 1992, was a milestone event bringing together many heads of state and chiefs of government along with delegates from United Nations agencies, officials of international organisations, and thousands of non-governmental organisation (NGO) representatives.

Conference of the Parties (COP1) in Berlin in 1995 and the most distinctive COP3 in 1997 in Kyoto, Japan that brought about the Kyoto Protocol, many developed countries that ratified the Kyoto Protocol have progressively embarked on decarbonisation processes. These decarbonisation efforts include setting GHG emission-reduction targets and energy-transition agendas and implementing policies to steer and manage the speed and direction through varying technological pathways towards set emission-reduction and renewable energy targets (RET). These climate-change mitigation efforts have led to various degrees of progress through to the first commitment period of 2008–2012 of the Kyoto Protocol (REN21, 2013; Smil, 2016).

In the decade 2004–2014, renewable energy (RE) supplied grew steadily to approximately 19% of the world's final energy consumption (Lins et al., 2014). In 2017, renewable power-generating capacity grew by almost 9% over the new capacity addition of 2016[3] to a record 178 gigawatts (GW) added globally. Despite the positive growing trend in RE capacity, global energy-related CO_2 emissions, after holding steady for three years, rose by 1.4% in 2017. This was due to robust global economic growth (of 3.7%), lower fossil-fuel prices and diminishing energy-efficiency efforts (REN21, 2018). Therefore, to achieve the adopted goals of the Paris Agreement 2015, which was ratified by 178 countries, to keep global temperature rise well below 2°C from pre-industrial levels, the speed in global transition towards low-carbon economy needs to accelerate significantly (UNFCCC, 2015b; 2016).

1.2 Research motivation and background

At the commencement of this research project in 2015, the 21st Conference of the Parties (COP21) on Climate Change was going to be held in December in Paris with a renewed push from the United States to reach the US–China Climate Change Agreement. It was anticipated that a global agreement on climate-change actions from all nations would be reached for more concerted actions for speedier decarbonisation of the world economy. Australia at the time, however, was viewed as going against the global climate change energy transition trend with the latest government actions in successfully repealing the carbon tax and reducing the 41,000 GW of Large Renewable Energy Target (LRET) originally set by the Clean Energy Act 2011 down to 33,000 GW. Further to these counter-trend actions was an unambitious Intended Nationally Determined Contribution (INDC) submission of 26–28% emissions reduction from the 2005 level by 2030 as Australia's post-2020 targets to the COP21 (Australian Government 2015a). This target was deemed inadequate by the

[3] In 2016, a record of 161 gigawatts of newly installed RE capacity was reached globally, accounting for around 24.5% of global renewable electricity production (REN21, 2017).

chairman of the Climate Change Authority, Mr Bernie Fraser, who instead recommended 45–63% by 2030 (Australian Government 2015b). Mr Fraser criticised the government's INDC to be 'at or near the bottom' of comparable OECD countries that the nation would slip further behind and face more future efforts to catch-up (Hasham, 2015a). Being dissatisfied that Australia was well behind Britain's pledge for 61% cuts and the United States with 35–39% cuts for the same period, Mr Fraser resigned on 8th September, 2015 (Hasham, 2015b). On the international stage, Australia's INDC targets were also rated 'inadequate' among the comparable countries by the Climate Action Tracker (2015a, 2015b).

These counter climate change mitigation governmental actions in Australia invited a more detailed investigation on climate change and energy transition discourse in Australia and four major issues/challenges from national perspective were identified. These issues/challenges could potentially affect Australia's social, economic and environmental future performance and its international competitiveness as a developed country as the global trend for renewable energy is gaining momentum. These were the initial issues/challenges identified:

1. Australia is endowed with equally diverse and abundant fossil- and renewable-energy resources such as coal, natural gas, uranium, oil, wind, solar, geothermal, tidal wave, and biomass. However, most of the renewable-energy resources remain largely untapped and the fossil-energy resources, especially coal and natural gas, are well developed with increasing significance for the country: it is ranked the world's ninth-largest energy producer and one of only three net-energy exporters in the OECD countries (BREE, 2014a). Domestically, the share of fossil-fuelled electricity has remained stubbornly high at 85% in 2014, while renewable electricity (excluding hydro) stood at only 7.5%, and the sector was by far the largest source of GHG emissions in the national inventory, accounting for 34% in 2014/15 and rose an additional 3% in 2015 (Australian Government, 2015c, 2015d).

2. Australia was the only Kyoto signatory nation to negotiate an increased emission target of 108% on the 1990 level and to ultimately refuse its ratification (Crowley, 2010). Consequently, without targets and much mitigation effort, the national emissions rose to 109% of the 1990 level in 2007 (ABS, 2010). It was not until 2007 that an unconditional emission-reduction target of 5% below the 2000 level by 2020, conditional 15–25% below 2000 by 2020 subject to international achievement, and 60% below 2000 levels by 2050 were ratified by the newly elected Labor government (Parliament of Australia, 2007). In tandem to the altered courses of Kyoto ratification, the climate/energy governance approaches were inconsistent with shifting

national emission/energy targets and policy agenda. Thus, the emissions intensity of electricity in Australia remained relatively higher than the US and China[4] and economy-wide emissions[5] were virtually unchanged between 1990 and 2011 as a result of increased mining activities (Vivid Economics, 2013). Australia was the top per capita CO_2 emitter among the OECD countries in 2015 (IEA, 2017).

3. The BNEF (2015) forecasted that by 2040, renewables will command just under 60% of new generating capacity driven by the economics of renewable technologies that will attract two-thirds of the $US12.2 trillion of projected global investment, whereas fossil fuels will shrink to 44% of generation in 2040 from the current two-thirds of the share. With an ongoing political disposition of financial subsidies to coal-industry development, Australia is not only at odds with the negative global outlooks on potential fossil-fuel divestment risks with stranded assets but is also unprepared to capitalise the emerging RE investment trend as a balanced economic growth to the waning resources boom (Bullard, 2014; Caldecott et al., 2013; Stock et al., 2015).

4. In the last two decades, Australia's economy has performed consistently well with an annual gross domestic product (GDP) growth rate ranging between 1.8% and 5% (World Bank, 2015). Economically, contrary to some common political arguments that the decarbonisation of energy systems will be a great cost to society and hurt the economy, Australia, like many European Union countries, can well afford to achieve more ambitious emission reduction and renewable-energy targets to be among the global leaders in the low-carbon economy.

In comparison to Australia's underachievement in emissions reduction and energy transition, between 1990 and 2014 Germany achieved almost 28% GHG emission reduction from 1990 level, which far exceeded its pledge of 21% reduction for the first Kyoto Protocol commitment period of 2008–2012 (BMUB, 2016). At the same time, the share of renewables in gross electricity consumption grew to 31.6% in 2015 (BMWi, 2015d). Parallel to these achievements, the German coalition government of the Social Democrats (SPD) and the Greens (1998–2005) also committed in 2000 to progressively phase out all nuclear-power stations, to be completed by 2021 (BMWi, 2000; IEA, 2007a). Since then, the share of nuclear power in primary energy consumption has steadily declined from the height of 12.9% in 2000 to just 7.6% in 2015 (AGEB, 2016). Moreover, Germany has committed to further ambitious progressive targets of the share of renewable-

[4] Electricity emission intensity of Australia was approximately 6% higher than China and 60% higher than the US.
[5] The emission includes land use, land-use change and forestry (LULUCF), whose changes particularly in forestry offset emissions from economic growth in other parts of the economy between 2008 and 2011.

electricity generation of 35% by 2020, 40–45% by 2035, 55–60% by 2035 and at least 80% by 2050 (BMWi, 2015a; 2017). Internationally, the energy-transition achievement of Germany has contributed significantly to the global ability to mitigate the climate change risks through commercialising two key RE technologies—wind and solar—that are now economically competitive with fossil fuel and enabling energy transition around the world (Morris and Jungjohann, 2016).

With these preliminary findings that Australia is lagging while Germany is leading in climate change mitigation and energy transition, I ponder why one country is performing better than the other? What are the true underlying causal factors between them that can be learnt from an insight gained through in-depth investigation of these two countries?

1.3 Aims and research questions, strategies and contributions

This research aims to gain insights and contribute new perspectives on the dynamics of drivers, challenges and causal factors underlying the contrasting energy-transition performance between Australia and Germany. In addressing these aims, the research study of this thesis is guided by the following three central research questions. The research questions are framed around an understanding of a unique profile of the socio-technical, economic and political structure of each country through time (1990–2017) and varying scales (energy-system perspective and national perspective).

1. *With abundant fossil and renewable energy resources and consistent trend of GDP growth, what is holding Australia back from transformation of its energy systems?*
2. *What are the underlying factors for an outstanding achievement of Germany in transforming its energy systems and what lesson can be learnt?*
3. *From the multi-level perspective, what are the true causal factors (drivers, barriers and challenges) underlying the contrasting energy-transition achievements in Australia and Germany?*

1.3.1 Research strategies

The research study was conducted in three stages and carried out in multi-disciplinary (social, economic, political and environmental) and multi-dimensional (energy policies, actors and technologies) approaches. The study focus was to examine the climate change and energy transition issues aiming to gain insight to the three main research questions posted above. Table

1-1 provides an organised summary to the three-stages study together with the associated research strategies and publication status of each stage.

Table 1-1 Research stages, research strategies and publication status matrix

Stages, questions and model developed	**Research strategies**	**Status of publication**
Stage 1 – Question 1 *MCA energy-transition evaluation model*	Mixed methods Grounded Theory Longitudinal nested case study Multi-criteria analysis (MCA)	Paper with the title of Chapter 4 published in *Journal of Energy Policy* in 2017 with citation of (Cheung and Davies, 2017)
Stage 2 – Question 2 *MCA energy-transition evaluation model +time-weighting coefficient enhancement*	Mixed methods Grounded Theory Longitudinal nested case study Multi-criteria analysis (MCA)	Paper with the title of Chapter 5 under review at *Journal of Energy Policy* with manuscript number of JEPO-D-18-01280
Stage 3 – Question 3 *MLP-MCA energy-transition analysis model*	Mixed methods Grounded Theory Longitudinal nested case study Multi-criteria analysis (MCA) Multi-level Perspective (MLP) Transition Theory Comparative analysis	Paper with the title of Chapter 6 submitted to *Journal of Energy Policy* on 21/09/2018

As presented in Table 1-1, the mixed methods, Grounded Theory and longitudinal nested case-study strategies combined with multi-criteria analysis (MCA) were adopted for all the research questions throughout the three stages. Stage 3 for Question 3 is further enhanced with synthesising the multi-level perspective (MLP) and multi-criteria analysis (MCA) strategies based on Transition Theory in a comparative analysis of Australia and Germany. Following is a brief description of each stage:

Stage 1: Adopting mixed methods and Grounded Theory to investigate issues, barriers and causal factors for Australia's poor performance in emissions reduction and renewable energy transition. An MCA analytical model based on mainstream energy-transition policies[6] will be developed to systematically analyse, assess and rank the chronological evidence-based climate/energy actions and policy measures of each government and its presiding leader over the period 1996–2015 for Australia. The four Australian prime ministers (PMs) were John Howard (1996–2007), Kevin Rudd (2007–2010), Julia Gilliard (2010–2013) and Tony Abbott (2013–2015). Each PM will be studied as an individual case to

[6] The mainstream energy-transition policies recommended by the literature of the Intergovernmental Panel on Climate Change (IPCC) (2001, 2007, 2012, 2014) and the International Energy Agency (IEA) (2003b, 2007b, 2008, 2010, 2011b, 2013).

be compared within the national case study to identify any emerging new perspective on Australia's energy transition performance. A peer-reviewed research paper with the title of Chapter 4 of this thesis was published as Cheung and Davies (2017) in the *Journal of Energy Policy*.

Stage 2: Applying the same MCA model from Stage 1 to assess, rank and compare the performance of the three German chancellors and their varying coalition governments on climate/energy actions and policy measures in energy transition in Germany in the period 1990–2017. The chancellors presiding over their coalition's government were Helmut Kohl (1982–1998)[7], Gerhard Schröder (1998–2005) and the incumbent chancellor, Angela Merkel (2005–present). Each individual case score of the chancellor/government will be compared to identify the underlying factors of drivers and barriers that have an impact on the performance in Germany. An enhancement to the model will add a time-weighting coefficient to the policy/measure criteria while comparing the results of leaders of Australia and Germany to gain new perspectives of causality to the differing transition performance. A peer-reviewed research paper with the title of Chapter 5 of this thesis was submitted to the *Journal of Energy Policy* and is currently under review with manuscript number of JEPO-D-18-01280.

Stage 3: Based on the tested concept of the constructed MCA model for Stage 1 and Stage 2, an MLP–MCA analytical model based on Transition Theory was developed to shed light on Question 3. The model draws on the Transition Theory concepts of *landscape*, *regime* and *niche* as actors who act as interwoven impactful forces that could shape the socio-technical transition processes. The focus of the analysis covers the tenure of five Australian prime ministers and their respective governments between 1996 and 2017 and three German chancellors in their terms of government between 1990 and 2017. The assessment results of the nested case study within the national case of Australia and Germany are compared to uncover true factors underlying the contrasting performance between the two countries in transforming the energy systems. A peer-reviewed research paper with the title of Chapter 6 of this thesis was submitted to the *Journal of Energy Policy* on 21/09/2018.

[7] However, Chancellor Helmut Kohl's climate/energy policy actions were only assessed from the period of 1990-1998 out of his full tenure of 1982–1998. The slection of the period based on the German reunification in 1990.

1.3.2 Contributions

The research of this thesis makes significant contributions to the crucial research field of climate change and energy transition in many areas. Firstly, this research has revealed insightful causalities of the impactful socio-political factors underlying the contrasting achievements between Australia and Germany in terms of GHG emissions reduction and transition to low-carbon economy. The findings offer new perspectives and valuable lessons for policy- and decision-makers around the world that harmonisation of any divisive political ideologies/stances is crucial in facilitating structural changes and minimising disruptive processes. Secondly, the findings from multi-level perspective and multi-criteria analysis add clarity and strength to the field of *Transition Theory* and conceptualisation. Thirdly, the MCA energy-transition analytical model used here, which was first applied to Australia and then to Germany for further testing and improvement, enhanced the utility, robustness, validity and adaptability of the model. More importantly, a semi-crisp scoring rule set[8] offers a simple and comprehensive analytical framework that could be easily adapted to apply to other national or state governments. Lastly, the developed MLP-MCA analytical framework offers a new method drawing on established techniques of MLP and MCA, which is an innovative and transformative conceptual approach, since it adopts a novel way of quantifying the mainstream transitional enacting forces among actors in a comprehensive evaluation framework that can identify and explain the true factors underlying the drivers and challenges of a nation's energy-transition discourse. Applied properly, the model could be a useful tool to foretell potential issues from the big-picture view of a country, thus, improving effectiveness of its transition.

1.4 Structure of the thesis

This thesis consists of eight chapters and their functional details are described as follow.

Chapter 1: *Introduction*

This chapter introduces the thesis and delineates the research motivation and background, aims and research questions, approaches and contributions of the research, and provides an outline of the thesis.

[8] The semi-crisp rule set is designed to eliminate subjective bias and provide flexibility at the same time for occasional non-conclusive situation during the assessment processes of the performance of each leader. This is done through an assessment of a parametric question of each tier-3 sub-criterion that requires answer with a 'Yes' for definite positive outcome to obtain a score of 1, or a 'No' for definite negative outcome to obtain a score of 0. Where there was a situation of either 'Yes' / 'No' from an uncertain/partial outcome that either has a positive or negative implication, a score of 0.5 was assigned.

Chapter 2: *Energy transition challenges, theoretical and analytical frameworks: literature review*

This chapter reviews the existing academic literature on the complexity of energy systems and multi-dimensional challenges in steering and managing socio-technological structural changes. Further review examines the underpinning theoretical and analytical framework that has been developed within the energy-transition arena to inform the research approach.

Chapter 3: *Methodology*

This chapter describes the methodology applied in the evidence-based research. It demonstrates the relevant strategies in developing a complex multi-disciplinary, multi-dimensional and revelatory nested case study of climate change and energy governance practices in Australian and German politics in the period 1990–2017. The chapter outlines the methodological strategies, scope of the longitudinal nested case study, sources of data and the development of the analytical model/framework and processes.

Chapter 4: *In the transformation of energy systems: what is holding Australia back?*

This chapter presents the peer-reviewed paper in the *Journal of Energy Policy* published on 26th June 2017. The research identified the causal factors underlying Australia's underachievement in GHG-emission reduction and energy-systems transformation. The study developed a methodological approach with combined mixed-methods, Grounded Theory, longitudinal nested case-study and multi-criteria analysis (MCA) strategies. Based on these strategies, an MCA energy-transition evaluation model was constructed and applied to analyse, assess and rank the climate/energy political actions and commitments, energy policies and enabling frameworks of four Australian prime ministers and their relevant governments between 1996 and 2015. The multi-criteria analysis was based on ex-post historical official climate/energy data drawn from government reports, IEA/IRENA member countries' energy-policy database and other relevant peer-reviewed studies in the field.

Chapter 5: *In the transition of energy systems: what lesson can be learnt from the German achievement?*

This chapter was submitted to the *Journal of Energy Policy* and is currently under review with manuscript number JEPO-D-18-01280. The study gained insight into factors underlying Germany's energy-transition achievement and tested the utility and robustness of the MCA model developed in Chapter 4. The MCA model was applied to examine the climate/energy actions and policies of three German chancellors and their respective coalition governments between 1990 and 2017 in a similar analysis process as used in Chapter 4. The results of the three German chancellors were compared to the four Australian prime ministers. In the comparative analysis process, a time-weighting coefficient to the ‘Energy policy measures/instruments’ criterion was incorporated as an enhancement to the model. The function of the time-weighting coefficient was to account for the time-cycle required to introduce and implement climate/energy policy to see its outcome and effectiveness. The chapter also discusses the utility and validity of the model, as well as suggestions on further enhancement for future application.

Chapter 6: *From a multi-level perspective, what is underlying the contrasting performance of energy transition in Australia and Germany?*

This chapter has been submitted to the *Journal of Energy Policy* and is under review. The study aimed to make two significant contributions to the energy-transitions literature. Firstly, a combined MLP and MCA transition-analysis model/framework will be developed based on the tested methodological strategies, results and concept on the MCA model from Chapters 4 and 5. Secondly, this analytical framework was applied to a comparative longitudinal nested case study of Australia and Germany for the period 1990–2017 to gain insights on causalities underlying their contrasting energy-transitions achievements. The main criteria in the MLP-MCA model were drawn from Transition Theory and the MLP concept of the *landscape*, *regime* and *niche*, and analysis was based on data obtained from ex-post historical official climate/energy data from government reports, IEA/IRENA member countries’ energy-policy database and other relevant peer-reviewed studies in the field.

Chapter 7: *Synthesis and discussions*

This chapter synthesises all the research findings, discusses my insights on findings, ongoing drivers and implications to the future trajectories of Australia and Germany. The chapter concludes by discussing the utility of the MCA energy-transition evaluation model and MLP-MCA transition analysis model, as well as their strengths and limitations and recommendations for future enhancement and application.

Chapter 8: *Conclusion*

This chapter briefly summarises and concludes the thesis by demonstrating the impacts and contributions of the research of this thesis in terms of both the findings that strengthen the Transition Theory and the innovative methodology strategic applications of my developed analytical models. The chapter concludes with my thoughts on the outlook and extension of the future research applications that could benefit the energy-transition discourses.

Chapter 2: Energy transition challenges, theories and analytical frameworks – literature review

2.1 Introduction

The United Nations Sustainable Development Goals (UNSDGs)[9] provides a framework for sustainable energy transition. The transition itself is dependent on governance structures and policies (decision-making), approaches (socio-technical pathways) and time frame in national context (targets and speed). These interrelated and dependent factors have a bearing on national performance related to international climate change commitments and the domestic energy transition agenda. Hence, to study sustainability/energy transitions requires, firstly, a deep understanding of complex multidimensional structural-change processes and challenges associated with these processes from social, economic, political, and technological perspectives; and secondly, the transition theories and analytical framework, both general and specific, as a foundation for the research strategy.

A review of 540 journal articles by Markard et al. (2012) identified four strands central to the theoretical framing of sustainability/energy transitions: transition management, strategic niche management, multi-level perspective, and technological innovation systems. To inform the formulation of an appropriate theoretical approach for this research, this section provides an extensive literature review with a different focus to the papers presented in Chapters 4–6. The review of the sustainability/energy transition literature firstly focuses on the challenges of decarbonisation of the energy systems from social, economic, political and technological perspectives, and then on the sustainability/energy-transition theories and analytical frameworks within the categorised strands of Markard et al. (2012).

2.2 Challenges in decarbonising the energy systems

2.2.1 Intertwining social, political and economic challenges

Energy is vital in economic development and industrialisation (Toman and Jemelkova, 2003). Economic growth and industrialisation generate an ever-increasing demand for raw materials and fossil energy that has aggravated the global GHG emissions trajectory and dampened the

[9] The United Nations Conference on Sustainable Development, also known as Rio+20, took place in Rio de Janeiro, Brazil on 20–22 June 2012. It resulted in a focused political outcome document which contains clear and practical measures for implementing sustainable development and a process to develop a set of Sustainable Development Goals (SDGs) built upon the Millennium Development Goals and converges with the post-2015 development agenda. https://sustainabledevelopment.un.org/sdgs

anticipated mitigating effects from transition to low-carbon energy sources, despite the potential of advancing renewable-energy technologies (Berkhout et al., 2009; 2012). Energy systems are inextricably linked with the socio-technical domains, however, van Vuuren et al. (2012) assert that an appropriate governance approach can reconfigure the energy systems in technological and economic terms. On the other hand, energy systems are characterised as socio-technical systems which would likely follow various paths of socio-technological transformation processes over an extended period of time in reaching the ultimate structural changes in society (Geels, 2004a; Rotmans et al., 2001). However, other transitions studies argue that transitions will not only simply be a technological fix, but rather will require a combination of economic, political, institutional and socio-cultural changes (Berkhout et al. 2009; Cohen et al. 2010; Stephens et al. 2008).

Transformation processes of energy systems are socially disruptive and often politically contested. Adopted policies, intended technological pathways and targeted speed of progress are themselves often non-linear and vary significantly from country to country (Geels et al., 2017). The disruptiveness stems from emerging multi-dimensional structural changes in sectors of resources/inputs (supply), consumers lifestyles/preferences (demand) and institutions/policies (legislation) (Geels, 2018; Unruh, 2000). These structural changes in the transitional trajectory threaten the economic positions and business models of the powerful established industries that entail interactive politics and power struggles between an inertia of the incumbent regimes in maintaining status quo to protect their vested interests and the niche-technology innovators in exploring new commercial opportunities (Elzen et al., 2004, 2011; Geels, 2014a; Hess, 2014; 2016; Mattauch et al., 2015; Smink et al., 2015). At the early stage of transition, markets for niche technologies are not easily formed subject to cost disadvantages when competing with incumbent technologies (Hess, 2014; 2016). For this reason, supportive policy protection is an important enabler for the emerging and disrupting innovations to reach technological and market maturity (Jacobsson and Bergek, 2004; Smith and Raven, 2012). Thus, the political contestation between actors'[10] disagreement and agreement on desirability of various climate/energy policies and low-carbon technological pathways naturally presented as resistances and pushes during implementation courses and manifested as setbacks, accelerations, or cycles of hype and disappointment (Kern and Smith, 2008).

Economically, the effects on national mitigation costs are subject to heterogeneous factors, such as the energy-resources endowment (both fossils and renewables); the economic structure

[10] The actors are from both the incumbent utilities and coal-mining industries and niche renewable energy technologies industries.

(resource-based or heavily industrialised); the timing (immediate or delayed actions) in implementation of climate/energy mitigation policies as first-best and second-best scenarios; and the targeted speed, all of which would have impacts on the national mitigation costs (Garnaut, 2008; Gerlagh et al., 2009; Sorrell and Sijm, 2003). Countries with well-endowed energy supplies, like Australia and the US, would likely lose[11] in the first-best scenario, whereas the energy importers like the EU countries would gain[12] from early renewable deployment (Bauer et al., 2010; 2012). The arguments of the mitigation costs in the first-best and second-best scenarios are based on economic modellings that incorporate assumptions of the carbon pricing and projected technological cost according to their market maturity (Bauer et al., 2010; 2012; Garnaut, 2008; Gerlagh et al., 2009; Sorrell and Sijm, 2003). The natural endowment and the potential costs of renewable-energy technologies are not only the determinants of a country's willingness to push for an early/delayed energy-transition agenda, but also shape the future climate/energy policy portfolio, energy-mix and national investment strategies (Baumstark, 2011; IEA, 2008). Socio-technical transformation processes can alter national economic structures because of a decrease in existing technologies, such as coal-based power, creating both geographic and social losers. Socially, in the course of such transitional changes, there are inevitably loser and gainer industries that could exacerbate massive loss of employment in the sunset sectors and create new employment for emerging sectors. This disruption to the social equilibrium requires political commitment to balance and govern an orderly phasing out of and appropriate assistance to the losing industry (Jänicke and Jacob, 2005; Smith et al., 2005). Given the long-term nature of the structural changes in complex societal systems (Geels, 2006; Verbong and Geels 2007), it is important to ensure policy stability through resilient political coalitions to keep reform from being derailed by changes in political personnel and a turbulent conjuncture (Meadowcroft, 2005).

Technological changes of energy systems require significant new capital investment in the research, development and deployment of the niche-innovative low-carbon energy technologies. Investing in low-carbon technologies is capital intensive, and at the early stage of transition, it often carries high financial risk due to relatively immature technologies (Hall et al., 2016; 2017). Governments can play a vital role in formulating and guiding the national investment strategies and policies that can: (1) minimise investment risk through fair and transparent market policies to provide long-term certainty and stability to build investors' confidence (Bolton et al., 2016; Gross et al., 2007; 2010); (2) lower the mitigation costs through effective management of capital-

[11] An early deployment of renewable energy would bear higher net cost to the economy as a result of the opportunity cost of sacrifice in fossil energy development and export revenue.

[12] Energy-importing countries would gain from the early adoption of renewable energy due to savings from the cost of imported fossil energy.

investment cycles[13] (Nelson et al., 2017); (3) diversify the RE technologies portfolio and configuration of the energy systems (centralised or decentralised) (IEA, 2007b; 2008); and (4) ensure socially equitable bearing of the mitigation costs (Mitchell, 2010). De-risking investment capital and managing investment cycles is critical in enhancing security of supply and improving the investment efficiency through enabling incumbents to adapt their business models and avoid a locked-in mechanism with stranded assets (Waissbein et al., 2013). These are the entwined reality of social, economic and political challenges confronting each nation embarking on the mitigation discourse of decarbonising their energy systems and economy. Ultimately, national achievements are the manifestation of how well these conflicts and challenges are balanced and managed.

2.2.2 Technological and supply security challenges

The nature of conventional energy systems, dominated by coal-fired power stations, is capital-intensive with long operational lifecycle, stable as a result of path dependency, secured and well-integrated with transmission and distribution infrastructures. These conventional systems were mostly developed and operated as state-owned monopolies, although more recently are being privatised (Jamasb and Pollitt, 2005; Pollitt, 2012). Electricity markets are heavily regulated. This is designed to safeguard the supply security and minimise sunk-capital risks (of government and the private sector) through guaranteed consumer pricing for electricity consumers (IEA, 2003b, 2014). This model of ownership,[14] integrated operation and regulation has become an impenetrable barrier for any new private energy players (Würtenberger et al., 2011). Since the 1990s,[15] many governments around the world have liberalised the electricity market and reformed regulatory frameworks for the power generation, transmission and distribution assets to be corporatised through privatisation processes (Eyre and Lockwood, 2016; Jamasb and Pollitt, 2005; Pollitt, 2012). Paradoxically, these changes were in parallel with the recognition of the need to support the transition to low-carbon power generation through effective policies to level the electricity market competition rule to attract the new investors (IEA, 2003a; 2008; 2014).

[13] A proposed new coal-fired power plant by the Australian Federal Government would cost around A$3 billion to build, which would be locked in for the next 40–50 years. Hence, it is more effective to invest in the RE generation in place of the old plants due for phasing-out and, at the same time, ban the construction of any new coal-fired plants, which would lock in the capital investment for their long life-cycle.

[14] Prior to the liberalisation of the electricity market, most generation, transmission and distribution infrastructure assets were either owned by the state governments or were in the hands of just a few big utilities companies; therefore, the market was literally monopolised without any competition from new players.

[15] An exception of the energy market of the UK is that its liberalisation reform started in 1980s following the Thatcher governments early climate action and closing of coal mines and carried on into the 1990s (Eyre and Lockwood, 2016).

From a technological perspective, the security of electricity supply is one of the most important issues and challenges during the transformation process. Conventional power generation (supply) needs to continuously fulfil the basic requirement of meeting variable demands, referred to as baseload and peak consumer demands, from the electricity market (Clarke, 2009). Most fossil-fuelled power stations are equipped to ramp up or down their energy generation on demand in tandem with the peak- and base-loads delivered through excess network capacity (Jordan-Korte, 2011; Moser, 2011) which can be idled, thus, underutilised the majority of the time (Clark, 2009). Environmentally, such intermittent ramping up and down of the peak-load capacity results in both increased GHG emissions and significantly reduced efficiency and lifespan of the coal-fired power plants (ESB National Grid, 2004; Pitt et al., 2005). Conversely, renewable-energy technologies are characterised by various intermittencies,[16] and thus are unable to produce electricity on-demand (Boyle, 2007; IEA, 2011a; Neuhoff, 2005). To improve supply security, it is vital to optimise a diversified portfolio of renewables with varying and complementary intermittency in the systems (AEMO 2013; Chalvatzis and Hooper, 2009; Diesendorf, 2016) or include adequate energy storage in the systems. However, the storage technologies have yet to reach market maturity to be cost effective (Budischak et al., 2013; Connolly et al., 2012; Rasmussen et al., 2012; Weiß and Schulz, 2013). An overarching challenge is how to ensure supply security through varying technological configurations that can balance and allow co-evolution of RE technologies and energy storage as they mature in the socio-technical pathways.

Other technological challenges are emerging for the transmission and distribution infrastructure as the share of wind and solar generations grow in the energy mix. The International Energy Agency examined the challenges of transmission infrastructure and recommended policies to encourage investment in transmission in many OECD regions (IEA, 2002a). The need for more investment in smart networks was echoed by the blackout in the United States and Canada in August 2003 (Liscouski and Elliot, 2004).[17] Globally, the growth of diversified portfolios and shares of RE worldwide has posted numerous challenges for the transmission and distribution network as well as the energy markets listed as follows:

[16] For renewable energy, except hydroelectric, geothermal, concentrated solar thermal and biomass, the generation of more commonly promoted and easier-to-be-deployed technologies such as solar PV and wind turbines rely on weather conditions of sunshine or wind, therefore their generation is intermittent.

[17] The Northeast blackout of 2003 was a widespread power outage throughout parts of the Northeastern and Midwestern United States and the Canadian province of Ontario on August 14, 2003, which took over a week for power to be restored.

1. The increasing share of geographically spread RE generations is straining the existing grid-network infrastructure and threatening supply security that requires extensive technical structural changes to the transmission and distribution network infrastructure (Fischer et al., 2016). This is consequential to the design of conventional networks based on economies-of-scale for large centralised generations, which were usually situated close to fuel resources such as coalfields or cooling water, and the grids were optimised for regional self-sufficiency, whereas the interconnections were originally developed for mutual support and trade between regions (Hammons, 2008; Jacottet, 2012).

2. The changing RE generation mix requires an integration of both smart and resilient network technologies, and an effective regulatory framework and market mechanisms to avoid risks of network blackout. This was witnessed by the South Australia (SA) regional blackout event on 28th September, 2016, which caused households, businesses, major industries, transport and community services to be without electricity. The Australian Energy Market Operator reported that the blackout was caused by an increased share of RE generation in SA, particularly wind-farms responding to extreme weather circumstances in a network solely relying on synchronous generators to provide network stability and security (AEMO, 2017).

3. As energy transition progresses, the development of secured and resilient electricity servicing networks with smart-grid and energy-storage technologies is increasingly critical to avoid expensive overcapacity in conventional power generation. This is the case in Germany, which is actively debating a massive extension and upgrading of a high-voltage grid system and capacity market as backup sources for supply security (Hager and Stefes, 2016).

4. An overcapacity of RE in the energy markets has driven down wholesale energy prices in the EU Internal Energy Market (BMWi, 2014a, 2015b, 2016a; Jacottet, 2012; Matthes, 2017b). This phenomenon has led to shifted power-generation patterns and cost structures of electricity, since many RE sources are characterised with high capital sunk-costs and zero marginal costs that affect merit-order market mechanisms (Zachmann, 2007).

2.2.3 Climate/energy policy and governance challenges

As elaborated in the two previous sections (2.1.1 and 2.1.2), steering and transforming the energy systems needs to navigate many complex and interlocking social, political, economic and technological challenges. Therefore, managing and governing an energy transition is a vital function of national government to engage in ongoing discursive decision-making processes of socio-technical structural changes. These national change processes require purposive choice of targets, achievable time frames and varying pathways in the national context that would all have material bearing on mitigation costs, associated challenges and national performance (Bauer et al., 2012; Garnaut, 2008; Gerlagh et al., 2009; Sorrell and Sijm, 2003). Economically, the power sector of OECD countries will need $4 trillion of investment between 2000 and 2030, and about half of this amount would be needed for investment in power generation alone (IEA, 2003a). Since the energy systems are inextricably interlinked within the socio-technical domains, managing and governing changes must adopt integrated approaches that can enable co-evolutionary socio-technical, socio-political and economic changes (Foxon, 2011; Geels, 2014a). Hence, with ongoing climate/energy policy and governance challenges within these complex societal systems, the policy-makers need to adopt integrated policy strategies that can reconfigure the energy systems, not merely based on a technological fix, rather through a combination of co-evolutionary economic, political, institutional and socio-cultural changes (Berkhout et al., 2009; Cohen et al., 2010; Stephens et al., 2008; van Vuuren et al., 2012).

These policy strategies were mainstream recommendations from the Intergovernmental Panel on Climate Change (IPCC, 2001; 2007; 2012; 2014) and the International Energy Agency (IEA, 2003b; 2007b; 2008; 2010; 2011b; 2013), based on ongoing policy expert reports from the global tracking of progression on the mitigation effort. These strategies are: (1) from an economic perspective, to further strengthen policy reforms with a more transparent regulatory framework that can attract new investment capital to RE generation technologies; (2) from a technological perspective, to provide funding support for R&D of innovative energy-storage and smart-grid technologies that can improve the supply-security challenge and reduce dependency on fossil power as standby overcapacity that can also improve cost-effectiveness of transition; (3) from a social and economic perspective, to manage the capital-investment cycle of fossil-power generation to phase-out in an orderly manner inefficient and ageing coal-fired power plants, which could minimise social disruption and maximise capital efficiency.

2.3 Energy transition theories and analytical frameworks

This section outlines the theories and analytical frameworks relevant to be applied in answering the research questions posted in Section 1.2. Within the Literature Review a broad range of applicable theoretical approaches was provided to explain the common characteristics of transitions. There are general theories based on: (1) evolutionary economic theory (Nelson and

Winter, 1982; van den Bergh and Gowdy, 2000); (2) actor network theory (Law and Hassard, 1999); (3) more specific approaches based on social technology (Porter et al., 2004; Rip et al., 1995; Truffer et al., 2008); (4) studies based on long waves (Freeman and Louca, 2001; Perez, 2002); and lastly (5) on the policy and governance (Kuhlmann et al., 2010; Voß et al., 2006; 2009).

However, the subsequent review and analysis focuses on the four theoretical-framework strands categorised by Markard et al. (2012), namely transition management, strategic niche management, multi-level perspective (MLP) on socio-technical transitions, and technological innovation systems. More specifically, the focal point is on the MLP, for this research is on socio-technical transitions adopting the systemic views of transformation processes of socio-technical systems that MLP is well-suited to shed light on.

2.3.1 Concepts and fields of sustainability transitions

Sustainability transition is an emerging scientific field of research that has drawn increasing interest in the social-science arena over the last two decades. Numerous conceptual frameworks have been developed for studying such processes (Grin et al., 2010; Markard and Truffer, 2008; Smith et al., 2010). The academic field of transition studies has largely been developed in the Netherlands based on case studies of the Dutch energy sector, and many scholars in the field have devised theoretical explanations for the various directions and paces of the energy transitions that are taking place in different countries (Bosman, 2012). Some literature perceives transition as a ‘fundamental change in structure, culture and practices’, which occurs as a response to persistent problems deemed as unsustainable within modern societies (Grin et al., 2010). Others conceptualise societal systems (such as energy and transport systems) as socio-technical systems that encompass networks of actors,[18] institutions,[19] materials, artefacts and knowledge (Geels, 2004a, 2004b; Markard, 2011; Weber, 2003). It was found that socio-technical transitions not only involve a wide-range of actors, but also typically unfold over considerable time spans (over 50 years) with large-scale and far-reaching multi-dimensional changes in technologies, materials, institutions, politics, economics and socio-culture (Geels and Schot, 2010; Kemp, 1994). Thus, socio-technical transitions are non-linear transformation processes of fundamental societal changes characterised by varying speeds of incremental changes (Rotmans and Loorbach, 2010; Rotmans et al., 2001). So, this phenomenon serves as a better theoretical representation of the energy realities for the ground investigative processes.

---

[18] Network of actors includes individuals, firms, and other organisations, and collective actors.
[19] Institutions refer to the societal and technical norms, regulations, and standards of good practice.

In the field of socio-technical transitions, four networked theoretical frameworks have drawn much attention to and have been commonly adopted by many transition scholars, as summarised by Markard et al., (2012). These networked theories are: (1) transition management such as Loorbach (2010) and Rotmans et al. (2001); (2) strategic niche management such as Kemp et al. (1998), Raven and Geels (2010) and Smith (2007); (3) technological innovation systems such as Bergek et al. (2008), Hekkert et al. (2007) and Jacobsson and Johnson (2000); and (4) the multi-level perspective (MLP) on socio-technical transitions such as Geels (2002), Geels and Schot (2007) and Smith et al. (2010). Within these theoretical frameworks there are distinguishing emphases on understanding the transition processes (dynamics) and how actors' motivation in influencing the transition processes. The investigation of transition dynamics usually takes multi-phase/level/pattern framework approaches because of the different levels in time, functional or geographical nature of the transition processes. Conversely, the discipline of investigating the possibility of influence or active governmental-intervention in the transition processes is the emphasis of transition management (Kern and Smith, 2008; Loorbach, 2007; Loorbach et al., 2008; Rotmans et al., 2001; Smith et al., 2005) which, in some cases, is referred to as 'transitions theory' (Twomey and Gaziulusoy, 2014). The central concepts of transitions studies to various degrees are based on the interactions of socio-technical regimes[20] and innovative niches, where regimes are established and stable dominant forces that are resistant to dramatic socio-technical changes. Niches are the protected emerging spaces for innovative technologies that have yet to be established and play their pivotal role. For transitions to take place, regimes need to destabilise or open up under the pressure of the niches (Grin et al., 2010; Loorbach and Verbong, 2012; Turnheim and Geels, 2013). However, the multi-level perspective on socio-technical transitions builds on the work of others to explain the technological transitions through the dynamics of interplays at three different levels of regimes, niches, and landscape (Geels, 2002). It is through this lens of the big-picture view of MLP that the questions of energy transition performance in Australia and Germany will be analysed to gain new perspectives.

2.3.2 The synthesis of multi-level perspective and multi-criteria analysis

Socio-technical transitions are complex processes through which a multitude of driving factors and impacts manifest in the co-evolving markets, networks, institutions, technologies, policies,

[20] Existing socio-technical regimes are characterised by path dependence and lock-in, resulting from stabilising mechanisms on the three dimensions (Unruh, 2000): (a) incumbent actors have vested interests; social networks represent 'organisational capital', (b) regulations and standards may stabilise regimes; cognitive routines may blind actors to developments outside their focus; (c) existing machines and infrastructures stabilise through sunk investments and technical complementarities between components.

individual behaviour and autonomous trends (Geels, 2005; 2014a). From the multi-level perspective, the socio-technical transition is a long-term process of the interactions between innovative practices at the micro-level (niche) and incremental changes induced by actors operating at the meso-level (regime) within the quasi autonomous macro-level dynamics (landscape). Within these complex societal systems, actors can shape and influence the dynamics of the system and co-evolve between and within these various levels but cannot alter the general direction and outcomes (Avelino, 2011; Grin et al., 2010). However, they can be studied by differentiating developments at these three levels and the degree of their alignment to foretell when transitions can occur or explain an altered course and speed (Berkhout et al., 2004; Geels, 2002; Grin et al., 2010). One of the difficulties in researching an on-going transition based on the discursive analysis of the MLP is how to cross-cut through all the complex interactive components to assess and quantify the underlying factors and associated impacts for their merits on the transition trajectories and performance at the national level.

A conceptual MLP approach with an integrated multi-criteria analysis evaluation method offers an analytical framework that can assess and rank the relevant actors' influencing dynamics at the three dimensions of regime, niche and landscape. The Multi-Criteria Analysis (MCA) evaluation method incorporating three standard measuring processes and techniques of the Analytical Hierarchy Process (AHP), the Multi-Attribute Theory (MAUT) and the Simple Multi-Attribute Ranking Technique (SMART) have gained popularity and attention in the last 15 years due to its potential to assist governments in identifying and optimising the selection of climate change mitigation policies and instruments more effectively (Choo et al., 1999; Konidari and Mavrakis, 2007; Stirling, 2010). The MCA-based evaluation method is increasingly adopted by policy-makers in the developed countries: (1) in assessments of domestic GHG mitigation policies to understand the effectiveness of these policies under specific criteria; (2) to facilitate selecting GHG mitigation policy options guided by a set of criteria; (3) to verify results and impacts of instruments on GHG emission reductions and development of energy systems (Bonney, 2000; 2001; IPCC, 2001; Neij and Astrand, 2006; Scrieciu et al., 2011). To answer the central questions for this research study, an integrated MLP-MCA evaluation framework was constructed, which consists of: (1) a set of criteria (landscape, regimes and niches) supported by their selected relevant sub-criteria describing the complex interactions/conditions within national domains; (2) an AHP process for defining weight coefficients for criteria and sub-criteria according to their relevant importance; and (3) a MAUT/SMART process for assigning scores/grades to each element that is evaluated for its evidence-based outcome under a specific/defined condition. The constructed MLP-MCA evaluation framework/model is explained in section 3.5. The application of the model aims to uncover the true underlying causal factors for the contrasting climate/energy transition achievements between Australia and Germany and the full MLP comparative analysis study of Australia and Germany is presented in chapter 6.

Chapter 3: Methodology

3.1 Introduction

Energy transition is a multi-disciplinary (social, economic, political and environmental) and multi-dimensional (energy policies, actors and technologies) transformative process. Investigations within energy transition need to be able to dissect the complexity and multi-dimensional dynamics. This requires multiple approaches operating across different scales. The approach used applied in this research is based on a mixed-methods and longitudinal case-study and comparative analysis of Australia and Germany. It developed and applied a multi-criteria analysis (MCA) approach to provide insights into and address the research aim of examining energy transitions. Subsequent to the analysis of the Australian and German case studies, the multi-level perspective (MLP) was applied as a lens to examine transitions and ascertain the significance of levels and actions therein that have aided or hindered energy transition. This approach sought to extend the utility of the MLP to energy transition to provide a more quantitative approach drawing on the two case studies.

Framing upon the profiles of the socio-technical, economic and political structures of Australia and Germany with an investigation time frame of 1990–2017 and scales at both energy-system and national perspective, the research approaches were guided by the following three central research questions.

1. *With abundant fossil and renewable energy resources and consistent trend of GDP growth, what is holding Australia back from transformation of its energy systems?*
2. *What are the underlying factors for an outstanding achievement of Germany in transforming its energy systems and what lesson can be learnt?*
3. *From the multi-level perspective, what are the true causal factors (drivers, barriers and challenges) underlying the contrasting energy-transition achievements in Australia and Germany?*

3.2 The mixed-methods and Grounded Theory approach

The mixed-methods strategy with integrated qualitative and quantitative data collection design can be used to enhance the scope and breadth of research analysis and results (Creswell, 2003; Creswell and Plano Clark, 2011; Greene et al., 1989; Smith, 1986; Tashakkori and Teddlie, 2003). A mixed-methods approach provides opportunities for the integration of various theoretical perspectives (such as Grounded Theory, Transition Theory, multi-criteria analysis and others).

Qualitative data can help researchers understand the processes in context and identify emerging themes over time. Quantitative data have the potential to provide measurable evidence that helps researchers to establish probable cause and effect. Hence, an integration of qualitative and quantitative data maximises the strengths and minimises the weaknesses of each type of data (Creswell et al., 2011). Qualitative data for this research study was drawn from a wide range of climate/energy politics/policy discussion and evaluation literature. Quantitative data was obtained from Australian and German governments' official sources and the IEA/IRENA website for RE policies/measures of its member countries.

Grounded Theory was first introduced by Glaser and Strauss (1967) as an approach where theory is 'grounded' in data and observation, rather than being influenced by pre-conceived theories. The grounded theory approach frees researchers from the constraints of pre-existing theory in developing new theory from observations while examining their research problems and issues (Charmaz, 2000; Ezzy, 2002). Hence, the grounded theory approach is particularly relevant for this research study to gain insights of the complex interweaving relationships of social, political, economic and environmental change processes (Charmaz, 2006; 2011; Dey, 1999; Halkier et al., 2011). The mixed-methods data collection in this research was used to reveal perspectives and insights based on grounded theory. In contrast, the case-oriented research strategy and multi-criteria analysis (MCA) method (Konidari and Mavrakis, 2007; Ragin, 1987; Rihoux and Grimm, 2006) helped to frame the focus of study by uncovering the causal barriers to performance of energy transition at the individual leader and government scale nested within national cases. Applying comparative analysis to the leaders' and countries' cases, qualitative data were used to provide an insightful narrative of new perspectives related to the development of influential events or conditions, whereas the relevant variables in the MCA and MLP-MCA models using quantitative method were to enhance the knowledge from the qualitative interpretation (Guest, 2013).

A constructed MCA energy-transition evaluation model (refer to Figure 3-1) was employed to investigate climate change mitigation, energy politics and policies across a 19-year period from 1996 to 2015 in Australia and a 27-year period from 1990 to 2017 in Germany. The difference in time periods between Australia and Germany reflects the period from which energy transition became an issue of national importance as reflected by new policy and program funding recorded in the IEA/IRENA RE policies/measures database. The MCA model was applied chronologically to evidence-based ex-post data for each of the three Australian prime ministers and their cabinets during their time in office, and then to each of the three German chancellors and their coalition governments in a similar way. Their actions on climate/energy policy frameworks were systematically analysed, scored against this constructed MCA model and then compared to identify what impacts their actions and climate/energy policy frameworks had on the national GHG emissions reduction and socio-technical transition performance.

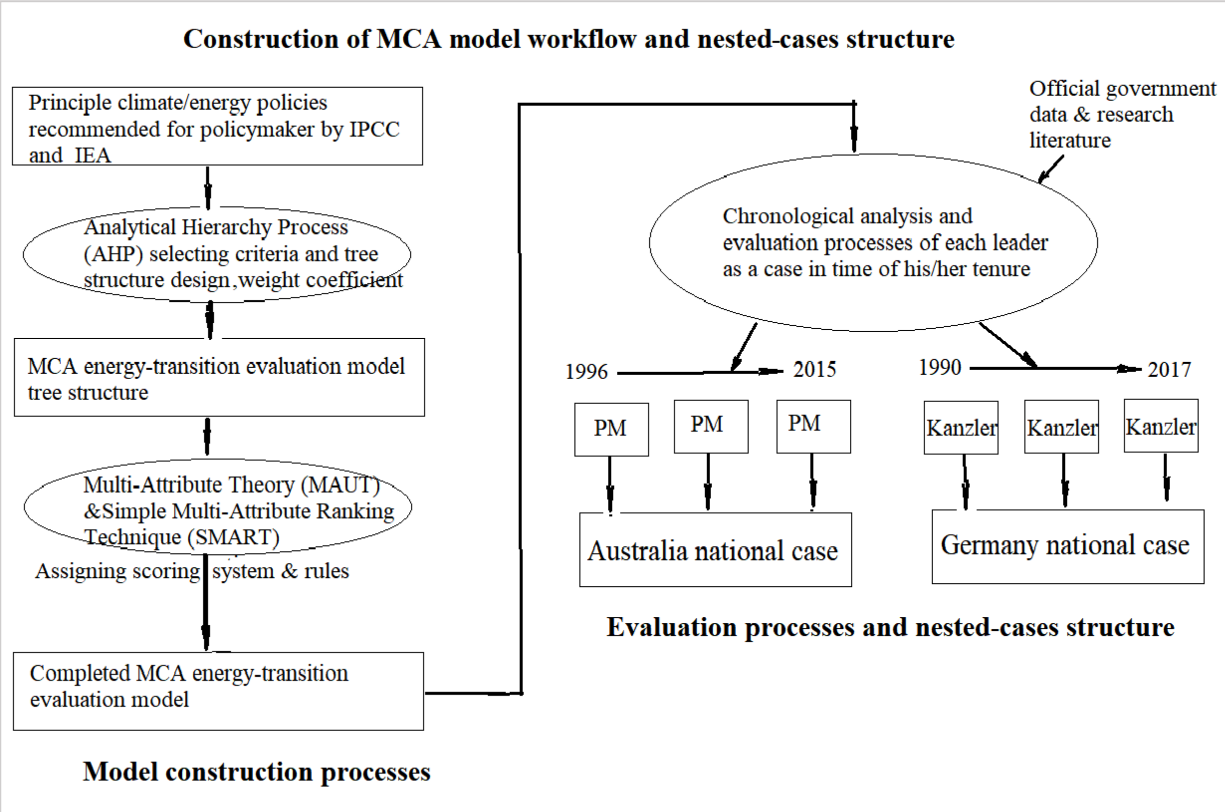

Figure 3-1 MCA model construction workflow, evaluation processes and nested-cases structure

3.3 The longitudinal case-study approach

The case-study methodology is one of five qualitative inquiry strategies identified for its utility in identifying general theoretical principles through detailed examination of an event or series of related events (Creswell, 1998; Mitchell, 1983).[21] The use of case studies in social research has evolved over the last century and has lost popularity since the late 1930s when it was criticised by scientific academia; it was re-popularised by the pioneers of Grounded Theory (Glaser and Strauss) as a useful way of generating new theoretical insights from data collection, analysis and observations (Glaser and Strauss, 1967). There are three basic types of study classified by Stake (1995; 2003):

[21] The five strategies are case study, biography, phenomenology, grounded theory and ethnography.

1. The *intrinsic* case study: the research is carried out as an interest in the phenomenon of the case due to its own unique qualities without an aim of understanding an abstract construct or generic phenomenon.
2. The *instrumental* case study: the research case is used to gain an understanding of the wider issue of interest as a means to reveal certain generalisable theory or generic issue.
3. The *collective* case study: the research is carried out with a bundle of similar cases to understand a general phenomenon that can facilitate theorisation of a larger collection of cases.

The boundaries of the different types of case study are traversable, in that some case studies could have elements of more than one type with a variety of issues of theoretical interest and or generalisability (Stake, 1995; 2003). The case studies in this research bear the hallmark of both *instrumental* and *collective* styles in that the objectives of the parallel national cases of Australia and Germany are to gain insights of wide issues in socio-technical transition and to seek an emerging new theory. Moreover, the collective cases of Australia and Germany are also nested within case studies of an individual leader of both countries during their time in office within the longitudinal national case study, as shown in Figure 3-1. Thus, the findings are potentially generalisable and transferable to other countries that have embarked on transformative changes of their energy systems.

3.4 Construction of the MCA energy-transition evaluation model

For the first and second research question, an MCA analytical model was developed, based on principal energy-transition policy frameworks recommendation for policy-makers by the IPCC and IEA. This MCA model (Table 4-1) was applied to systematically analyse, assess and rank the chronological evidence-based climate/energy actions and policy framework of each government and its presiding leader. The periods of investigation varied, with the analysis of Australia covering 1996–2015 and for Germany 1990–2017.

The three standard measuring processes and techniques of the Multi-Criteria Analysis (MCA) evaluation method, namely the Analytical Hierarchy Process (AHP), the Multi-Attribute Theory (MAUT) and the Simple Multi-Attribute Ranking Technique (SMART), were adopted in the construction processes shown in Figure 3-1 (Choo et al., 1999; Konidari and Mavrakis, 2007; Stirling, 2010). The AHP was adopted for its strength in disaggregating complex evaluation process into a hierarchical structure in order to reach a defined goal at the top of the hierarchy and the hierarchical structure is also scalable to solve various problem perspectives (Beria et al., 2011). For the MCA energy-transition evaluation model, the AHP was used in selecting the crucial main criteria and their relevant constituent sub-criteria, designing the hierarchical tree structure, and defining the weight coefficients for criteria and sub-criteria according to their relevant importance. The MAUT/SMART processes were then carried out in assigning a range of scores to each element and the rule set of awarding each score during the analysis and evaluation processes. The weight coefficients and the ranking-score rule set of the MCA model are covered at length in Chapter 4 of this thesis, whereas the strenghts and weaknesses, and the common applications of the MCA method to performance-type problems, resource management, public policy, political strategy and planning (Velasquez and Hester, 2013) were cover at length in Chapter 5.

3.5 An integrated MLP–MCA analytical approach

To facilitate an understanding of and gain insight for the third central question for this research study, an integrated evaluation framework synthesising multi-level perspective (MLP) and multi-criteria analysis (MCA) was undertaken. The MCA model (elaborated in the previous section 3.3) was applied to address the research questions 1 and 2. Hence, the MCA model was framed at the energy-system transition level (scale). In other words, the investigation through the MCA was focused on the climate/energy policy framework and the actions of the leader at the governance and management of the transition-process perspectives. The findings reflect that the marked symptomatic causes to the contrasting performance between the two countries were the varying political acceptability. However, the root causes to the different political acceptability were absent. To gain an insight into the root causal factors underlying the two countries' emissions reduction and RE transformation achievement, a big-picture view at the national level was warranted. In other words, the analytical model needed to be upscaled to investigate the nationwide energy endowment, economic structure, political inclination on energy and the interaction dynamics of the technological regimes and innovative niches to the energy policy and market environment.

Building on and extended from my tested concept of the MCA model for Chapters 4 and 5, an integrated MLP–MCA evaluation model was constructed (Table 6-1), which consisted of:

- a set of the top-tier criteria adopted from the MLP theories and concepts of landscape, regimes and niches (Geels, 2002; Geels and Schot, 2007; Smith et al., 2010);

- each top-tier criterion was supported by selected sub-criteria at tier 2 and 3 levels that are relevant to describe their profile, position and complex interaction conditions within national domains; and
- a set of well-defined assessing scores that functioned as a refined description of their conditions derived from ex-post government official data and other research literature in the field of socio-technical transition.

The construction, analysis and assessment processes were similar to the MCA model as demonstrated in Figure 3-1. The evaluation results of the assessment from this MLP–MCA model provided a richer tapestry view, enabling a deeper comparative analysis of energy transitions occurring in Australia and Germany (Ragin, 1987; Rihoux and Grimm, 2006). Chapter 6 of this thesis provides full details of this model and my findings, as it is dedicated to exploring and answering the third question. This chapter is also structured as a research paper and was submitted on 21 September 2018.

3.6 Applications of the MCA and MLP-MCA analytical models

As elaborated in Chapter 2, socio-technical energy transitions are complex and protracted processes that need to navigate many intertwining social, political, economic and technological challenges. Hence, to investigate a multitude of driving factors that have impacts on a nation's transition performance requires methodological strategies that can cross-cut through all the complex interactive components to assess and quantify the associated impacts for their roles in shaping the transition trajectories. The constructed MCA and MLP-MCA analytical models were designed to facilitate an easy and quantifiable investigation of energy transition at different perspectives of a country, namely, at the energy-system transition policies/politics level and then extended to a bigger-picture view of *Landscape*, *Regime* and *Niche* of MLP within which MCA model is merely one of the member criteria of the *Landscape* dimension.

The quantifiability and other designs of both models enable an easy and comprehensive comparative analysis between Australia's and Germany's climate/energy transition performance. This was achieved by these characteristic designs of the models: (i) selection of a generic set of climate/energy policy recommendations for policy-makers by IPCC and IEA as evaluation criteria for MCA model and MLP dimensions (*Landscape, Regime* and *Niche*) for MLP-MCA model; (ii) extraction of national climate/energy longitudinal data from the same source (IEA/IRENA database for Australia and Germany) to be supported by each national official data; (iii) standardisation of the evaluation method based on a defined ruleset (semi-crisp ruleset for MCA and well-defined conditional scores for MLP-MCA model) to simplify evaluation processes of a huge volumn of longitudinal data and minimise subjectivity of the researcher.

The detailed applications of the MCA and MLP-MCA models are presented in the following three chapters (Chapter 4-6) as three publication papers. Chapter 7 provides a summary of these three chapters and insightful dscussions of findings and utility of the models. The application of the MCA energy transition evaluation model is covered in detail in Chapter 4 and 5 to investigate energy transtion in Australia and Germany to shed light on the research question 1 and 2 listed at section 3.1, whereas Chapter 6 was dedicated to examine a big-picture view of Australia and Germany through the lens of MLP to uncover new perspective for the research question 3. While the detailed applications including aims, findings and discussions were covered in detail in each of the three chapters that follow, a bit of an orientation of the basic data collection and analysis structure of these papers could help better understanding of the complex investigation processes.

3.6.1 Data collection and analysis structure of Chapter 4 and 5

Both chapters adopted the same MCA model to examine the longitudinal climate/energy actions and policies of leaders/governments of Australia (Chapter 4) and Germany (Chapter 5). Data of both chapters were sourced from the IEA/IRENA (2016, 2018) database to ensure their consistency and comparability. These data were structured into a policy master table and included in Appendix A1 for Chapter 4 and Appendix A for Chapter 5. These two appendixes provided a backbone data for all the data analysis processes in ranking the leaders' actions and their policy performance as individual case study for each leader. The detailed assessment and ranking tables for the four Australian prime ministers and three German chancellors were included as Appendix B of Chapter 4 and 5 correspondingly. Chapter 4 focus on investigating the causal factors unerlying the Australia's climate/energy transition underachievement and was published as Cheung and Davies (2017) in the Journal of Energy Policy. Chapter 5 adopted the same model and approach to the national case of Germany to test the validity and robustness of the model in a different political context. The comparative analysis of Australia's and Germany's results (in Chapter 5) reflected the limitation of the semi-crisp scoring ruleset which indicated the need of a time factor in respect to the lengthy processes of policy-making. Also as a way of enabling a comparison between the two countries, the MCA model was enhanced with a time-in-office weighting coefficient for one of the three top-tier criteria, the *Policy measures/instruments criterion,* to reflect the fact that an outcome of energy policies requires time to achieve the targeted goals (refer to Chapter 5 for more details). Chapter 5 has been submitted to the Journal of Energy Policy and had been substantially revised based on peer-reviewed reports and currently pending for publication.

3.6.2 Data collection and analysis structure of Chapter 6

To investigate and gain insght for the research question 3, the perspective of just the energy-system policy/politics needs to be expanded to include all related aspects such as a country's energy endowment and policy, economic and citizen inclination profile (landscape), as well as the enactments between the existing and propspective socio-technical development (regime and niche). The MLP-MCA analytical model (Table 6-1) based on the MLP transition theory was applied to cross-cutting such complex intertwining multi-dimensional national entity into more managable and quantifiable components that are easier to be examined. The assessment score for one of the sub-criteria (A2 – Climate/energy targets and policies) of the *Landscape* (presented in Table 6-1) was based on the national policy data from the master tables of Appendix A1 of Chapater 4 and Appendix A of Chapter 5. A set of well-defined condtional scores with detailed description of relevant conditions is included in Appendix A of Chapter 6. Other data sourced from ex post government official data, IEA energy reports and other research literature in the field of socio-technical transition were collected concurrently during data analysis for ranking scores suppoted with relevant references to the data. Detailed data adopted in the data analysis for each milestone period of Australia and Germany is provided in Appendix B and C correspondingly. In other words, Appendix B and C represent both data collection and analysis result.

Chapter 4 – Chapter Introduction

This chapter contained an article published in the peer-reviewed *Journal of Energy Policy* with similar title of the chapter:

Cheung, G. & Davies, P. J. 2017. In the transformation of energy systems: what is holding Australia back? Energy Policy, 109, 96-108.

The literature review in Chapter 2 reveals that the socio-technical energy transitions are complex and protracted processes that need to navigate and overcome many intertwining social, political, economic and technological challenges. Hence, to gain insights to the question posted in this chapter, "*In the transformation of energy systems: what is holding Australia back?",* an investigation needs to cross-cut a multitude of driving factors impacting Australia's energy transition performance.

The role of this chapter and paper was to develop, present and test a methodological approach framed around climate change and energy transition policy and politics of Australia. It is built around a multi criteria analysis (MCA) as elaborated in the Chapter 3. The constructed MCA analytical model was designed with an ability to dissect the complex policy and political components of the energy-system transition. In doing so, it applies a semi-crisp quantifiable ranking scale and ruleset to simplify an otherwise highly complex data analysis process and offers a model that is repeatable.

Apart from the purposefully designed MCA model, this chapter also investigates energy transition through a nested longitudinal national case study focusing on four Prime Ministers and their governments spanning from PM John Howard (1996-2007), PM Kevin Rudd (2007–2010), PM Julia Gilliard (2010-2013) and PM Tony Abbott (2013-2015). This was informed by a grounded theory approach applied to longitudinal data of national climate/energy policies sourced from the IEA/IRENA members' renewable energy policy database.

The selection of the study period for investigation in this chapter was subjected to the availability of data from IEA/IRENA websites and was aligned to the 1995 Conference of Parties (COP 1) in Berlin. Therefore, the commencement of the PM Howard in 1996 does not assume nor dismiss the climate and energy policies of previous governments. Rather, 1996 was used to establish a time boundary and enable a parallel study of Germany's energy transition, presented in Chapter 5, and to facilitate a comparative analysis between Australia and Germany, as presented in Chapter 6.

While the details of the MCA framework, results and discussions are covered in the published paper that followed, key highlights of this chapter's contributions to the aims of the thesis: *in gaining insights and new perspectives on the dynamics drivers, challenges and causal factors underlying the contrasting energy-transition performance between Australia and Germany* are listed below.

From an energy-transition research perspective, the findings of this chapter:

1. Add strength to the work of Grin et al. (2010) and Meadowcroft (2009, 2011) and reinforcing the critical role of power and politics on energy transition.
2. Reinforce the significance of goal-oriented plans as noted by Smith et al. (2005).
3. Build on the cumulative knowledge of sustainability transitions of Geels (2006), van Rooijen and van Wees (2006) and Verbong and Geels (2007) that reinforce the need for consistency, stability and certainty of government policy to support long-term socio-technical changes.
4. Add a new insight that underlying economic conditions of a nation are not a prime determinant of national climate change actions and achievements in RE transformation.

From a research methodological strategy perspective:

1. The collective cases of four Australia's PMs nested within a 20-years longitudinal national case study enabled detailed examination and comparison of each leader's climate/energy policy and politics that can better explain an individual time-in-office issue within a wider national phenomenon.
2. The framing of the MCA model provided a socio-political lens with a focus on dissecting transition-specific politics, policies and governance. This in itself has contributed an innovative quantifiable policy-analysis technique. The design of a semi-crisp MCA evaluation ranking scales and ruleset are relatively simple, yet can comprehensively differentiate the climate/energy political actions and policies performance of leaders and their relevant governments.

Chapter 4: In the transformation of energy systems: what is holding Australia back? *

Grace Cheung, Peter J Davies

Department of Environmental Sciences, Faculty of Science and Engineering, Macquarie University NSW 2109, Australia

Abstract

Australia has had a strong GDP growth rate, is endowed with a diversity of renewable energy resources yet has been unable to unshackle its dependency on fossil fuels. Our study identifies causes underlying Australia's underachievement in its transformation towards a renewable-energy economy. We apply a combined mixed-methods case-study and multi-criteria analysis to evaluate the greenhouse gas emissions and energy targets, policies and programs of four Australian Prime Ministers between 1996 and 2015. We identify four high-impact factors that contribute to Australia's underachievement. The Prime Minister's political stance on climate and energy is critical in setting the direction of government. The absence of target-driven policy frameworks results in less-effective policy outcomes. Orderly and cost-effective energy system transformation requires bipartisan, strategic long-term planning and substantial capital investment to provide policy certainty and stability that can induce new investment in renewable technologies and industries. Energy policy is primarily a political and ideological issue not one driven by underlying economic conditions. Going forward, Australia must achieve a bipartisan position on climate and energy policy at both federal and state levels. This will provide long-term certainty and stability to support investment in renewable energy and so doing achieve international emission reduction obligations.

Keywords

Energy system transformation; Climate change politics; Multi-criteria analysis; Renewable; Energy policy; Energy economics

* Published as: *Cheung, G. and Davies, P.J., 2017. 'In the transformation of energy systems: what is holding Australia back?', Energy Policy, 109, pp. 96–108.*

4.1 Introduction

Australia is underperforming in greenhouse gas (GHG) reduction and energy systems decarbonisation among the developed nations. Despite its healthy gross domestic product (GDP) growth rate ranging 1.8% to 5% in the last two decades (World Bank, 2015) and rich endowment of diverse renewable-energy resource potential (BREE, 2014a), the contribution of fossil-fuelled electricity has remained stubbornly high at 85%, while renewable electricity (excluding hydro) stands at 7.5% (Australian Government, 2015d). The electricity sector by far is the largest source of GHG emissions in the national inventory accounting for 34% in 2014/15 and this rose an additional 3% in 2015 (Australian Government, 2015c). There remains an ongoing political disposition to financially subsidise the coal industry in-spite of inevitable longer-term social, economic and environmental impacts associated with climate change (Bullard, 2014; Caldecott et al., 2013). At the Paris Agreement of the Conference of the Parties (COP) 21 in 2015, Australia found its political position on energy caught between the tension of its entrenched support for the coal industry and an urge to keep pace with rapidly shifting international actions on climate change. Understanding the factors which inform, influence and drive energy policies in Australia remains deeply shrouded in complexity and have been simplified in public debates as ideological political positions.

The aim of this study is to identify the causes underlying Australia's underachievement in energy systems transformation and GHG emission reduction. Applying a combined mixed-methods case-study and multi-criteria analysis (MCA) evaluation framework to ex-post historical data, reports and studies, we investigate the political commitment, policy and enabling frameworks, monitoring and reporting systems of four Prime Ministers (PMs) in their term of government between 1996 and 2015.

Our study contributes to the crucial research field of climate change and energy systems transformation by providing insights to the underlying causalities to the underachievement of Australia's GHG emission reduction obligations and transition to a renewable energy (RE) economy. The findings from this study offer lessons for policy- and decision-makers as to the factors that may support or deter RE transition. Additionally, our MCA evaluation model can be applied to assess the effectiveness of other national governments as to their climate change mitigation action and RE transition policies.

The remainder of the paper is made up of the following sections. Section 4.2 provides a review of the complexity and cross-scale challenges in transforming the energy systems from the global political perspective and how these impact on the economic dimensions in Australia. Section 4.3 describes the development of the MCA involving the mixed-method approach and its ranking rule set. Section 4.4 presents the evaluation of the four PMs' performance under the MCA related to emission targets, climate mitigation planning, and funding and policy implementation. Section 4.5 discusses the findings and section 4.6 concludes our study and identifies implications for the possible way forward for Australia.

4.2 Challenges and complexity in transforming energy systems

4.2.1 Global context

The 2015 United Nations Framework Convention on Climate Change (UNFCCC) COP21 in Paris represented a turning point in the geopolitical landscape to reduce global carbon emissions (UNFCCC, 2015a; 2015c). At the Paris meeting, 146 countries and the European Union, representing 86% of global GHG emissions reached an agreement to reduce emissions. 119 nations submitted their Intended Nationally Determined Contributions (INDC) that outlined their intended post-2020 climate actions under the new international agreement. The long-term goal of the Paris INDC Agreement was to limit the global average temperature rise to 2°C as a minimum effort and then to 1.5°C by ratcheting up more global efforts to achieve net-zero emissions in the second half of this century (UNFCCC, 2015b). Despite comments that the combined achievements would be insufficient (Climate Action Tracker, 2015a), the commitments, nevertheless, represent a positive shift internationally and are in stark contrast to the lack of collective agreement, progress and political will expressed at previous UNFCCC meetings since 1995 (Helm, 2009a).

Decarbonisation of the energy systems is the key to address the climate change challenge. The energy sector accounts for over two-thirds of the global GHG emissions and the power sector alone contributes more than 40% to the total energy-sector emissions (IEA, 2014b; 2015a; 2015b). Globally, fossil-fuelled electricity supplies two-thirds of the power demand which is projected to increase to over 70% in the period from 2013 to 2040 (IEA, 2015b). In spite of recent strong international commitments to transform energy systems, this projected increase highlights the complex interwoven social, economic, political and technological challenges that confront national and global energy systems. Globally, there are 1,469 listed oil and gas companies which represent one of the world's largest asset classes worth nearly $5 trillion. A further 275 top coal firms are worth $233 billion as of the July 2014 stock market values. These assets are mostly owned by the world's largest investors and many governments are the major stakeholders (Bullard, 2014; IEA, 2014a). Politically, this represents an entrenched tension and arguably conflict of interest between the incumbent stakeholders to maximise a return on their capital for as long as possible thus avoiding or serving as an economic barrier to transition to a RE economy.

Economically, any investment in fossil-energy generation today will lock-in long-term future emission trajectories due to the heavy sunk-cost and long life-cycle of coal-fired power plants (IEA, 2014a). To ensure energy security, while transforming to a RE system, IEA (2014a) has projected \$53 trillion in global investment capital by 2035 is required just to keep up with the energy supply and improve energy efficiency in order to get the world onto a 2°C emissions trajectory. Additional projected investment would also be required for new renewable power plants (\$11.3 trillion) and 75 million kilometres of transmission and distribution lines (\$8.4 trillion) over the period 2015-2040 (IEA, 2015b).

Transforming the energy systems alone will not achieve the emission reduction target required to limit the global average temperature rise to below 2°C (UNFCCC, 2015b). An additional \$14 trillion would be needed to improve energy efficiency and productivity by 15% to 2035 (IEA, 2014a). Capping or reducing the energy end-use (demand) cannot be achieved without full understanding and acceptance by society as to the causal link between energy consumption and the anthropogenic impacts of climate change. This can be achieved through energy-efficiency regulations and standards. However, this requires a broader understanding and acceptance of the impacts of climate change and in turn long-term, multi-partisan commitments and a strategic alignment of government planning and policies (IEA, 2008; 2013).

As the energy resource endowment and socio-economic development profile of each country is unique, the mix of technology and policy choices to transition towards a RE economy will vary (IEA, 2008). The use of technologies and policies must be framed within the complex social, economic, political and environmental interactions. They must be able to support new long-term capital investment to boost RE technology development and deployment. They must also address the concurrent concern and resistance from the incumbent fossil-fuel industry. This can be achieved through an orderly phase-out of the ageing coal-fired and other fossil-fuel energy generation plants (Nelson et al., 2017). Policies also need to balance energy security and minimise social and economic disruption with appropriate transitioning speed and scale that enable the development of a low-carbon economy with consideration to the predicted pace of climate change impacts.

4.2.1.1 Energy systems and renewable energy characteristics

Investment in energy systems have traditionally been based on capital-intensive fossil-fuel power stations and many of these were state owned and regulated monopolies. This ownership, operation and regulation model minimised the capital risk for energy investors through guaranteed pricing for energy consumers (IEA, 2003b). However, the flip-side has been an impenetrable barrier for new private energy players (Würtenberger et al., 2011). More recently, many governments have liberalised their power generation, transmission and distribution assets that are now corporatised or fully privatised assets. Paradoxically, these neoliberal changes have also occurred in parallel with the recognition of the need to support RE transformation through policies to promote more effective market competition, including grants and subsidies (IEA, 2003b; 2008; 2014c).

While the method of electricity generation may be changing, the basic requirement of the electricity market continues to rely on a guarantee of supply from generators to meet variable demands. This requires generation to meet low base and high peak consumer demands (Clarke, 2009). Some types of fossil-fuelled power generation systems are able to ramp up or down their generation on demand with peak-loads delivered through excess network capacity (Jordan-Korte, 2011, Moser, 2011) which can be idled or underutilised for most of the time (Clark, 2009). The intermittent ramping up and down of the peak-load capacity results in both increased GHG emissions and significantly reduced efficiency and lifespan of the coal-fired power plants (Connolly et al., 2012; ESB National Grid 2004; Pitt et al., 2005). Unlike many fossil power-generation systems, most RE generation (except hydroelectric, geothermal, concentrated solar thermal and biomass) is intermittent. That means technologies such as solar PV and wind turbines are unable to produce electricity on-demand (Boyle, 2007). Presently, these RE systems can only serve both base and peak demands with adequate energy storage (Budischak, 2013; Moser, 2011; Shaw, 2011). However, many studies suggest that as RE technologies improve 100% renewable electricity supply scenarios in Australian is technically feasible (AEMO, 2013; Diesendorf, 2016; Elliston et al., 2012; Lenzen et al., 2016) and economically can be cost competitive to fossil-fuelled electricity (Elliston et al., 2013; 2014; 2016).

4.2.1.2 Enabling renewable energy policy framework

Ideally, RE transformation would be optimised if undertaken in tandem with a country’s power generation investment cycle to replace its ageing fossil generation assets (IEA, 2007b). This idealised timing rarely coincides and consequently transition must rely strong political leadership with consistent policy direction to provide a favourable and stable investment conditions necessary to minimise risk and optimise return for investors. These factors must also be supported by an innovation drive in the research and development (R&D) of emerging and promising RE technologies that can support more innovative and cost-effective transitioning pathways for a clean and sustainable energy future (IEA, 2003b; 2007; 2010).

A significant body of literature from the Intergovernmental Panel on Climate Change (IPCC) (2001; 2007; 2012; 2014) and the International Energy Agency (IEA) (2007; 2013) has emphasised and recommended that leadership, integrated policy frameworks with appropriate market instruments, together with monitoring and reporting of the implementation processes are crucial for any effective RE transformation. Hence, these three elements are chosen as high-level criteria in analysing the impacts of aggregated policy instruments in our MCA model to evaluate Australian's energy transformation performance. The constituent-policy criteria that make up these three elements were drawn from the Policies and Measures Database of the International Energy Agency and the International Renewable Energy Agency (IEA/IRENA, 2016) which has been used by many scholars globally to analyse RE policy-instrument performance in OECD countries (e.g. Aguirre and Ibikunle, 2014; Cárdenas-Rodríguez et al.,2013; Marques and Fuinhas, 2012; Polzin et al., 2015). The selection of the sub-criteria was based on the RE policy instruments and measures that had been implemented domestically and were extracted from the IEA/IRENA (2016) database (Appendix A1). The characteristics of the three elements are defined below:

Leadership

- Strong, clear and consistent political leadership support in setting a target, strategic plan and policy framework.

Integrated policy and market instruments

- Liberalise and reform the electricity market with transparent rules and long-term stability to minimise capital risks for new players.
- Diffuse market barriers with innovative financial incentives to induce private investment in the RE sector.
- Funding for R&D of promising RE technologies.
- Manage capital investment cycle to orderly phase-out inefficient and ageing coal-fired power plants.

Monitoring and reporting frameworks

- Consistent policy framework and monitoring processes to close the gap between targets and actions.

4.2.2 Australia national context

4.2.2.1 Energy economics and decarbonisation obstacles

Australia is the eighth largest fossil-energy producer in the world and one of the only three net energy exporters in the OECD[22] countries (BREE, 2014a). It has a diverse source of coal, natural gas, oil and uranium energy resources and an extensive yet relatively untapped wind, solar, geothermal and biomass energy potential (BREE, 2014b). Between 1990 and 2015, Australia's economy reported an annual GDP growth rate ranging from 1.8% to 5% (World Bank, 2015), whereas the CO2 emissions remained comparatively stable moving between 490 Mt and 615 Mt Co2-e) (Figure 4-1) (refer to Appendix C for detailed data). Over this period, energy exports grew consistently and in 2013/14 contributed 7% to the national GDP ($71.5 billion) with energy related industries employing 170,000 (BREE 2014a).

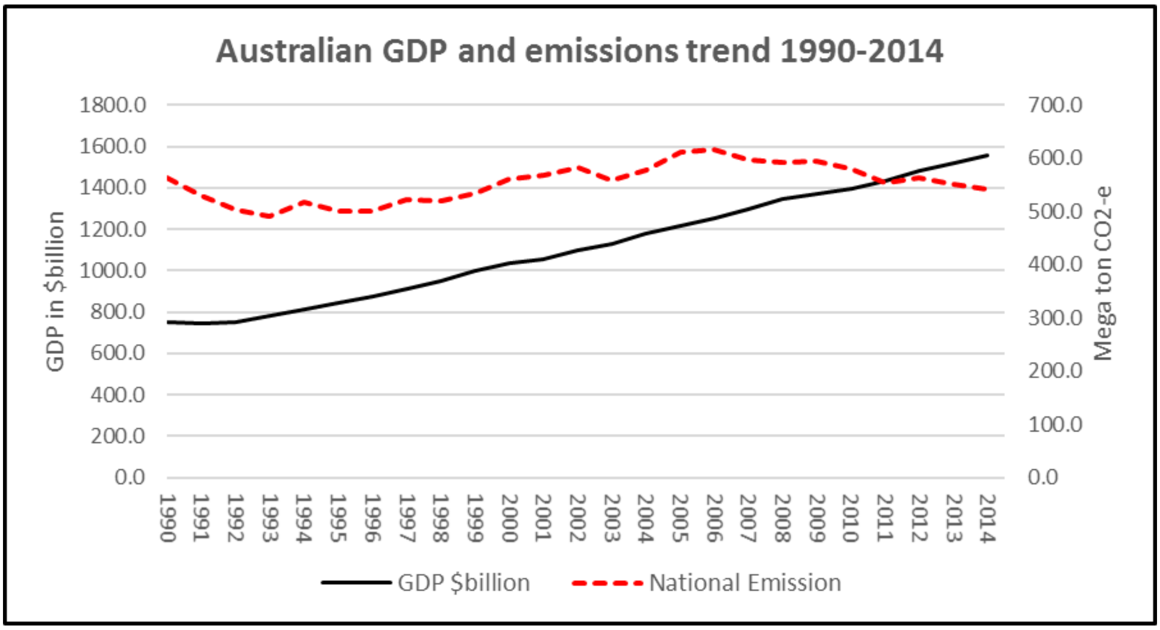

Figure 4-1 Australian GDP and emissions trend from 1990 to 2014 (Source: Dept. of Environment and ABS see Appendix C)

In 2014, coal provided around 65% of Australia’s electricity production with approximately twice as much black coal burnt as the less thermally efficient brown coal. Gas is the next dominant source, followed by hydro then other RE sources making up less than 10%. BREE estimates that coal will maintain its share at 65% and renewables will only increase to 14% (BREE, 2014b).

[22] Organisation for Economic Co-operation and Development

These predictions reflect past energy market trends (Figure 4-2) that defy two decades of international commitments to reduce GHG emissions and may suggest that Australia's pledge of a 26% – 28% GHG reduction target from 2005 level by 2030 at the COP21 in Paris (Australian Government, 2015a) may be political not realistic.

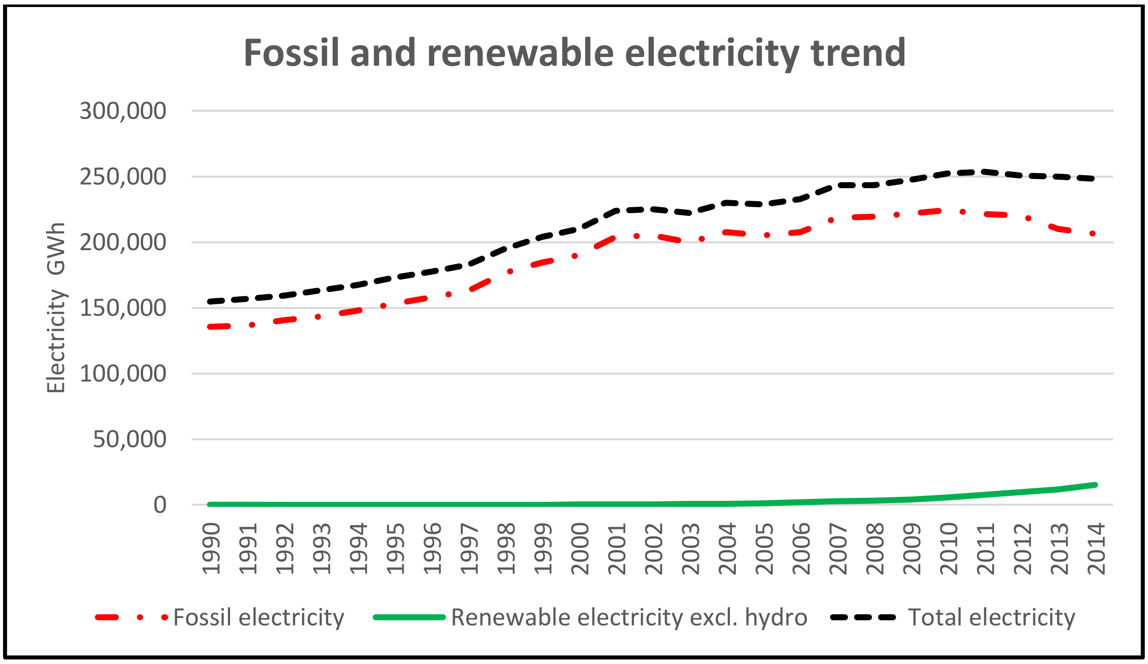

Figure 4-2 Fossil and renewable electricity trend 1990-2014 (Source: Dept. of Environment and ABS see Appendix C)

Australia's lack progress on GHG emission reductions and its pledge at the COP21 has been criticised as inadequate by the Bernie Fraser, Chairman of the Australian Climate Change Authority. Fraser recommended a reduction of 40% – 60% below 2000 level by 2030 based on Australia having the highest emissions per capita and emission-intensity per GDP in the developed world (Australian Government, 2015b). The global group, 'Climate Action Tracker', also critiqued the proposed reduction based on Australia's poor track record to deliver GHG emission reductions making specific reference to the lack of effectiveness of the current Emission Reduction Fund and related policies that are struggling to achieve even the 5% Kyoto reduction target on 2000 level by 2020 (Climate Action Tracker, 2015b; Höhne et al., 2015).

4.2.2.2 Obstacles rooted in politics not economics

The politics of climate change in Australia is rooted to the abundance of low-cost fossil-fuels for its domestic electricity generation and export revenue (Crowley, 2017; Curran, 2009) and the limits of federalism to successfully coordinate and deliver RE policy (Jones, 2009). Complex and entrenched political and economic interests of the fossil-fuel industry (Garnaut, 2008; Hamilton, 2007; Pearse, 2007) has constantly shaped the national climate/energy policy agenda over the last two decades (Beeson and McDonald, 2013; Crowley, 2010; 2011; 2013a; Hetherington and Soutphommasane, 2010; McDonald, 2012; 2013; 2015). This is reflected within Australia's climate/energy policy from both major political parties that has also been subjected to internal party-political divisions impacting on goals, pathways and mechanisms to achieve RE transformation (Warren et al., 2016). Federal-state relationships that include energy policy have been far from cooperative despite the acknowledgement that energy supply is a shared responsibility and constitutionally is a state and territory power. The federal-state relationships on energy remain also deeply rooted in political and industry interests, notwithstanding cooperative agreements between level of governments established under the Coalition of Australian Governments through a Ministerial Council on Energy and subsequent committees (Jones, 2009) and the National Electricity Market that connects five state jurisdictions to support a wholesale energy generation and supply.

From a technical perspective, however, many studies have demonstrated that Australia has abundant RE resources (Geoscience Australia and BREE, 2014) that are economically viable and able to transform its carbon-intensive energy systems to a sustainable clean alternative (ClimateWorks, 2014; Elliston et al., 2014; Nelson et al., 2013; Rutovitz et al., 2013; Sivaraman & Horne, 2011; Wright & Hearps, 2010).

The politics of energy transformation, nevertheless, is one that has, to-date, proven to be too great to overcome the sustained partisan-political stance and industry influence. Warren et al. (2016) noted that frequent changes in climate/energy policies have been linked to electoral cycles and the change in prime ministers in the last decade. These factors have added to the instability and uncertainty of climate/energy politics that has failed to induce and mobilize long-term capital investment needed for the development of RE technologies and related industries in Australia (Christoff, 2013; Crowley, 2013a; Diesendorf, 2012; Simpson and Clifton, 2014). Therefore, this study investigates and evaluates the leadership of four Australian PMs and their cabinet in relation to climate/energy policies and the enabling climate/energy governance frameworks. In doing so, we seek to gain insight to the causal factors to the barriers and identify opportunities for RE transition in Australia.

4.3 Methodology

The key objective of this study and the development of the MCA was to assess, rank and compare the performance of four Prime Ministers (PMs) and their government on climate change mitigation and RE transformation. The PMs included John Howard (1996-2007), Kevin Rudd (2007–2010)[23], Julia Gilliard (2010-2013) and Tony Abbott (2013-2015). A grounded theory approach (Glaser and Strauss,1967) was employed to investigate climate change mitigation and energy politics and policies across a 19-year period (1996 and 2015) in Australia. The grounded theory approach is particularly relevant to understanding complex interweaving relationships of social, political, economic and environmental processes (Charmaz, 2006; Dey, 1999; 2011; Halkier et al., 2011). Causal barriers to and opportunities for RE transformation were identified by applying a case-oriented research strategy combined with multi-criteria analysis (MCA) method (Konidari and Mavrakis, 2007; Ragin, 1987; Rihoux and Grimm, 2006). This was applied chronologically for each PM and his/her cabinet in relation to their actions on climate and energy. The actions were systematically analysed, scored against a constructed MCA model and compared to identify what climate and energy policy frameworks were developed that had an impact on GHG emissions and the RE sector.

The mixed-methods strategy enhanced the scope and breadth of research analysis and results (Guest, 2013). Both quantitative and qualitative data sources were integrated (Creswell, 2003; Greene et al., 1989; Smith, 1986; Tashakkori & Teddlie, 2003). Quantitative data was obtained from government and related sources. Qualitative information was aimed to enrich the narrative related to the development of influential events or conditions that shaped the variables revealed by the quantitative method. This multi-strategy study takes place sequentially from the stages of research question formulation, data collection, analysis and interpretation.

4.3.1 Data collection and analysis

Data was sourced from the Australian Bureau of Statistics for national economic statistical data, Bureau of Resources and Energy Economics, national communication reports to UNFCCC (Appendix C) and IEA/IRENA (2016) and a wide-range of climate policy-evaluation literature. These data were matched chronologically with the PM's and the UNFCCC COP from COP1 in Berlin to COP21 in Paris to reflect the political actions at a national and global level to form the 'master table' (Appendix A1). A brief description of key policies was provided to avoid possible double counting of both policy and funding sources (as policies are often allocated through an overarching umbrella approach rather than by a single policy). A summary table PM's tenure,

[23] Kevin Rudd had a second term as PM between 27/06/2013 – 18/09/2013, replacing PM Gillard as a result of a successful leadership challenge within the Australian Labor Party. This was considered too brief to have had any chance of setting and implementing new policies, hence was excluded from the analysis.

COPs, number of policies still ‘In Force’ and the total funding was constructed from the master table (Appendix A2).

Historical economic, GHG emissions and the RE growth data were collected from 1990 to 2014. These data were merged and matched to the relevant PM and their policies and funding. This was undertaken to identify possible relationship or effect on the national emissions and RE outcomes (data table in Appendix C).

Our model and analysis also considered IPCC reports on mitigation and energy transformation policies and instruments recommendation for policy-makers around the world (IPCC, 2001; 2007; 2012; 2014). The enabling factors and policy framework (section 4.2.1.2) were used to construct our MCA evaluation model.

4.3.1.1 Multi-criteria analysis model

The MCA method is increasingly used by governments and researchers in the field of energy policy to: assess the dynamics of instruments and approaches to optimize their effectiveness (Matthes et al., 2005); verify results and impacts of instruments and policies on emission reductions and development of energy systems (Neij and Astrand, 2006); select the most appropriate instruments and policies at a national level (IPCC, 2001; Mourmouris and Potolias, 2013); and evaluate instruments and policies that have complex socio-economic and environmental impacts that are hard to measure in monetary terms (Konidari and Mavrakis, 2007; Morris and Belton, 2011; Scrieciu et al., 2011).

Our MCA model systematically examined through evidence-based actions and the performance of each PM and his/her cabinet in: setting their national climate mitigation targets; formulating strategic plans and relevant climate/energy policy instruments; and reporting results via a measurement and evaluation framework. The model (Table 4-1) encompasses a three-tier criteria hierarchical structure based on: ‘Political acceptability’; ‘Policy measures / instruments’; and ‘Implementation, tracking & reporting’. The selection of the tier-1 criterion is based on the premise that at the macro social and economic level, if national mitigation targets are to succeed, politics, policies and implementation have to go hand-in-hand. If any of these elements are missing the results would be compromised and an effective RE transformation cannot be sustained. Each tier-1 criterion comprises of second and third sub-criteria. The selection and application of these sub-criteria are to provide additional and granular detail to the efficacy of political, policy and implementation criteria (Table 4-1).

4.3.1.2 Sub-criteria ranking scales and basic rules

Weighting factors were applied for tier-1 criteria as follows: 50% for 'Political acceptability'; 40% for 'Policy measures / instruments'; and 10% for 'Implementation, tracking and reporting'. The weighting for the tier-1 criteria was based on the outcomes of the IPCC reports (IPCC, 2001; 2007; 2012; 2014) stating that underlying political acceptability of the need for climate change mitigation is paramount and that this is required if meaningful carbon reduction targets are to be set. Following the setting of a carbon reduction target is the introduction of relevant policies. This was ranked as the second criterion as the setting of policies and implementing programs is best followed and relates to a target or 'mandate'. The third criteria, tracking and reporting, was placed in this hierarchical order as measurement and performance monitoring is most relevant where it relates to firstly an adopted target and to assess the efficacy of policies and programs.

The model adopts equal weight coefficients for both the tier-2 and tier-3 sub-criteria (Table 4-1). This assumes that each sub-criterion has an equal contribution towards its higher-tier criterion. Therefore, the value of each tier-1 criterion is the average of all scores of its tier-2 criteria and each tier-2 criterion score is the average of its tier-3 sub-criteria. The total score is then calculated by applying the relevant weighting factors assigned to the tier-1 criteria e.g. (Ax0.5+Bx0.4+Cx0.1). The normal arithmetic rounding practice was adopted throughout calculation and a gradient scale is adopted in the interpretation of the value. As an example, a value below 0.5 would be interpreted as an insufficient response while a score above 0.5 would be regarded as sufficient.

Table 4-1 Multi-criteria tree structure and scoring hierarchical codes

Tier 1 criteria	Tier 2 criteria	Tier 3 ranking parameters and codes[24] *With scale values: 0 = no; 0.5 = partial; 1 = yes*
A – Political acceptability 50%	***A1 – Leadership support***	**A11** – advocacy for strong domestic mitigation target
		A12 – positive actions on CC mitigation in funding and policy making
		A13 – promoting actions from states / local governments
	A2 – International commitment	**A21** – recognise the need for CC mitigation and global fair-share in emission reduction
		A22 – ratification of international commitment (Kyoto Protocol)
		A23 – participating in regional climate actions and international cooperate
	A3 – National targets and strategic planning (A3)	**A31** – set ambitious national emission reduction and RE target for actions
		A32 – modelling cost/benefit in formulating strategic pathways
		A33 – setup national plan for the chosen pathway to achieve the set target
B – Policy measures / instruments 40%	***B1 – Public funding for R&D and RE incentive***	**B11** – funding for renewable energy and/or CCS technologies R&D
		B12 – funding incentives for adoption of RE in general public
	B2 – Private investment inducement	**B21** – support for RE technology commercialisation
		B22 – ongoing financial instrument aiding RE sector development
		B23 – policy certainty for long-term capital investment in commercial RE generation
	B3 – Market structural and regulatory reforms	**B31** – integrate and reform national electricity market
		B32 – initiatives to improve market accessibility for new players
		B33 – ongoing regulation review for market integration and efficiency
	B4 – Policies feasibility and effectiveness	**B41** – design and functioning of carbon pricing mechanism
		B42 – design and functioning of feed-in tariffs
		B43 – feasibility of policy/instruments as a whole to achieve the set goal
	B5 – Policies consistency and continuity	**B51** – policies design with long-term mitigation objectives
		B52 – monitoring mechanism of policy performance for ongoing improvement
		B53 – policies still in-force despite the change of governing party
C – Implementation, tracking and reporting 10%	***C1 – Implementation institute capacity***	**C11** – dedicated institutes to oversee the implementation of the national mitigation plan
		C12 – institutes in support of RE sector development and investment inducement
		C13 – sufficiency of supporting institutes' capacity
	C2 –Tracking and reporting mechanism and clarity	**C21** – well-defined implementation tracking review mechanism
		C22 – clarity of tracking and reporting

[24] NOTES: climate change is denoted by (CC); carbon capture and storage is denoted by (CCS)

We understand that MCA is inherently subjective, both in terms of the criteria selection and their values chosen. To minimize subjective ranking, the assessment of each tier-3 sub-criterion was based on parameter/question that requires answer with a 'Yes' for definite positive outcome to obtain a score of 1, or a 'No' for definite negative outcome to obtain a score of 0. When there was a situation of either 'Yes' / 'No' from an uncertain/partial outcome that either has a positive or negative implication, a score of 0.5 was assigned. This form of scoring is regarded as a semi-crisp rule set which aims to eliminate subjective bias and provide flexibility for occasional non-conclusive situation during the assessment processes of the strong or weak performances of each PM. The score for each tier-3 sub-criterion was evidence-based drawing on official government sources, IEA reports and relevant literature in the field. Appendix B (Table B 4-1 – Table B 4-4) provides supplementary details for the evaluations of each PM. The alphabet A, B and C are assigned to tier-1 criteria, whereas each tier-2 and tier-3 criterion would add its sequential sub-criteria number to the code inherited from its corresponding higher tier criterion (see Table 4-1).

4.3.2 Evaluation processes

The MCA model (Table 4-1) was used to assess each ex-PM's climate change political acceptability, mitigation actions and policies performance. Details of the evaluation are included in Table B 4-1-Table B 4-4 of Appendix B. The score is awarded based on the analysis of the information from the Appendix A1 '**Australian Prime Ministers' climate policies chronology**' and Appendix A2 '**Australian Prime Ministers' climate policies summary table'**, the Australian government energy white papers, the IEA policy review reports for Australia and other climate policy, critical/evaluation study journal articles. These case-study tables are then consolidated into the master case-table as shown below in Table 4-2 (Section 4.4) for comprehensive comparative analysis.

4.4 Results

4.4.1 Prime Ministers' climate action ranking results

The result of the MCA evaluation for the four Australian ex-PMs is provided in Table 4-2. The MCA reported a significant range of scores across the PMs. As part of the interpretation of the results we have referred to the length of time they held office as the tenure of a PM will have bearing on the time taken to develop, implement and assess the impact of a policy.

Table 4-2 Multi-criteria analysis of the performance evaluation scores of four Australian ex-PMs

Criteria / sub-criteria	**PM John Howard** (Liberal) *(11.75 years)* 11/03/1996–03/12/2007	**PM Kevin Rudd** (ALP[25]) *(2.5 years)* 3/12/2007–24/06/2010	**PM Julia Gillard** (ALP) *(3 years)* 24/06/2010–27/06/2013	**PM Tony Abbott** (Liberal) *(2 years)* 18/09/2013-15/09/2015
Criterion A Political acceptability	**0.39**	**0.94**	**1**	**0**
Leadership support	0.67	1	1	0
International commitment	0.33	1	1	0
National targets and strategic planning	0.17	0.83	1	0
Criterion B Policy measures / instruments	**0.47**	**0.87**	**0.97**	**0.15**
Public funding for R&D and RE incentive	1	1	1	0.25
Private investment inducement	0.33	1	1	0
Market structural and regulatory reforms	0.67	1	1	0
Policies feasibility and effectiveness	0.33	0.5	0.83	0.17
Policies consistency and continuity	0	0.83	1	0.33
Criterion C Implementation tracking and reporting	**0.42**	**0.67**	**1**	**0.5**
Implementation institute capacity	0.33	0.83	1	0
Tracking and reporting mechanism and clarity	0.5	0.5	1	1
Total performance ranking scores	**0.43**	**0.89**	**0.99**	**0.11**

4.4.2 Analysis of leaders' performance ranking results

4.4.2.1 PM Howard - international climate mitigation recalcitrant

PM Howard was a neoliberal conservative who maintained close relations with fossil-fuel industries throughout his term of government (Crowley, 2010). His refusal to ratify the Kyoto

[25] Australian Labor Party

Protocol target of 108% above 2000 level was framed as in defense of economic growth, jobs and industrial competitiveness. That had left Australia without a GHG reduction target for actions. The recommendation by both Industry Commission and Treasury to adopt a carbon pricing scheme as the least cost and most economically rational approach was not pursued. As Payne (2010) and To et al. (2013) subsequently reported, no causal relationship exists between domestic energy consumption and economic growth so discredits the assertion by Howard (and also that of future Liberal governments) that a carbon pricing policy would have a detrimental effect on Australia's economic growth.

The MCA evaluation showed (Appendix B, Table B 4-1) that despite Howard's international recalcitrance, domestically he had contributed positively to the establishment of the early National Electricity Market reform, provided funding towards RE R&D, engaged local governments through ICLEI's[26] Climate Protection Program, supported private investment to RE and established institutes to implement and report on policies and programs. The critical failure of his term of office without a genuine integrated climate/energy reform was that his government had no plans to reduce Australia's emissions (Pearse, 2007), hence, no GHG reduction target was set which would otherwise have set a strategic pathway for climate/energy reform and transition to low-carbon economy. This reflects that the underlying climate/energy agenda was mainly dictated by a small group of Australia's biggest carbon polluters and lobbyists (Pearse, 2007).

At a macroeconomic level, PM Howard benefited from a long mining boom (2001-2008) from which the government received A$180 billion in additional taxation revenue (Hetherington and Prior, 2012). This economic windfall could have provided a foundation for investment in RE transformation but was otherwise prioritized to other areas of spending ($109b), debt reduction ($36b) and taxation cuts ($25b) (Hetherington and Prior, 2012).

4.4.2.2 PM Rudd - climate crusader and hastened spender

PM Rudd was elected in 2007 on a platform that included action on climate change citing this as a fundamental 'threat to national security' (Curran, 2011; Hetherington & Soutphommasane, 2010; Pietsch and McAllister, 2010; Tranter, 2011). His first act of parliament was to ratify the Kyoto Protocol with unconditional target of 5% below 2000 by 2020 and conditional 15% - 25% below 2000 by 2020 subject to international achievement and 60% below 2000 levels by 2050 (Durrant, 2010; Parliament of Australia, 2007). He commenced the framing of the Carbon Pollution

[26] International Council for Local Environmental Initiatives

Reduction Scheme (CPRS), committed $8 billion towards R&D and RE technologies supporting-policy programs (Appendix A1 & A2) and led a large delegation at the COP 13 in December 2007.

Unlike PM Howard, PM Rudd's government was short and impacted by the global financial crisis in 2008. Several programs such as Solar Rebate, Green Loans and Housing Insulation subsidy schemes were hastily implemented to deliver quick economic and political results in order to primarily stimulate the economy, whilst also achieving energy efficiency and addressing climate mitigation targets. These programs, however, failed to meet their initial expectations and have been subsequently critiqued (Crowley, 2011; 2013a; Durrant, 2010; McDonald, 2012, 2015). PM Rudd's twice failed attempts in gaining support from the Senate for a CPRS which ultimately contributed to the loss of his prime-ministership which also reflected the toxic nature of the climate change issues in Australia (Bailey et al., 2012; Falk & Settle, 2010; Pezzey et al., 2010). The Australian Greens', which held the balance of power in the Senate at the time, rejected the CPRS due to its perceived weaknesses that included allowing Australia's emission reductions to be achieved overseas through the Clean Development Mechanism and carbon offsets in the developing countries (Crowley, 2011; 2013b; 2017).

PM Rudd's actions on climate change and RE transformation have been described as largely symbolic apart from the ratification of the Kyoto Protocol (McDonald, 2012). However, his government should also be credited for: legislation to expand PM Howard's MRET[27] of 9,500 GWh by 2010 to 45,000 GWh by 2020; the introduction of a mechanism to achieve a revised GHG target through the creation and trading of renewable energy certificates (St John, 2014); and the commissioning of an economic modelling report on the impacts of climate change, the Garnaut Review. Importantly the Garnaut review (2008) set the foundation and evidence basis for the conception and successful implementation of PM Gillard government's Clean Energy Plan (CEP) (Commonwealth of Australia, 2008; Garnaut, 2008).

4.4.2.3 PM Gillard - achievement because of a minority government

PM Gillard was elected in 2010 as a minority government supported by the Australian Greens and three independent Members of Parliament. As part of her agreement with the Australian Greens to form her minority government and against her election campaign on 'no carbon tax', she created the Multi-Party Climate Change Committee which brought together diverse stakeholders to de-politicise the political and public debates over carbon pricing and renegotiated the passing of the

[27] MRET – Mandatory Renewable Energy Target.

Clean Energy Act 2011 (Chubb, 2015; Crowley, 2013b). Her leadership succeeded in legislating the carbon tax, setting 41,000 GWh large renewable energy target by 2020 and commitments to GHG emissions reduction of 5–25% from 2000 levels by 2020 and establishing a higher long-term target of 80% by 2050 subject to the scale of global actions (Commonwealth of Australia, 2011a; 2011b). An Energy Security Fund was established to minimize the impact of the energy transition process by assisting the incumbent coal-fired power stations while moving to cleaner energy future (IEA, 2012b).

The political commitment, policies and programs of the CEP were highly commended by the IEA (2012) as being a relatively balanced package with significant capital (A$22 billion, Appendix A2) to stimulate investment in clean energy transition through strong elements of carbon pricing, RE and annual pollution caps targets. The carbon tax was planned to be switched to a market-based emissions trading schemes to accelerate the deployment of the RE technologies in 2014-15, a timing that fell outside her term in office (Commonwealth of Australia, 2011b). As part of the Clean Energy Act 2011 (Cth), the state-based feed-in tariff schemes were left to be maintained through an intergovernmental agreement rather than being managed by a uniform federal scheme. The state-based feed-in tariff schemes were still mostly funded by states' budget at the time that was financially unsustainable and ultimately altered to be paid by consumers through levies on distributors (IEA, 2012b; Martin & Rice, 2013; Zahedi, 2010).

4.4.2.4 PM Abbott - climate skepticism and policy oppugnancy

As opposition leader of a conservative party during PM Gillard's time in office, Tony Abbott campaigned on a policy to scrap the carbon tax and reduce the cost of living after the passing of the CEP. Against credible evidence to the contrary (Alberici, 2012; Commonwealth of Australia, 2013), his campaign asserted that the carbon tax introduced by PM Gillard is indisputably a 'great big tax on everything' and added to the cost-of-living (ABC News, 2014; Crowley, 2017; Grattan and Wroe, 2011; Liberal Party of Australia, 2013). Once elected, PM Abbott, a self-confessed climate change sceptic and pro-coal advocate (Grattan, 2015; Keane, 2015; Readfearn, 2014), promptly moved to repeal carbon pricing legislation (McKenzie-Murray, 2015), refuse to send a minister to UNFCCC talks in Poland, scrap the Climate Commission, sideline the Climate Change Authority, reduce funding for science and climate research and establish the groundwork for walking away from both the 5% Kyoto and the 20% RE targets (Crowley, 2017; McDonald, 2015; Milman, 2013).

Like PM Rudd, PM Abbott's political imperatives were blocked by the Senate, ironically this time favouring action on climate change The result meant a 10-month delay in repealing the carbon tax provisions from the Clean Energy Act 2011 with a negotiated outcome to leave the climate governance institutes[28] and their funding intact (Crowley, 2017; DOE, 2014; Griffiths, 2014; dee,effectiveness being questioned and greatly criticized by many experts (Burke, 2016; Hollo, 2016; RepuTex, 2013; Reputex Carbon, 2013). PM Abbott was able to quickly reorganize departmental structures by creating a new Department of Environment to assume authority over the functions of climate change governance bodies and programs to substantially reduce their responsibility and funding (Talberg et al, 2013). He also placed a ban on ARENA[29] and CEFC[30] to provide funding support to key wind projects (Parkinson, 2013; Norman, 2015; Sansom, 2014) and by negotiation with the Labor opposition, reduced the renewable energy target from 41,000GWh to 33,000GWh resulting in a significant reduction in private investment confidence in the RE sector (Crowley, 2017; Hannam, 2015; McDonald, 2015).

Like the two PMs before him, PM Abbott's term in office was short-lived (compared to PM Howard) and he was replaced in mid-term by his party colleague, the current PM Turnbull. PM Abbott's climate legacy reflects one that defines the partisan and entrenched conservative position set along political lines (Hudson, 2016; Reece, 2013). This continues with the current Liberal-National Coalition Government and for RE policy in particular remains beholden to the conservative faction of the party (Kenny and Wen, 2015; Taylor, 2016).

4.5 Discussion

The political acceptance of climate change has had a significant influence on national policy, law and governance in Australia (Crowley, 2010; 2017; Hetherington and Prior, 2012; Stock et al., 2015). This has been driven by two key factors, the political stance of the PMs and their cabinet (setting the agenda and public debate) and the influence of the two-house system (House of Representatives and Senate) which exists in Australia (both houses of parliament are required to pass bills and budgets before gazettal or adoption). Woven within these influencing factors is the perceived impact of the nation's economic condition and the impact a transition to RE would have on the national and household budget.

[28] Climate Change Authority, ARENA and CEFC
[29] Australian Renewable Energy Agency
[30] Clean Energy Finance Corporation

The political stance of the PMs, sustained by the partisan and variable positions related to climate/energy policies by the two major political parties, has had a direct and significant impact nationally. This has informed the domestic funding of government programs and policies and internationally as to what Australia has taken to international negotiations on setting emission reduction targets. Our model ranked PMs Gillard and Rudd as having high political commitment and understanding of climate change issues that were subsequently reflected in their scores related to policy and action. This was followed by PM Howard as mid-range who presided over the period of emergence of the international political focus on climate change. PM Abbott had the lowest score reflecting his publicly displayed scepticism of climate change, pro-coal political stance and vigorous actions to repeal the carbon tax and dismantling the CEP. We consider these results to be a robust reflection of the political stance of each PM and their cabinet in relation to their impactful (positive and negative) actions on climate policy and energy reform within their term of government.

PM Gillard received the highest score (99%) reflecting her political astuteness in turning the weakness of her minority government to her advantage and her capacity in successfully negotiating through both houses of parliament, with the support of the Australian Greens, and legislated a comprehensive CEP. Her success can be attributed, in part, to the momentum of reform and political groundwork of climate/energy as an important issue established by her predecessor PM Rudd (Crowley, 2017).

PM Rudd (89%) introduced, in haste, many domestic policies and programs reflecting his pro-climate change political agenda which initially brought him to office and ironically was also responsible for his demise in the leadership spill by PM Gillard. PM Rudd's strategy to manage the global financial crisis demonstrated that energy efficiency and RE energy transformation could operate in concert in spite of adverse economic conditions. On the international stage, PM Rudd championed climate change and energy reform by taking a global leadership role, in a stark contrast to his predecessor PM Howard and subsequently that of PM Abbott. Domestically, PM Rudd's major shortcoming was an inability to withstand fossil-industry pressure that compromised his government's key climate CPRS policy which was deemed to be ineffective in tackling GHG emissions hence being rejected by the Senate.

PM Howard ranked close to middle-of-the-road (43%). Early in his term as PM he remained sceptical towards climate change, which shifted somewhat at the end of his term in office. PM Howard did establish a few early RE programs although without any overarching structure or view to achieving a pre-determined carbon reduction target. An evaluation of PM Howard needs to account for his time at the emergence of the international climate change movement and the general slow uptake of climate policies internationally. During his era, there were many conservative state governments in power which remained convinced that a transition from coal to a RE economy would have an adverse impact on their state (economy and jobs) and broadly impacting on the national budget and economy. This is evidenced by PM Howard's negotiated position under the Kyoto Protocol for an increase in emissions of 108%.

Finally, PM Abbott scored the lowest rank (11%) which reflected his personal pro-fossil energy and climate sceptic political stance and consequent persistent actions to dismantle all CEP and programs on coming to office. This antagonism led him to exercise both executive powers (circumventing the Senate) through his direct involvement in dismantling programs and departments, and political power to repeal carbon-tax laws (in negotiation with the Senate) as introduced by his predecessor PM Gillard.

The two-house political system in Australian comprising the House of Representatives and Senate, is designed to provide the check and balance to the democratic process. Recent history of climate politics in Australia has shown that the Senate has had an impactful role in both assisting (e.g. Gillard) and frustrating (e.g. Rudd and Abbott) the government's reform agenda on climate/energy policy. The powers established under the Australian Constitution and complex electoral system in Australia has historically made it difficult for an elected government to hold the balance of power in both houses of parliament that would otherwise provide certainty to deliver its policies. PM Howard, however, did hold the balance of power in both houses of parliament in his fourth and final term of government (2004 –2007). This enabled Howard to pass various laws but was not used to bring about climate/energy related reform. What has been reinforced though the climate/energy policy arena is the need for a PM and his/her government to negotiate with the varying interests of the Senate, and in particular satisfying the demands of minor parties in order to achieve their political agenda.

The underlying economic conditions during the term of each PM had a significant influence on Australia's climate/energy policy. In particular, there has been a causal socio-political nexus between the national accounts and the household budget. That has remained a core position of the conservative (Liberal-National) Coalition Government as part of its ongoing opposition to a carbon pricing scheme, such as a carbon tax, within recent past and current periods of high national debt and lower financial prosperity. PM Howard enjoyed the most financially prosperous period buoyed by the super mining-boom cycle which generated an additional A$180 billion to the budget (Hetherington and Prior, 2012). This had a twofold effect: it reinforced a relationship between the wealth generated by coal and other mining industries and the nation's prosperity; and, through tax cuts and social spending programs linked the national wealth to an improvement to the household budget. The economic prosperity and policies of the Howard era were however responsible for the slow uptick of RE generation (Figure 4-2) that was subsequently built on by PMs Rudd and Gillard during different economic circumstances.

The 2008 global financial crisis presented a different economic scenario for Australia. PM Rudd used this as an opportunity to identify and leverage the co-benefits of RE transformation to the national and household budget. He introduced an economic stimulus package to support job creation, that also addressed household budget concerns linking RE and energy efficiency as two pillars of his policy reform. The legacy of some of these programs still remains, with ARENA and CEFC continuing to promote RE technologies and their deployment, despite the intentions of PM Abbott to deconstruct the Labor's clean energy architecture.

Politically, the nexus between the underlying economic activities and actions on climate change has become the definable gulf that divides the major political parties in Australia preventing bipartisan commitment to a long-term cost-effective RE transformation.

4.5.1 Political and policy partisanship

The ideological positions related to how best to address climate change and support RE transformation with both parties have switched over time. In 1999, the conservative Liberal-National coalition government led by PM Howard supported an emissions trading scheme although it was never introduced (Talberg et al., 2013). An emission trading scheme was subsequently supported and introduced into parliament by the Labor Government under PM Rudd including a carbon tax which was not supported by the Australian Greens, who at the time held the balance of power in the Senate. PM Gillard publicly stated an opposition to a carbon tax as part of her electoral campaign in 2010, a position she later overturned in 2011 as part of her minority government established in negotiations with the Senate and the Multi Party Climate Change Committee[31]. PM Abbott and his successor and current PM Turnbull (since coming to office) have remained in opposition to any form of carbon tax which was repealed and replaced

[31] Multi Party Climate Change Committee – comprising of Labor, Greens and the independent members of parliament.

with PM Abbott's DAP, even though it remains widely criticized as an ineffective policy (e.g. Crowley, 2017). This conflated and shifting personal and political positions of PMs and their parties have created a conspicuous socio-political barrier to the advancement of carbon policy in Australia and arguably has increased community cynicism towards and lessened their support for a strong national climate change policy.

A constant theme since the late 1990's has been the independent support for a carbon pricing approach to achieve a reduction in GHG emissions (Jotzo, 2012; Jotzo et al, 2012, 2014; Whitmore et al, 2014). The alternative DAP approach has been criticized by the Australian National Audit Office and many other reviews as an ineffective and unstainable policy as a government funded initiative to pay heavy polluters to reduce their carbon emissions rather than using market pricing mechanisms accessible to all to support a transformation to RE. (BNEF; 2014; Climate Action Tracker, 2013; Denniss and Grudnoff, 2011; Garnaut, 2014; Jotzo et al, 2014). Empirically, the impact on GHG emission related to a carbon pricing scheme and the DAP can be seen in Figure 4-2 and Figure 4-3 which showed an uptrend of RE generation and down-trend of sector's emission in the period of the two Labor PMs (2009/10-2013/14) and the subsequent increase in emissions since PM Abbott from 2014.

4.5.2 Risks and consequences of carbon-intensive economy

An inherent contradiction exists with respect to Australia's energy policies and politics. As a nation, Australia has abundant fossil-fuel and RE resources and generally affordable energy, although this is on the rise. Australia is also on track to become the largest exporter of LNG[32] (Cullinane, 2017; DRET, 2012) and both the Federal and Queensland State Government remain in support of one of the largest coal-mining projects by the Indian energy company, Adani (Chang, 2017). Coal continues to capture significant political, social and economic interest and has an entrenched hold on climate/energy policy in Australia continuing to act against a RE transition in spite of global trends towards renewables (Goldenberg et al, 2015). This hold by fossil fuel industry on the political process has contributed to an ineffective climate and energy policy landscape despite the views opined by independent experts and even government led reviews. The politics of adopting then abandoning carbon pricing had left Australia out-of-line with evidence-based science and international GHG mitigation efforts (Crowley, 2017). As noted by many researchers, a fossil-intensive economy, such as Australia, cannot afford to ignore the broad ranging risks that could arise from a sharper RE transition and fossil-energy divestment that may

[32] LNG – Liquefied natural gas

eventuate from the Paris Climate Agreement (Alexander et al., 2014; Hannam, 2014; IEA, 2016; Liinanki, 2013). However, such risks are outweighed by Australia's major political parties determined to politicise climate and energy policy.

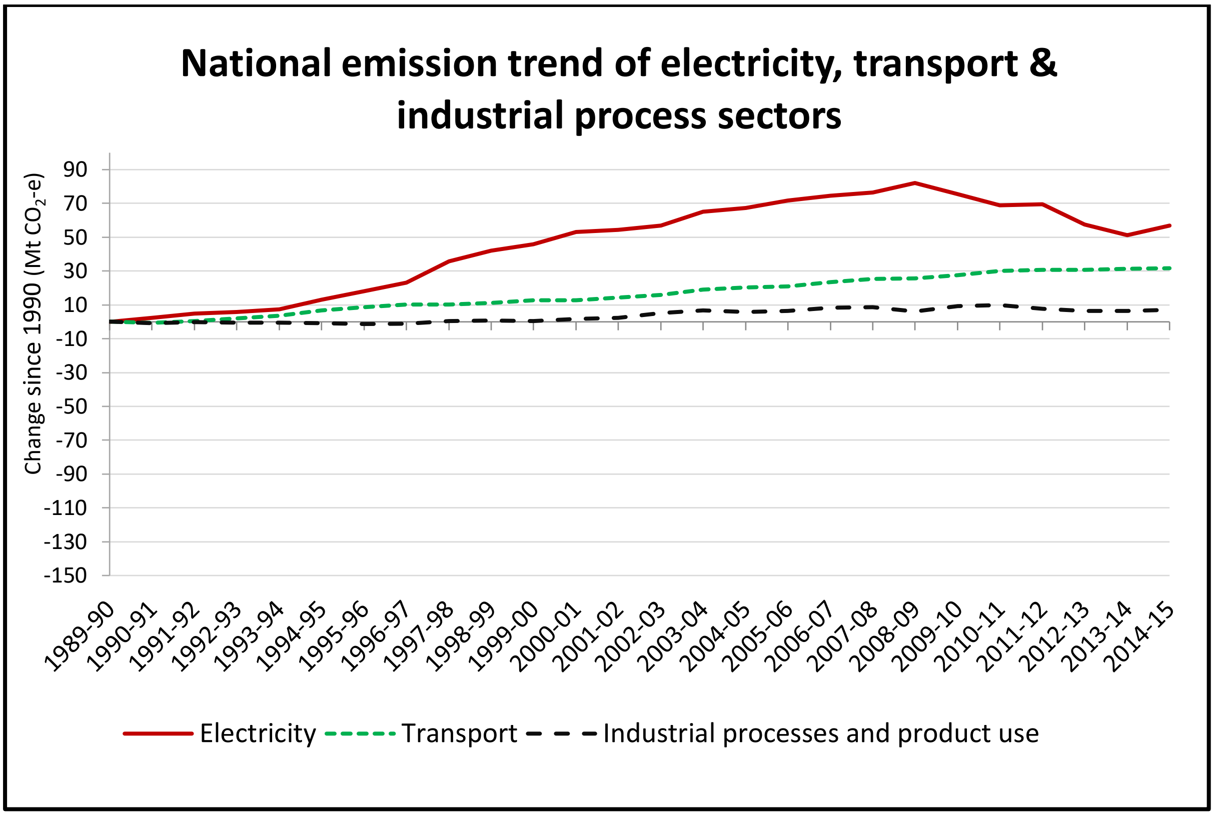

Figure 4-3 National emission trend in three sectors 1990-2015 (source: Australian Government, 2015c)

Political equivocation on climate/energy policy by the major and minor (in the Senate) political parties, their subsequent partisan approach has adversely impacted the business sector investing in RE (BNEF, 2015). The Bloomberg New Energy Finance (2015) has projected that up to two-thirds of the $12.2 trillion of global investment will be directed to RE and Australia must capture this investment opportunity to rebalance its waning mining boom (Stock et al, 2015). Australia is currently over-invested in coal and coal-fired power which could quickly become stranded assets and serve as additional barriers to the RE transition and burden to the national economy (Caldecott, 2013; McMahon, 2016). A 35% over-capacity projection in coal supply has already seen coal price fall from US$131/ton in 2011 to US$53/ton in 2016 (IEA, 2015b, p.25-26; Scott and Edwards, 2015). From a power-generation perspective, three quarters of Australia's coal-fired power stations are considered old, inefficient and past their design asset life (Stock, 2014). This is evidence by the State of Victoria decommissioning in March 2017 its largest coal-fired power station, but not without a call for its continuation by the former PM Abbott (ABC News, 2017) re-emphasising the pro-coal position of the right faction of the Liberal government.

4.5.3 Multi-criteria analysis results

Our MCA model was developed as a tool to evaluate and rank the climate change and RE transformation policies and actions of four Australian PMs and their governments. The use of three-tier criteria structure (based on political acceptability; policy measures/instruments; and implementation, tracking and reporting) supported by a semi-crisp three-point scoring system (0=no, 0.5=partial, 1=yes) has provided an effective method to score and compare the four Australian PMs. Our evaluation reported a wide discrepancy in scores. We believe that this is not a shortcoming of the model but rather reflects the partisan approach to climate/energy policy adopted by the two major political parties and their respective PMs. To test the robustness of the model, the weighing coefficients of tier-1 criteria (A – political acceptability, B – policy measures and instruments and C – implementation, tracking and reporting) were varied from our original choice of (Ax0.5+Bx0.4+Cx0.1) to (Ax0.4+Bx0.4+Cx0.2) and (Ax0.33+Bx0.33+Cx0.33). The results in Figure 4-4 showed that the ranking scores of each PM is not sensitive to the change of the weighing coefficients. This implies that the criteria and weightings reflect the importance of each criterion and importantly the leadership role of the PM in setting the political narrative to inform policy, actions and evaluation.

The MCA model has limitations in evaluating the quality of climate/energy policy including its effectiveness post implementation and specifically when subject to short (politically triggered) time horizons. Therefore, the ranking score of each PM is not reflecting his/her climate/energy policy performance, but rather the collective (PM’s and cabinet’s) political stance for or against, hence, the existence or non-existence of their climate actions. Additionally, the case study with time-series approach offers concise causality to the detriment of Australia’s decarbonisation performance as a result of the climate policy instability and uncertainty caused by the political divide as demonstrated by the four PMs.

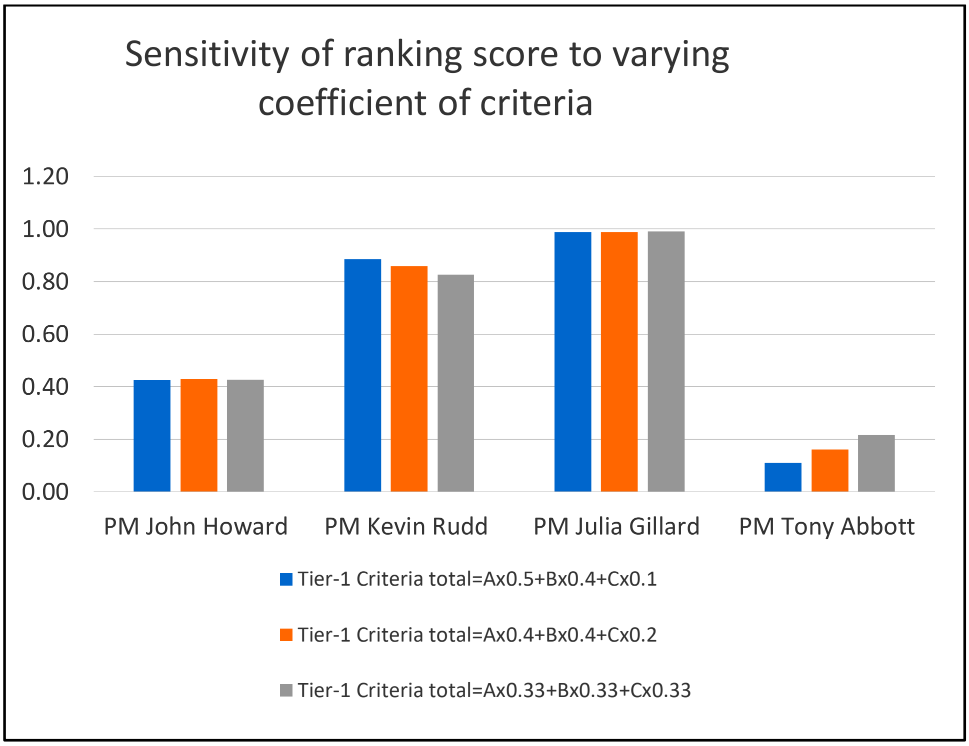

Figure 4-4 PM's ranking score sensitivity to the varying coefficient of the three tier-1 criteria

4.6 Conclusion and Policy Implications

We have developed a new mixed-method case study and multi-criteria analysis evaluation model to assess the impact and performance of a Prime Minister and his or her government on their climate mitigation and renewable energy actions. The model was framed around an analysis of four former Australian Prime Ministers using ex post historical data from official reports and other literature to answer the question: ‘What is holding Australia back in transformation of its energy systems?’

We reveal four high-impact factors which contribute to Australia’s GHG emission trajectory and poor decarbonisation outcomes. First, political stance of the Prime Minister and that of their political party towards climate change is a critical and fundamental political and policy driver. Second, an absence of targets directing policies and programs results in less effective outcomes. Third, an orderly and cost-effective energy systems transformation requires strategic long-term planning and substantial capital investment underpinned by a bipartisan approach from federal and state governments to provide policy certainty and stability to induce new investment. Finally, underlying economic conditions are not a determinant of whether climate change action and RE transformation can be achieved, but rather energy and climate policy is political, ideological and prioritisation issue.

While this research has focused deliberately on four former PMs, it is noteworthy to add that the current PM Turnbull who leads the Liberal-National Coalition Government with a minority of votes in the Senate, has prior to becoming PM, expressed strong support for climate action with carbon pricing as a key lever for change. However, his assentation to power was beholden to commitments to the right-wing conservative fraction of the Liberal Party to retain PM Abbott's Direct-Action legacy despite ongoing critiques of this policy. This party-political approach is leaving Australia increasingly out-of-step with its international peers and key trading partners[33] looking to establish emissions trading schemes post Paris Agreement. This position is further exacerbated by the potential risk of an emerging and global momentum towards energy decarbonisation that may adopt even more ambitious emission reduction and renewable energy targets beyond the current timeframe of 2020 (CMI, 2016).

As the impasse at the federal government level continues, it has offered an opportunity for the states/territories to show their leaderships. As reported by Parkinson (2017) most states and territories are already pursuing renewable energy targets far beyond their federal counterpart, such as ACT[34] (100% by 2020), Victoria (40% by 2025), Queensland and Northern Territory (each 50% by 2030), South Australia (50% by 2025 with 36% already achieved) and NSW[35] (net-zero state-wide emissions by 2050). Going forward, Australia's domestic climate/energy political landscape must be built upon a bipartisan platform with a line of sight to international obligations as well as supporting and enabling state and territory governments to reform and so providing much needed certainty and stability in what has been a tumultuous policy area.

[33] Key trading partners with or considering ETS include: China, part of USA, South Korea, Europe, Canada, New Zealand and Japan.
[34] Australian Capital Territory
[35] New South Wales

4.7 Appendix A1 Australian federal leaders' climate policy table

Leaders (Political party) Office term [1]	Conference of Parties (COP)	Federal Climate Initiatives / Policies[2]	Funding[2] ($Million)
Paul Keating (ALP) 20/12/1991 - 11/03/1996	COP 1 (1995) Berlin Mandate	1994 – 1996 ***Ethanol Production Bounty Scheme*** $3m - subsidise ethanol production, $4m - R&D over two years. 1994-2008 ***Renewable Energy Initiative*** Multi-sectoral policy targeting multiple RE sources. http://www.ausindustry.gov.au/content/level3index.cfm?ObjectID=B7C70A4B-E588-40C9-AD6542408BFD1AAB&L2Parent=AEB901E5-7CB8-4143-A3BF33B2423F9DA6	$7 $4.8 + $10
John Howard (Liberal) 11/03/1996 – 03/12/2007	COP 3 (1997) Kyoto Protocol	1997 – In Force ***GreenPower Scheme*** Voluntary government accredited program in enabling RE electricity purchase for households or businesses. http://www.greenpower.gov.au 1998 – 2007 ***Safeguarding the Future: Australia's Response to Climate Change*** Managed by Australian Greenhouse Office (AGO). Funding contribute as part of the RECP (see below). http://www.climatechange.gov.au ***REIP - Renewable Energy Industry Programme***. Grant programme - develop RE industry in Australia. **Terminated in 2005** when all funds were fully committed. 1999 – 2004 ***Cities for Climate Protection (CCP) Australia*** Cities for Climate Protection (CCP) Australia was formally established in September 1998 and entered into force in 1999. It was an international trade-marked program of the International Council for Local Environmental Initiatives (ICLEI) in collaboration with the Australian Greenhouse Office. In participating in	 $28 $2.235 $13 (over five years)

		CCP Australia, councils commit to progress through five milestones to reduce their greenhouse gas emissions: 1. Assess the emissions produced by their own facilities (corporate emissions) and by the community 2. Establish an emissions reduction goal 3. Develop a local action plan 4. Implement the local action plan 5. Monitor and report on the implementation of the local action plan. http://www.environment.gov.au/archive/settlements/local/ccp/index.html	
		1999 – 2006 ***Greenhouse Accounting Project/Co-operative Research Centre for Greenhouse Gas Accounting*** A Co-operative Research Centre (CRC) on Greenhouse Accounting was awarded AUD 15.3 million over 7 years to ensure that Australia was in the strongest position possible to argue internationally for a comprehensive system of accounting for carbon emissions and sinks, as well as that these measures contribute to the core goals of reducing the impact of climate change and are viewed as a cost effective approach. Partners in the CRC were to provide an additional AUD 55 million in cash and in-kind resources.	$15.3
		1999 – 2012 ***REEF - Renewable Energy Equity Fund*** Provided venture capital and managerial advice for small, innovative companies developing RE technologies. Commonwealth fund to be matched by private equity on a 2:1 basis, total of $26.6 million over ten years of the program.	$26.6 (Government: $17.7 + Private sector $8.9)
		1999 – 2007 ***RECP - Renewable Energy Commercialisation Programme*** An umbrella competitive grants programme with funding of $28 million from the ***Safeguarding the Future package*** and $26 million from the ***Measures for a Better Environment package*** aimed to reduce greenhouse gas emissions through assisting renewable energy technology commercialisation which had to fund at least 50% of project costs. The programme also included $ 6 million for ***Renewable Energy Industry Development*** component from 2003-2007.	$6 ($54m fund over 5 years counted in their original program)
		2000 – 2007 ***Renewable Energy Action Agenda***	

		Australian government and industry partnered to develop the Renewable Energy Action Agenda (REAA), launched in 2000 with vision "to achieve a sustainable and internationally competitive renewable energy industry with annual sales of AUD 4 billion by 2010". 2000 –Ended ***Measures for a Better Environment Package*** The Federal Budget adopted in May 2000 allocated nearly AUD 800 million of additional funding to greenhouse gas reduction programmes over four years. They include: • ***Greenhouse Gas Abatement Programme*** (2000 - ?, $243m) http://www.environment.gov.au • ***Photovoltaic Rebate Programme*** (2000 – 2009, $52m) • ***Remote Renewable Power Generation Programme*** (2000 – 2009, $328m) http://www.environment.gov.au/renewable/rrpgp/index.html • ***Renewable Energy Commercialisation Programme*** (1999 – 2007, $26m) • ***Alternative Fuels Conversion Programme*** (2000 – 2008, $75m) 2000 – 2009 ***Solar Homes and Communities Plan*** (formerly ***Photovoltaic Rebate Program***). A $150m extension of the ***Photovoltaic Rebate Programme*** ($52m) which commenced in the year 2000. The programme provides rebates for household PV system installations and grants for community and iconic buildings. The programme varied several times ended in June 2009 to be superseded by the Solar Credits Initiative under the expanded Renewable Energy Target Scheme. 2001 - 2009 ***Mandatory Renewable Energy Target (MRET)*** The Renewable Energy (Electricity) Act 2000 sets the framework for ***the Mandatory Renewable Energy Target (MRET)***. The governments renewable energy target seeks to raise the contribution of renewable energy sources in Australia's electricity mix by 9 500 GWh per year by 2010 and maintain this requirement until 2020. Under this measure, tradable Renewable Energy Certificates (RECs) are used to demonstrate compliance with the objective. All	$800 $495.3

		wholesale electricity purchases on grids of more than 100 MW of installed capacity have to apply mandatory renewable energy targets since 1 April 2001. In order to meet their obligation, liable parties (wholesale purchasers) surrender Renewable Energy Certificates to the Renewable Energy Regulator. A Renewable Energy Certificate represents 1 MWh of electricity. The penalty payment for non-compliance is AUD 40 per MWh (non-tax deductible). All interim targets for the elapsed years 2001 to 2007 have been met, with over 99.7% of target being met by REC surrender. Legislation to increase the MRET target to 20% (or 45,000GWh) of electricity consumption by 2020 is expected to be in place by mid-2009. 2003 – 2007 ***Renewable Energy Industry Development (REID)*** The programme provided grants to Australian companies who demonstrated that their projects will assist the development of the domestic renewable energy industry. Industry development grants were typically AUD 100 000. 2004 – 2008 ***Local Greenhouse Action*** It was an Australian Government initiative to assist local government, communities and individual households to reduce their GHG emissions. Introduced in May 2004, the measure built on the highly successful Cities for Climate Protection Australia, Travel Demand Management and Cool Communities initiatives to enhance the ability of local governments to work with their communities to reduce emissions, particularly in the areas of energy use, transport and waste. The programme ceased as at 30 June 2009 in accordance with the Wilkins Review recommendations. 2004 – 2004 ***Biofuel Capital Grants*** To increase the availability of biofuels for the domestic transport market, in July 2003 the Australian Government announced a fund for one-off capital grants to projects that provide new or expanded biofuels production capacity.	$6 $13.8 $37.6 ($24.6275m funding provided)

		2004 – 2014 ***Improving Grid Accessibility*** The Australian Government has worked with states and territories to identify and act on specific rule changes required in the National Electricity Market (NEM) to maximise the benefits of distributed (including renewable energy) generation. Work to date has focussed on addressing barriers when establishing new national distribution regulatory frameworks. A broader review of the national transmission framework was made in 2012. http://www.ret.gov.au/Documents/mce/default.html 2004 – 2013 ***Securing Australia's Energy Future*** - White Paper on Energy In 2004, the federal government announced its Energy White Paper (EWP), Securing Australia's Energy Future. The EWP supports a range of energy policy initiatives that will set Australia on a long-term course to lower greenhouse emissions from the energy sector, and further develop Australia's renewable energy industry. The initiatives include: - • ***Low Emissions Technology Demonstration Fund*** (2004 – 2008, $500m) • ***Renewable Energy Development Initiative*** (2004 – 2008, $100m) • ***Solar Cities Trial*** (2004 – 2013, $94m) http://ee.ret.gov.au/energy-efficiency/grants/solar-cities-program • ***Wind Energy Forecasting Capability***[11] (2004 – 2009, $14m) http://www.ret.gov.au/energy/energy%20programs/wind_energy_forecasting_capability_initiative/Pages/WindEnergyForecastingCapabilityInitiative.aspx • ***Advanced Electricity Storage Technologies*** (2004 – 2012, $20.5m) • ***Identifying barriers and impediments to renewable and distributed energy*** The Government announced the development of a new Energy White Paper in September 2008. The White Paper will provide a comprehensive energy policy framework through to 2030, as well as short- to medium-term recommendations for government and industry, focusing on investment and employment in the resources and energy sectors. The timing of the Energy White Paper has been delayed following the Government's decision to delay an emissions trading scheme.	$700

		http://www.ret.gov.au/energy/facts/white_paper/Pages/energy_white_paper.aspx	
		2004 – 2009 ***The Greenhouse Challenge / Challenge Plus - Industry Partnerships*** The key elements of this program for emissions inventory reporting and assisting companies in reducing their greenhouse emissions, have been superseded by the National Greenhouse & Energy Reporting Systems (NGERS).	$31.6
		2005 – 2009 ***Funding for Low Emissions Technology and Abatement*** To encourage ongoing investment in the development, demonstration and deployment of smaller-scale low emissions technologies, and other cost-effective abatement activities. Elements included: -Strategic Abatement targeting cost-effective abatement for local government and communities	$26.9 (over four years)
		2006 – 2011 ***Asia-Pacific Partnership for Clean Development and Climate*** The APP brings together Australia, Canada, China, India, Japan, South Korea and the United States to address the challenges of climate change, energy security and air pollution in a way that encourages economic development and reduces poverty. The APP represents around half of the world's emissions, energy use, GDP and population, and is an important initiative that engages, for the first time, the key greenhouse gas emitting countries in the Asia Pacific region.	$100
		2006 – 2009 ***Ethanol Distribution Program*** The purpose of the programme is to increase the number of retail service stations selling 10 per cent ethanol blended petrol (E10); increase the volume of E10 sold; and encourage the sale of E10 at a lower price than regular unleaded petrol. The programme provides grants of up to AUD 20,000 for retail service stations to reduce the cost of installing or converting infrastructure to supply E10.	$14.3
		2007 – 2008 ***Green Vouchers for Schools*** Announced on 17/07/2007, the programme offers grants of up to $50,000 to Australian primary and secondary schools for the installation of rainwater tanks	$336.1

		and/or solar hot water systems aiming to provide a practical opportunity for schools to improve their energy and water efficiency. 2007 – 2012 ***Solar Hot Water Rebate*** Introduced in July 2007, it is a rebate system for the installation of solar and heat pump hot water systems in existing homes. Rebates of AUD1000 are available to the installed solar hot water system that replaces an electric storage hot water system and eligible for at least 20 Renewable Energy Certificates (RECs). The scheme was modified in February 2009 by the Energy Efficient Homes Package. 2007 – 2009 ***Household and Small Business Climate Action Initiative*** Announced in 2007, the initiative aimed to make households, communities and small businesses reduce their greenhouse gas emissions through the application of energy conservation and efficiency strategies. 2007 – superseded ***National Greenhouse & Energy Reporting System (NGERS)*** The NGER Scheme was introduced by the Australian Government in 2007 to provide data and accounting in relation to GHG emissions and energy consumption and production. The Scheme's legislated objectives are to: •inform policy-making and the Australian public; •help meet Australia's international reporting obligations; •provide a single national reporting framework for energy and emissions reporting.	$252 $53.3
Kevin Rudd (ALP) 3/12/2007 – 24/06/2010	COP 15 (2009) Copenhagen Accord	2008 – 2012 ***Geothermal Drilling Program*** The program was a competitive merit-based grants that provided assistance to companies seeking to develop geothermal energy with the cost of proof-of-concept projects including drilling geothermal wells as a dollar-for-dollar matched funding up to 50% of the total eligible expenditure. 2008 – 2012 ***Clean Business Australia***	$50 $214.25

		This programme provided $118.7 million in support of retro-fitting and retro-commissioning of existing commercial office, hotel and retail buildings with projected savings of over 285,000 tonnes of greenhouse gas emissions per annum. The $19.6 million to establish the Re-tooling for Climate Change (RCC) element to help small and medium sized organisations undertaking manufacturing in Australia to reduce their environmental footprint, through projects that improve the energy and/or water efficiency of their production processes. The Climate Ready was funded with $75.95 million to support the development and commercialisation of innovative products, processes and services that address the effects of climate change. http://www.ausindustry.gov.au/programs/innovation-rd/gbf/Pages/default.aspx 2008 – 2012 ***National Travel Behaviour Change Programme - Greenhouse Gas Abatement Programme*** The project aims to reduce car reliance by encouraging and supporting alternative transport modes such as walking, cycling public transport and ride sharing. Over 5 years (2008-12), more than 186,000 households participated in voluntary programs which analysed their travel behaviour and their effect on the environment. It was anticipated that the program could result in a reduction of more than 3 billion car kilometres travelled. It received support from the Greenhouse Gas Abatement Programme: up to AUD 6.487 million. 2008 – 2012 ***Australian Trade Commission (Austrade) - Clean Energy Export Strategy*** In partnership with public and private sector organisations, Austrade's global clean energy and environment industry provided network of over 100 officers, advise of trade and investment opportunities in renewable energy sectors, including wind, biomass and next generation biofuels, solar, geothermal, wave and tidal. 2008 – 2013 ***National Solar Schools Program***	$18 (minus $6.487?) $14.9 over 3 years (2009/10 - 2011/12) $421.2

		Over $217 million has been provided to 5,310 schools (or almost 60 per cent of all Australian schools) to install renewable energy systems, rainwater tanks and a range energy efficiency measures. The solar power systems already installed are producing enough electricity to power the equivalent of 4600 average households every day. The 2012-13 funding round was the final opportunity for schools to apply for solar schools funding. The Program closed on 30 June 2013. http://ee.ret.gov.au/energy-efficiency/grants/national-solar-schools-program 2008 – 2011 ***Contribution to the Clean Technology Fund (CTF)*** The CTF was one of two World Bank-administered Climate Investment Funds that promoted scaled up financing for demonstration, deployment and transfer of low-carbon technologies with significant potential for long-term GHG emissions savings. The CTF finances projects in 12 countries and one region. http://www.climateinvestmentfunds.org/cif/node/2 2008 – 2012 ***Green Precincts Fund*** To support high-profile demonstration projects that delivered water and energy savings while educating the community about water and energy efficiency. The demonstration projects include those that deliver substantial reductions in greenhouse gas emissions through energy efficiency measures, solar power generation, solar hot water services, smart metering, energy efficient appliances and lighting, wind generation and functional green building design. The program was completed in June 2012. http://www.environment.gov.au/water/policy-programs/green-precincts/index.html 2009 – 2015 ***LivingGreener.gov.au - Online portal*** The objective of LivingGreener.gov.au is to deliver a single, user-friendly government website to link households to all Commonwealth, state, territory and local government sustainability programmes. LivingGreener enables ready access and therefore greater uptake of environmental programmes for sustainability (energy, water, waste and personal transport) by Australian householders. The	(From 2008-09 to 2014-15) $100 $13.3 Over four years $8.5

		website is designed to be the central hub for Australians to find information, inspiration and action on their journey towards living more sustainably. http://www.livinggreener.gov.au/ 2009 – 2011? ***Clean Energy Initiative*** The CEI is designed to support clean energy generation and new technologies to reduce carbon emissions and stimulate the clean energy sector. The initiative includes the following four components. 1. Support for low emissions coal technologies: i. ***National Low Emissions Coal Initiative*** (2008 – In Force, $247.3m) ii. ***Carbon Capture and Storage Flagships Program*** (2009 – In Force, $281m) 2. Support for solar technologies: iii. ***Solar Flagships Program*** (2009 – 2012, $1.5 billion) iv. ***Australian Solar Institute*** (2009 – 2013, $150m) 3. Support for technology development and commercialisation: v. ***Australian Centre for Renewable Energy*** (2009 – superseded, $700m) 4. Further support for renewable energy and energy efficiency through the Renewable Energy Future Fund. 2008 – In Force ***National Low Emissions Coal Initiative*** The initiative aims to accelerate the use of low emission coal technologies in Australia, cut greenhouse gas emissions and secure the economic future of the Australian Coal Industry through a coordinated, national approach to clean coal technology R&D. Developed and implemented with the support and involvement of stakeholders from state and territory governments, industry, researchers and the community, the Initiative focused on the research, demonstration and deployment of low-emission coal technologies involving carbon capture and storage (CCS). The NLECI provides funding for the Australian National Low Emissions Coal Research and Development (ANLEC R&D) initiative and also includes the	 $5100

		Advanced Lignite Demonstration Program (ALDP) which is a joint initiative between the Australian Government and Victorian State Government to support technology development and the more effective utilisation of Victorian lignite. The ALDP provides up to $75 million of joint Commonwealth and Victorian Government funding for low emission coal demonstration projects in Victoria's Latrobe Valley. The NLECI had also supported the $50 million funding for the National Carbon Mapping and Infrastructure Plan (NCMIP) (2009 – 20?). 2009 – In Force ***CCS Flagships Programme*** The program provides support for the accelerated deployment of industrial scale CCS demonstration projects. This funding will support 2 to 4 projects and there is no maximum level of funding support per project other than the limit of program funds. The CCS Flagships Program builds on the National Low Emissions Coal Initiative (NLECI), which includes research, demonstration, mapping and infrastructure elements, and the Global Carbon Capture and Storage Institute established by the Government to provide support for the accelerated deployment of industrial-scale CCS projects world-wide. The program is also complemented by the National CO2 Infrastructure Plan. http://industry.gov.au/resource/LowEmissionsFossilFuelTech/Pages/Carbon-Capture-Storage-Flagships.aspx 2009 – 2012 ***Solar Flagships Program*** The Solar Flagships Program was established in December 2009 to support the construction and demonstration of large-scale, grid-connected solar power stations in Australia. The program supported solar power playing a significant role in Australia's electricity supply and operating within a competitive electricity market. The program is closed. http://arena.gov.au/about-arena/history/ 2009 – 2013 ***Australian Solar Institute*** The ASI was established by the Australian Government in 2009. It announced funding for 48 projects with a total leveraged value of approximately $255 million	

		from an initial Commonwealth investment of approximately $89 million. This included foundation projects and projects selected through five competitive funding rounds, including two rounds under the United States-Australia Solar Energy Collaboration, projects announced through the Australia-Germany Collaborative Solar R&D Funding Call and several Skills development round. The portfolio's leveraged value includes significant industry investment. The ASI became part of the Australian Renewable Energy Agency (ARENA) on 1 January 2013. http://www.arena.gov.au/programs/initiatives/index.html 2009 – superseded ***The Australian Centre for Renewable Energy (ACRE)*** The ACRE was established to promote the development, commercialisation and deployment of renewable energy and enabling technologies and improving their competitiveness in Australia. ACRE commenced in 2009 and was incorporated into ARENA on 1 July 2012. ACRE managed over $690 million of funding committed to support renewable energy and enabling technology development. The following ACRE programs became the responsibility of ARENA: a. ***Emerging Renewables Program*** (2011 – In Force, $126.6 million) b. ***Renewable Energy Venture Capital Fund*** (2011 – In Force, $100 million) c. ***Support for advanced biofuels*** (2009 – 2012, $15 million) 2011 – In Force ***Emerging Renewables Program*** Currently under review. The funds support the development, demonstration and early stage deployment of renewable energy technologies with the potential to lower the cost, and thereby increase the supply, of renewable energy in Australia. The program is also open to activities that remove or reduce roadblocks to the delivery of ARENA's strategic initiatives and activities to fill critical knowledge gaps within the industry.	

		2011 – In Force ***Renewable Energy Venture Capital Fund*** ARENA's $100 million Renewable Energy Venture Capital Fund was created to foster skills and management capability and provide funding confidence to renewable energy projects to strengthen their chance of success. Southern Cross Venture Partners Pty Ltd was appointed manager of the Fund and Softbank China Venture Capital matched ARENA's $100 million investment creating the $200 million Southern Cross Renewable Energy Fund, which is the largest venture capital fund dedicated to renewable energy in Australia. The Southern Cross Renewable Energy Fund provides management expertise and makes equity investments in early-stage Australian renewable energy companies to help them overcome capital constraints, develop technologies, increase skills and forge international connections. 2009 – 2012 ***Second Generation Biofuels Research and Development Program (Gen 2***) The program was a competitive grants program which supported the research, development and demonstration of new biofuel technologies and feedstocks that address the sustainable development of a biofuels industry in Australia. Applications for the Program closed on 30 January 2009. ARENA assumed responsibility, from the former Department of Resources, Energy and Tourism, for projects supported under the program. ACRE also managed a number of projects under legacy programs including the ***Renewable Energy Demonstration Program***, the ***Geothermal Drilling Program*** and the ***Low Emissions Technology Demonstration Fund***. http://arena.gov.au/about-arena/history/ 2009 – 2014 ***National Energy Efficiency Initiative - Smart Grid, Smart City*** The Smart Grid, Smart City project has demonstrated Australia's first fully integrated, commercial scale smart grid. The project trialled a range of customer and grid side smart grid technologies and applications, to help quantify the benefits of smart grids and to inform broader industry and consumer acceptance	

		and adoption of smart grids across the Australian energy market. The project has gathered robust information about the costs and benefits of smart grids and is being used to inform future decisions by government, electricity providers, technology suppliers and consumers across Australia. Reports and data, including data interrogation tools, are publically available through the project website. The grid side application trial outcomes provide useful information to network businesses to improve system reliability and security; manage peak demand in a more cost effective way; identify operational efficiencies; and support the integration of distributed generation and storage, and intermittent renewable energy sources, such as solar and wind power. Households participating in the trials had unprecedented access to transparent and near real-time electricity usage and cost information; were financially rewarded for reducing their energy use at peak times, had greater control over their energy use and bills and were able to avoid expensive peak demand charges. Access to applications such as simple in home displays (S-IHDs), home area networks, online consumer portals, smartphone apps and energy rebates, maximised household utility from dynamic tariff offers. The Smart Grid Smart City project also trialled distributed generation and storage technologies, including small community wind turbines, residential and grid side battery storage devices and gas fuel cells. These trials sparked a high degree of community interest in alternative energy infrastructure. An electric vehicle trial was also undertaken for both fleet and private usage patterns. This demonstrated the benefits of electric vehicles for consumers and businesses and provided data on the likely impacts that the uptake of EVs will have on electricity network operations. The analysis shows potential savings of up to AUD 28 billion over the next 20 years, through:	$100 (plus $500 from industry contributions in-kind & cash)

		•Technological development, deployment and enablement of smart grid technologies; •Cost reflective electricity pricing including dynamic tariffs; •Changing consumer behaviour; and •Energy market reforms to support smart grid technologies. The project trials were completed by 28 February 2014 with the final reports and supporting material published on 28 July 2014 which are available on the project website: www.smartgridsmartcity.com.au/ich. http://www.industry.gov.au/Energy/Programmes/SmartGridSmartCity/Pages/default.aspx 2009 – In Force ***National Strategy on Energy Efficiency (NSEE)*** In July 2009, the Council of Australian Governments (COAG) agreed to the comprehensive, 10-year National Strategy on Energy Efficiency (NSEE), to accelerate energy efficiency improvements and deliver cost-effective energy efficiency gains across all sectors of the Australian economy. The NSEE was updated in July 2010 and aims to streamline roles and responsibilities across government by providing a nationally consistent and coordinated approach to energy efficiency. The overarching National Partnership Agreement on Energy Efficiency is the Intergovernmental Agreement that gives effect to the NSEE and sets out specific action to be taken by the Commonwealth, State and Territory Governments to maximise cost-effective energy efficiency gains across the economy http://www.industry.gov.au/Energy/EnergyEfficiency/Pages/NationalStrategyEnergyEfficiency.aspx 2009 -2014 ***Enterprise Connect*** Enterprise Connect was a $200 million Australian Government initiative designed to boost productivity. The Clean Energy Innovation Centre was a $20 million commitment over 4 years under Enterprise Connect to assist companies	$88.3

		innovating in the clean energy sector. It helped small and medium sized clean energy companies enhance their performance by providing a range of business improvement core services offered by the Enterprise Connect network including: • Business Review : conducted for free by Business Advisers • Tailored Advisory Service : provides funding to implement actions identified in the Business Review • Researchers in Business : offers the placement of researchers from universities or public research agencies into businesses to help develop and implement new commercial ideas It also offered a range of industry specific assistance including: • Facilitating quick access to services provided under Austrades Clean Energy Export Strategy • Finding and adapting the latest research and technology to help firms improve their products and manufacturing processes • Provision of expert, customised advice to improve commercialisation planning and execution • A range of initiatives aimed at enhancing information exchange within the clean energy sector As part of the 2014-15 Federal Budget, the Government has decided to cease the Enterprise Connect programme from 1 January 2015. The Enterprise Connect programme stopped accepting Business Review applications on 30 June 2014. http://www.business.gov.au/grants-and-assistance/closed-programs/EC/Pages/default.aspx 2009 – 2012 ***Renewable Energy Demonstration Program (REDP)*** The REDP provided large grants to fund renewable energy power generation demonstration projects using various technologies across a range of geographic areas, up to one third of the eligible expenditure on each project. The grants supported the commercialisation and deployment of large scale, grid feeding, renewable energy projects.	$200

		Six projects were funded: • two geothermal projects (AUD 90 million and AUD 62 million) • one ocean energy (AUD 66 million) • one integrated energy (AUD 15 million) • two solar (AUD 35 million and AUD 60 million) The projects funded through the Renewable Energy Demonstration Program (REDP) were transferred to the Australian Renewable Energy Agency. http://www.arena.gov.au/programs/projects/index.html	$235
		2009 – In Force ***Heavy duty vehicle emissions test facility*** The emissions test facility was commissioned in operation in September 2009. The first project for the facility was cetane and load effects project undertaken for DEWHA (now SEWPaC) with the data feeding into a review of the National Automotive Fuel Standards, providing up-to-date information on the performance of biofuel and synthetic diesels, as well as input data to the NTC review of truck GVM limits on the Hume Highway. The facility has also been used on a commercial basis to support fuel majors and additive providers with the development of products, and also for the development of low emission on-road truck solutions. http://www.climatechange.gov.au/	$2.76
		2010 – 2016 (superseded) ***Low Carbon Communities*** The program was originally planned for four years aimed at supporting communities to take action on climate change and reduce their energy costs through energy efficient upgrades to street lighting, community facilities and council buildings via providing competitive grants to local councils to fund: 1. Small scale grants of up to AUD 500,000 for local councils to reduce energy consumption in council buildings and facilities such as outdoor lighting. 2. Large scale grants of up to AUD 5 million for operators of community facilities to invest in energy efficient upgrades such as the installation of cogeneration or new heating and air conditioning.	$330

		3. Greener Suburbs grants of up to AUD 500,000 for councils to implement capacity building and demonstration projects that improve the use of parks and green spaces in urban areas. The program was then expanded to provide funding through competitive grants to local councils and communities to improve energy efficiency in council and community-use buildings and facilities, and to assist low-income households. The funding was increased from AUD 80 million to AUD 330 million and then has been re-designed and expanded as part of the Clean Energy Future package in July 2011. The program in its new format has been now extended from 30 June 2014 to 30 June 2016. 2010 –ceased by2030 ***Renewable Energy Target*** The Renewable Energy Target (RET) is designed to deliver a 20% share for renewables in Australia's electricity mix in 2020. The RET legislation includes annual Large-Scale Renewable Generation Targets (LRET), rising to 41,000 gigawatt-hours in 2020, while the Small-Scale Renewable Energy Scheme (SRES) is uncapped. http://www.climatechange.gov.au/government/initiatives/low-carbon-communities.aspx 2010 – 2014 (superseded) ***Carbon Farming Skills*** The initiative was designed to ensure that landholders had access to credible, high quality advice and carbon services. This measure funded: • development of a new nationally accredited qualification for carbon service providers • accreditation of carbon brokers and aggregators operating in the Carbon Farming Initiative • information workshops for farm extension officers, catchment authorities and rural service providers about carbon farming	$4 (over 5 years from 2012?)

		The program was ended as part of the repeal of the Clean Energy Act 2011. All parts of the Carbon Farming Initiative will roll into the Emissions Reduction Fund. http://www.climatechange.gov.au/government/initiatives/carbon-farming-skills.aspx 2010 – 20? ***Carbon Australia Limited – Energy Efficiency Program and The Carbon Neutral Program*** Formerly the Australian Carbon Trust was established to be the Low Carbon Australia Limited (LCAL) the Commonwealth by the Australian Government in May 2009 to further support action on climate change by business. It managed two programs of the Energy Efficiency Program and the Carbon Neutral Program. The Energy Efficiency Program aimed to provide finance and advice to eligible business and the public sector in order to retrofit commercial properties. It does so by providing seed funding and finance solutions for retrofitting. The Carbon Neutral Program provided a voluntary certification process for organisations that have carbon neutral products or operations under the National Carbon Offset Standard (NCOS). This program commenced on 1 July 2010 and replaces the 'Australian Government's Greenhouse Friendly™ initiative (2001 to 2010). LCAL's energy efficiency programs, staff, systems and platforms have been merged with the Clean Energy Finance Corporation and the merger completed by 30 June 2013. http://www.climatechange.gov.au/en/government/initiatives/low-carbon-australia.aspx 2010 – 2012 ***Renewable Energy Bonus Scheme*** REBS helped eligible home-owners, landlords or tenants replace electric storage hot water systems with solar or heat pump hot water systems. Under REBS,	 $100

		eligible households could claim a rebate of $1000 for a solar hot water system or $600 for a heat pump hot water system. http://ee.ret.gov.au/energy-efficiency/grants/renewable-energy-bonus-scheme%E2%80%94solar-hot-water-rebate 2010 – 2011 ***Connecting Renewables Fund*** The Government recognises the importance of transmission infrastructure to connect new large scale renewable projects expected to come online in coming years. The Connecting Renewables Fund (CRF) will invest $1 billion over the next decade in electricity networks to facilitate connecting renewable energy projects to the grid. The CRF aims to accelerate the development of transmission infrastructure that supports the connection of renewables generation that otherwise would not proceed without Australian Government support. Investments will be through co-contributions with governance arrangements to be consistent with the national energy market framework. http://www.martinferguson.com.au/page15090/Connecting-renewables.aspx	$89 $1000 (over 10 years)
Julia Gillard (ALP) 24/06/2010 – 27/06/2013	COP 16 (2010) Cancun Agreements	2011 – In Force ***Low Income Energy Efficiency Program*** This program is a competitive merit-based grant program established by the Commonwealth Government to provide grants to consortia of government, business and community organizations to trial approaches to improve the energy efficiency of low income households and enable them to better manage their energy use. http://www.industry.gov.au/Energy/EnergyEfficiency/GrantsFunding/LowIncomeEnergyEfficiency/Pages/default.aspx 2011 – In Force ***Carbon Farming Futures***	$55.3 $429

		The program is part of the Australian Government's $1.7 billion Land Sector Package, which was announced as part of the Clean Energy Future Plan. It will ensure that advances in technologies and techniques for emissions reduction and adaptation will continue the evolution of management practices in the land sector to maintain productive and sustainable land use under changing climate. These advances will allow farmers and other land managers to benefit from the economic opportunities of the Carbon Farming Initiative (CFI), a carbon crediting scheme, while assisting Australia in achieving its long-term emission reduction targets. The Carbon Farming Futures Program comprises five elements: - 1. Filling the Research Gap: supporting research into abatement technologies and practices that reduce greenhouse gas emissions from the land sector, store carbon in the landscape and enhance sustainable agricultural practices. The research outcomes will support the development of offset methodologies under the CFI. 2. Action on the Ground: assisting with the on-farm trialling and demonstration of practices and technologies to reduce agricultural sector greenhouse gas emissions and/or the storage of carbon in the landscape. 3. Extension and Outreach: delivering technical information and support to farmers and land managers about greenhouse gas emissions mitigation practices and the benefits of creating land-based carbon credits through participating in the CFI. 4. Conservation tillage refundable tax offset: providing a 15 per cent refundable tax offset for new conservation tillage equipment installed between 1 July 2012 and 30 June 2015. 5. Methodology Development Program: converting research into estimation methodologies for use in the CFI. The multiple components of this program are managed by different agencies. The Department of Agriculture, Fisheries and Forestry (DAFF) administers the Filling the Research Gap, Action on the Ground and Extension and Outreach programs. The Department of Climate Change and Energy Efficiency administers the	(from 2011/12 – 2016/17)

		Methodology Development Program. The conservation tillage refundable tax offset is jointly administered by DAFF, the Australian Taxation Office and Treasury. http://www.daff.gov.au/climatechange/carbonfarmingfutures 2011 – In Force ***Clean Energy and Other Skills Package*** The Package is to enable tradespeople and professionals in key industries to develop the skills needed to deliver clean energy services, products and advice to Australian communities and businesses. The Package has four elements: • baseline mapping project • trades training • professional training • integration of energy efficiency skills http://www.industry.gov.au/skills/AssistanceForIndividuals/ClimateChangeAndSkillsForSustainability/Pages/CleanEnergySkills.aspx 2011 – In Force ***National Carbon Dioxide (CO2) Infrastructure Plan*** In June 2011, the Australian Government announced the creation of a National CO2 Infrastructure Plan (NCIP). The Plan was developed to accelerate the identification and development of sites suitable for the long term storage of CO2 in Australia that are within reasonable distances of major energy and industrial CO2 emission sources. It will complement the work undertaken as part of the CCS Flagship program. The NCIP builds on work under the National Low Emissions Coal Initiative and is scheduled to end in July 2015. http://industry.gov.au/resource/LowEmissionsFossilFuelTech/Pages/National-CO2-Infrastructure-Program.aspx 2012 – In Force ***Clean Energy Finance Corporation*** The Clean Energy Finance Corporation (CEFC) was established on 3 August 2012, with $10 billion in funding available over 5 years. The CEFC invests in renewable energy, low-emissions technology and energy efficiency projects. Funding is generally provided through loans on commercial or concessional terms. However,	 $32 (over 4 years) $30 $10,000 ($2 billion per annum for 5 years

		the CEFC is not restricted from using other structures to address impediments to investment in the clean energy sector. The new Australian Coalition Government has announced its intention to abolish the CEFC. http://www.cleanenergyfinancecorp.com.au 2012 – ended 2014 ***Clean Technology Innovation Programme*** The program provided grants to support business investment in research and development (R&D) in the ARENAs of renewable energy, low pollution technology and energy efficiency. As part of the commitment to deliver savings by abolishing the Carbon Tax, the new **Australian Coalition Government** announced its intention to discontinue funding for the Clean Technology Program. This includes the three program components: the Clean Technology Investment Program, the Clean Technology Food and Foundries Investment Program, and the Clean Technology Innovation Program. http://www.business.gov.au/grants-and-assistance/closed-programs/CleanTechnology/CleanTechnologyInnovation/Pages/default.aspx 2012 – in Force ***Jobs and Competitiveness Program*** The program will support local jobs and production, and encourage industry to invest in cleaner technologies. The ongoing program will provide assistance over the first three years of the carbon pricing mechanism, targeted at companies that produce a lot of carbon pollution but are constrained in their capacity to pass through costs in global markets. The most emissions-intensive trade-exposed activities will receive assistance to cover 94.5 per cent of industry average carbon costs in the first year of the carbon price, with less emissions-intensive trade-exposed activities to receive assistance to cover 66 per cent of industry average carbon costs. Assistance will be reduced by 1.3 per cent each year to encourage industry to cut pollution. Regular reviews will ensure that the program remains in step with international action on climate change and continues to support jobs and competitiveness.	commencing 1 July 2013) $200 (over 5 years) $8600

		http://www.climatechange.gov.au/government/initiatives/jobs-competitiveness-program.aspx 2012 – In Force ***Coal Mining Abatement Technology Support Package*** The objective of the package is to maintain and enhance the international competiveness and viability of the Australian coal mining sector to meet Australia's greenhouse reduction targets. Funding is directed at three elements: • research, development and demonstration of technologies and processes associated with coal mining greenhouse gas mitigation including the measurement and monitoring of emissions, avoidance and abatement technologies • work to address safety and regulatory issues associated with the development and deployment of greenhouse mitigation related technologies, equipment and processes • assistance to small and medium coal sector participants to develop abatement strategies or undertake feasibility studies to reduce emissions from current and proposed mines	$36.7
		2012 – In Force ***Coal Sector Jobs Package*** The package provides transitional assistance to coal mines that have a high fugitive emissions-intensity. The objective is to ease their transition to the introduction of a carbon price, thereby supporting jobs and the local communities that rely on the mines. The program is administered by the Department of Industry. The program is closed to new applicants as no funding left after 1 July 2014. However, one funding agreement will remain active until 30 April 2015.	$448.7
		2012 – In Force ***Industrial Energy Efficiency Data Analysis Project*** The project estimates the potential for energy efficiency improvement in different industrial sectors through quantifying the scale and value of untapped energy efficiency potential across a range of key technologies, processes and fuel types. It consolidates and analyses company data already collected through the	$0.95

		Energy Efficiency Opportunities (EEO) Program, the ***National Greenhouse and Energy Reporting (NGER) system*** and a range of state based programs. The project also involved a detailed barriers-analysis to gain a better understanding of what may be preventing greater uptake of industrial energy efficiency projects. This will inform how these opportunities could be unlocked, and which policies may best achieve this. The most recent phase of the IEEDA project has included geospatial capability to allow for detailed geographical analysis of industrial energy use and energy supply data to support better management of future network demand and network growth. http://www.climateworksaustralia.org/project/current/industrial-energy-efficiency-data-analysis 2011 – 2014 ***Remote Indigenous Energy Program*** The program was to assist smaller remote Indigenous communities to access reliable power through the installation of renewable energy systems. It had also provided education to community members to ensure that people don't waste power and to some community members on how to look after the renewable energy systems. The program is now closed, as part of the repeal of the Clean Energy Future plan. http://www.indigenous.gov.au/healthy-homes/policy-programs/ 2012 – 2014 ***Local Government Energy Efficiency Program (LGEEP)*** The LGEEP was a non-competitive grant program that will assists local governing authorities (LGAs) install solar and heat pump hot water systems to drive smarter energy use in their buildings and community facilities. http://www.industry.gov.au/Energy/EnergyEfficiency/GrantsFunding/LocalGovernmentEnergyEfficiency/Pages/default.aspx 2011 – 2015? ***Clean Technology Focus for Supply Chains***	$40 $6.8

		The funding is to help the clean technology aspects of existing business development and facilitation programs. It enhances the role of Supplier Advocates for the clean technologies, water, and built environment sectors appointed under the Supplier Advocate program and implements strategies for industry development activities that enhance Australian industry involvement in the supply of goods and services for energy efficiency solutions and Enterprise Connect services to these sectors. Six projects are expected to be completed during the life of the program. http://www.innovation.gov.au/Industry/CleanEnergyFuture/Pages/default.aspx 2012 – In Force ***Australian Renewable Energy Agency (ARENA)*** ARENA is an independent agency established by the Australian Government on 1 July 2012 to improve the competitiveness of renewable energy technologies, and to increase the supply of renewable energy in Australia. ARENA has approximately $2.5 billion in funding to: • fund renewable energy projects • support research and development activities • support activities to capture and share knowledge Amended: The Clean Energy Legislation (Carbon Tax Repeal) Bill 2013 took effect on 17 July 2014. The Bill profiled $370 million in funding for ARENA over the forward estimates moving the funding into later years (2019–20 to 2021–22). In addition, the Bill reduced ARENA's funding to achieve a saving of $434.9 million over the forward estimates (2014–15 to 2016–17). http://www.arena.gov.au 2012 In Force ***National Greenhouse & Energy Reporting System (NGERS)*** From 1 July 2012, The NGER Scheme is being used as the reporting and compliance framework within which liable entities report their carbon price liability under the Australian Government's Clean Energy Future Plan. Since 1 April 2012 the NGER Scheme is administered by a new statutory authority, the	$5 (over 5 years) $2500

		Clean Energy Regulator. Generally, entities that control facilities directly responsible for more than 50,000t of greenhouse gas emissions per year have to report under the NGER Scheme and carbon pricing mechanism. http://www.cleanenergyregulator.gov.au/National-Greenhouse-and-Energy-Reporting/Pages/default.aspx 2013 – In Force ***Accelerated Step Change Initiative (ASCI)*** The allocation of funds to ASCI projects will be at the discretion of ARENA. There is no maximum funding for ASCI which is only constrained by the limit of available funds from ARENA. This gives ARENA the flexibility to support exceptional, breakthrough projects that are not otherwise eligible under existing ARENA programs. It is only open to projects that are truly exceptional and sit outside the eligibility criteria for other ARENA initiatives and programs. A project must require an ARENA contribution of $5 million or more, with the overall project cost expected to be more than $20 million. ASCI is open to Australian and international companies and research institutions. http:// http://arena.gov.au/initiatives-and-programs/the-accelerated-step-change-initiative-asci/ 2012 – 2014 ***Clean Energy Future Plan*** The Australian government's Clean Energy Future Plan pulled together a range of existing programmes and measures including those programmes that were funded through the Clean Energy Initiative (CEI). The Clean Energy Future package supported research, development, demonstration and deployment of clean and renewable energy technologies. The new Australian Coalition Government repealed the Clean Energy Future Plan along with the carbon pricing mechanism as part of the repeal of the Clean Energy Act 2011, effective 1 July 2014. The carbon pricing mechanism will be replaced with the Direct Action Plan. http://www.cleanenergyfuture.gov.au/ http://www.LivingGreener.gov.au	

		2012 – 2014 ***Carbon Pricing Mechanism*** The Australian government introduced a price on carbon, which took effect on 1 July 2012. The carbon pricing mechanism was fixed at a price of $23 a tonne in 2012-13, and was then set to transition to a flexible market price under a 'cap and trade' scheme in 2015-16. In both the fixed and the flexible price periods, liable entities had to pay a price for every tonne of carbon (or the equivalent amount of certain other greenhouse gases) that was emitted. Liable entities were to be required to report on their emissions, and can meet their obligations by either surrendering the appropriate number of allocated units, or paying a unit shortfall charge. A price on carbon pollution was expected to create incentives for Australia's biggest polluters to reduce their emissions and invest in clean energy. The Clean Energy Act 2011 has now been repealed by the Coalistion Government. This abolished the Carbon Pricing Mechanism with effect 1 July 2014. http://www.environment.gov.au/climate-change/repealing-carbon-tax http://www.cleanenergyregulator.gov.au/Carbon-Pricing-Mechanism/Pages/default.aspx 2012 – 2012 ***Australian Biofuels Investment Readiness Program*** The program was launched in response to an Advanced Biofuels Study conducted in 2011 to support the pre-commercial projects in Australia that will produce high energy renewable fuels that can be 'dropped-in' to existing infrastructure. The program is closed and no further assessments under this program will be undertaken. http://arena.gov.au/about-arena/history/support-for-advanced-biofuels/	 $15
Kevin Rudd (ALP) 27/06/2013 – 18/09/2013	COP19 (2013) Warsaw Outcomes		

Tony Abbott (Liberal) 18/09/2013 - 15/09/2015		2014 – In ***Force Emissions Reduction Fund (ERF)*** The objective of the ERF is to help Australia to meet its emissions reduction target of five percent below 2000 levels by 2020. Through the ERF, the Government will purchase lowest cost abatement (in the form of Australian carbon credit units) from a wide range of sources, providing an incentive to businesses, households and landowners to proactively reduce their emissions. http://www.environment.gov.au/climate-change/emissions-reduction-fund 2014 – In Force ***Research and Development (R&D) Program*** The R&D Program supports renewable energy technologies that will increase the commercial deployment of renewable energy technology in Australia. The first round of the R&D Program focused on Solar Excellence. In August 2014, $21.5 million funding was awarded to 12 projects ranging from enhancing existing technologies to advancing emerging technologies in solar photovoltaics (PV), solar thermal and solar storage. The program is currently under review. 2014 – In Force ***Supporting High Value Australian Renewable Energy (SHARE) Initiative*** The SHARE initiative is the first stage in ARENA's knowledge sharing function. It was established to build on the store of publicly-available knowledge about renewable energy technologies and approaches that are best suited to Australia. Industry may apply for funding to undertake studies, or to create knowledge products that align with ARENA's priorities. ARENA is seeking industry applications for projects to close knowledge gaps in 3 priority areas: understanding renewable energy potential, grid integration and international engagement. http://arena.gov.au/initiatives-and-programs/supporting-high-value-australian-renewable-energy-knowledge-share/ 2014 – In Force ***Regional Australia's Renewables (RAR)***	$2550 $300 (from 2013 – 2022) $400

		Funding: Up to $400 million, shared with the Industry Regional Australia's Renewables Program. The RAR initiative supports trials of renewable energy solutions, including hybrid systems, in regional and remote locations with the aim of increasing the use of these technologies for power generation once they become affordable. The initiative has two parts. The RAR Industry Program (I-RAR) aims to build a portfolio of renewable energy solutions in regional and remote Australia, focusing on hybrid and integrated systems in off-grid and fringe-of-grid communities. It will also contribute to knowledge sharing and skills development, especially in regional and remote areas. The RAR Community and Regional Renewable Energy Program (CARRE) aims to demonstrate viability and reliability of renewable energy systems in grids for small communities and islands, grow supporting technologies, show commercial viability and contribute to knowledge sharing. Expressions of interest for program funding closed on 31 December 2013. http://arena.gov.au/initiatives-and-programs/regional-australias-renewables/	
Malcom Turnbull (Liberal) 15/09/2015 - current	COP21 (2015) Paris Deal?		

4.8 Appendix A2 Leaders climate policy funding summary table

Leaders (Political party) Office term	Conference of Parties (COP)	Federal Climate Policies still in force	Funding Provision ($Million)
Paul Keating (ALP) 20/12/1991 - 11/03/1996	COP 1 (1995) Berlin Mandate	None	21
John Howard (Liberal) 11/03/1996 – 03/12/2007	COP 3 (1997) Kyoto Protocol	1	2,949
Kevin Rudd (ALP) 3/12/2007 – 24/06/2010	COP 15 (2009) Copenhagen Accord	7	8,089
Julia Gillard (ALP) 24/06/2010 – 27/06/2013	COP 16 (2010) Cancun Agreements	11	22,399
Tony Abbott *(Liberal) 18/09/2013 - 15/09/2015	COP19 (2013) Warsaw Outcomes	4	3,250
Malcom Turnbull (Liberal) 15/09/2015 - current	COP21 (2015) Paris Deal?		
Total Federal climate policy funding provision			***36,708***

4.9 Appendix B Australian prime ministers' climate actions performance ranking

Table B 4-1 MCA ranking of John Howard's climate actions performance

Tier 1 criteria	Tier 2 criteria	Tier 3 sub-criteria	**John Howard –** Liberal (*11 years 9 months)* 11/03/1996 – 03/12/2007 **Grade ranking rationale**
Total performance ranking = Ax0.5+Bx0.4+Cx0.1 = 0.33x0.5+0.43x0.4+0.17x0.1 =			
Political acceptability A=(0.67+0.33+0)/3=0.33	*Leadership support* A1=(0+1+1)/3=0.67	A11=0	No advocacy nationally for strong domestic mitigation target (refer to A21).
		A12=1	Established the Australian Greenhouse Office (AGO), reformed to liberalise the National Electricity Market (NEM) and provided $2.9 billion in total fund for R&D and policy measures for renewable energy (RE) technologies development. Refer to Appendix A1 & A2.
		A13=1	Provided $13m over 5 years to the Cities for Climate Protection (CCP) program to promote actions from local governments in Australia. Local Greenhouse Action initiative provided $13.8m to assist local government, communities and individual households to reduce their GHG emissions. Refer to Appendix A1.
	International commitment A2=(0+0+1)/3=0.33	A21=0	Insisted on and negotiated an increased emission target of 108% on 1990 level for Kyoto Protocol (Crowley, 2010; Beeson and McDonald, 2013; McDonald, 2015).
		A22=0	Ultimately, refused to ratify the negotiated increased Kyoto target which had left Australia without target mandate for any serious emission reduction action (Crowley, 2010; Beeson and McDonald, 2013; McDonald, 2015).
		A23=1	$100m for Asia-Pacific Partnership for Clean Development and Climate (Table A1)
	National targets & strategic planning A3=0	A31=0	The national emission was left to rise due to the factors mentioned in A21 and A22.
		A32=0	Without any international obligation, the White Paper on energy entitled "Securing Australia's Energy Future" and the National Greenhouse Strategy raised in 1998, did not lead to any holistic national emission reduction strategy that required serious cost analysis/modelling to formulate any long-term strategic pathways/plans (Commonwealth of Australia, 2000, 2004; IEA, 2005).
		A33=0	Refer to A32 above.

	Public funding for R&D and RE incentive B1=(1+1)/2=1	B11=1	$700m towards "Securing Australia's Energy Future" for duration of 2004-2013 and $26.9m over four years as Funding for Low Emissions Technology and Abatement initiative. Refer to Appendix A1, Commonwealth of Australia, (2004) and IEA (2005, p180) for more details.
		B12=1	Solar Homes and Communities Plan provided $495.3 for the photovoltaic rebate to incentivise uptake of solar PV in communities and household. Solar Hot Water Rebate provided $232m for the installation of solar and heat pump hot water systems. Refer to Appendix A1 and IEA (2005, p58).
	Private investment inducement B2=(1+0+0)/3=0.33	B21=1	Renewable Energy Commercialisation Programme provided in total of $60m to assist renewable energy technology commercialisation at 50% of the project costs. Renewable Energy Equity Fund provided $26.6m in venture capital and managerial advice for small, innovative companies developing RE technologies. Refer to Appendix A1.
		B22=0	None
		B23=0	None
Policy measures / instruments B=(1+0.33+0.67+0.17+0)/5=0.43	*Market structural & regulatory reforms* B3=(1+1+0)/3=0.67	B31=1	Australia was one of the first countries to undertake substantial electricity market reform. The Australian Energy Market Commission (AEMC), Australian Energy Regulator (AER) and National Electricity Market Management Co (NEMMCO) were the three institutes established (IEA, 2005 p33-34). Since 1998, the AER enacted the National Electricity Law over the NEM which covers six jurisdictions (Queensland, New South Wales, the Australian Capital Territory, Victoria, South Australia and Tasmania) and are now all linked by at least one interconnector to be one of the longest AC interconnections in the world by geographic span (IEA, 2005; Commonwealth of Australia, 2007; Baritaud and Volk, 2014).
		B32=1	The Improving Grid Accessibility initiative was to work with the states and territories governments to identify and act on specific rule changes required in the National Electricity Market (NEM) to maximise the benefits of distributed (including renewable energy) generation. Refer to Appendix A1.
		B33=0	None
	Policies feasibility and effectiveness B4=(0+0+0.5)/3=0.17	B41=0	No carbon pricing mechanism introduced.
		B42=0	No feed-in tariff policy.
		B43=0.5	All policies/measures are listed in Appendix A1. In terms of effectiveness, these policies had be rated to be below average among OECD countries by IEA

			(2005) due to lack of market based instruments such as carbon pricing and feed-in tariff. The MRET policies were found to have design limitation as reported by Buckman and Diesendorf (2010).
	Policies consistency and continuity B5=0	B51=0	As can be seen (in Appendix A1) that many of the policy measures introduced by the Howard government were of a one-off and short-term nature.
		B52=0	Due to the one-off and short-term nature of most policy measures, there was no monitoring mechanism for policy performance and ongoing improvement.
		B53=0	There is only one policy (***GreenPower Scheme)*** still in forces (as shown in Appendix A1 & A2) which confirmed the lack of policy continuity due to their short-term nature.
Implementation, tracking & reporting *C=(0.33+0)/2=0.17*	*Implementation institute capacity* C1=(1+0+0)/3=0.33	C11=1	Australian Greenhouse Office (AGO) was established in 1998 as part of the Department of Environment and Heritage and was responsible for delivering the majority of programmes under the Government's climate change strategy. The Office of the Renewable Energy Regulator (ORER) was the statutory authority to oversee the implementation of the Government's Mandatory Renewable Energy Target (MRET). Refer to Appendix A1 and (Commonwealth of Australia, 2004; Talberg et al., 2013).
		C12=0	None
		C13=0	None
	Robustness of tracking & reporting C2=0	C21=0	The AGO was tasked to tracking and report on the Kyoto Australia's Greenhouse Emissions Trends. The Office of Renewable Energy Regulator (ORER) is tracking and reporting on the MRET (Commonwealth of Australia, 2000, 2004). The National Greenhouse & Energy Reporting System (NGERS) was introduced in 2007 to provide data and accounting in relation to GHG emissions and energy consumption and production Commonwealth of Australia, 2007). The Scheme's legislated objectives are to: • inform policy-making and the Australian public • help meet Australia's international reporting obligations • provide a single national reporting framework for energy and emissions reporting However, none of these was structured with implementation tracking and performance review imperatives due to the lack of national emission reduction target. Refer to the parameter A22 above.

		C22=0	None - as illustrated in C21 parameter.
		C23=0	None - as illustrated in C21 parameter.

Table B 4-2 MCA ranking of Kevin Rudd's climate action performance

Tier 1 criteria	**Tier 2 criteria**	**Tier 3 sub-criteria**	**Kevin Rudd –** ALP *(2 years 6 months)* 3/12/2007 – 24/06/2010 **Grade ranking rationale**
Total performance ranking = (A+B+C)/3 = (0.94+0.8+.025)/3 = 0.66			
Political acceptability A=(1+1+0.83)/3=0.94	*Leadership support* A1=1	A11=1	Kevin Rudd had made addressing climate change his signature policy commitment both before and after the 2007 election that brought the Australian Labor Party to power (Pietsch and McAllister, 2010; Curran, 2011). His election promises to: ratify the Kyoto Protocol; setup a national emissions trading scheme (ETS); cut Australia's GHG emissions by 60% on 2000 levels by 2050. His Government had also promised to pursue a strong action on global climate change (Hetherington and Soutphommasane, 2010; McDonald, 2015).
		A12=1	After Rudd's election victory, he began to outline the framework of the Carbon Pollution Reduction Scheme (CPRS) including commitment to a 20 per cent renewable energy target by 2020 and an investment in an energy-efficiency program to be supported by a total committed funding of around $8 billion (McDonald, 2015). Refer to Appendix A1& A2 for policies and funding details.
		A13=1	In July 2009, the Council of Australian Governments (COAG) agreed to a 10-year National Strategy on Energy Efficiency (NSEE) with funding of $88.3m to accelerate energy efficiency improvements and deliver cost-effective energy efficiency gains across all sectors of the Australian governments. The NSEE was updated in July 2010 to streamline the roles and responsibilities across all tiers of governments by providing a nationally consistent and coordinated approach to energy efficiency. Refer to Appendix A1.
	International commitment A2=1	A21=1	As illustrated at parameter A11 and A12.
		A22=1	As the first act of his Government, PM Rudd quickly moved to ratify the Kyoto Protocol with an unconditional 5% below 2000 by 2020 for the second

			commitment period and 15% - 25% below 2000 by 2020 subject to international achievement. Ultimate ambition was 60% below 2000 levels by 2050 (Parliament of Australia, 2007). He had also led a large delegation at the COP 13 UNFCCC meetings in Bali in December 2007 (Durrant, 2010).
		A23=1	Contribution of $100m to the Clean Technology Fund (CTF) which was one of two World Bank-administered Climate Investment Funds that promoted scaled up financing for demonstration, deployment and transfer of low-carbon technologies with significant potential for long-term GHG emissions savings. The CTF finances projects in 12 countries and one region. The Australian Solar Institute (ASI) was established by the Australian Government in 2009 with funding of approximately $89m for 48 projects with a total leveraged value of approximately $255m. The projects selection was under the United States-Australia Solar Energy Collaboration and the Australia-Germany Collaborative Solar R&D Funding to leverage significant investment from industry in those countries. Refer to Appendix A1.
	National targets & strategic planning A3=(1+1+0.5)/3=0.83	A31=1	Refer to parameter A12 and A22 for target ambition and the actions taken.
		A32=1	The Garnaut Review (2008) commissioned while the Labor Party was in Opposition was tasked specifically to investigate the economic implications of climate change for Australia ‘emissions trading’ and the ‘carbon tax’ concluded that a well-designed emissions trading scheme had advantages over other forms of policy intervention (Durrant, 2010; McDonald, 2015). This review became a blueprint for the Climate Change Plan in 2011 (Commonwealth of Australia, 2008, 2011a, 2011b). The Wilkins Review (Strategic Review of Australian Government Climate Change Programs) analyses current climate change programs to determine whether they are complementary to the CPRS. In response to the Wilkins Review: Government agrees to close 13 programs that were deemed not complementary to an ETS (Talberg et al., 2013).
		A33=0.5	Despite there was no plan eventuated from all Rudd’s actions. However, he had managed to set 20% Renewable Energy Target which is still in place for the nation to achieve (St John, 2014) and Garnaut Review had set a framework for the Climate Change Plan in 2011. As illustrated above due to his twice failed attempt to pass the CPRS through the senate, the score needs to reflect the positive advocacy actions which has a merit to his political acceptability assessment.

Policy measures / instruments B=(1+1+1+0.33+0.67)/5 =0.8	*Public funding for R&D and RE incentive* B1=(1+1)/2=1	B11=1	The Clean Energy Initiative with committed funding of A$5.1 billion aimed to support clean energy generation including low-emission coal, CCS and new RE technologies to reduce carbon emissions and stimulate the clean energy sector. Refer to Appendix A1.
		B12=1	National Solar Schools Program with funding of $421m for all Australian schools to install renewable energy systems, rainwater tanks; Green Precincts Fund with $13.3m to support demonstration projects that deliver substantial reductions in greenhouse gas emissions through energy efficiency measures, solar power generation, solar hot water services, smart metering; the Smart Grid, Smart City project with $100m funding to trial a range of customer and grid side smart grid technologies and applications; Renewable Energy Bonus Scheme (REBS) with $89m to help eligible home-owners, landlords or tenants replace electric storage hot water systems with solar or heat pump hot water systems. Refer to Appendix A1.
	Private investment inducement B2=(1+1+1)/3=1	B21=1	The Climate Ready was part of ***Clean Business Australia*** programme funded with $75.95m to support the development and commercialisation of innovative products, processes and services that address the effects of climate change; the Australian Centre for Renewable Energy (ACRE) was setup with $700m funding commitment to support the technology development and commercialisation and was incorporated into ARENA on 1 July 2012; the Clean Energy Innovation Centre with $20m from the Enterprise Connect's $200m umbrella funding to assist companies innovating in the clean energy sector; Renewable Energy Demonstration Program (REDP) provided $235m as large grants to supported the commercialisation and deployment of large scale, grid feeding, renewable energy projects. Refer to Appendix A1.
		B22=1	The design of an expanded national RET was referred to the COAG with the intention of absorbing separate state schemes. Legislation for the expanded RET was passed in 2009, as the *Renewable Energy (Electricity) Amendment Act 2009*. This amendment increased the target from 9,500 GWh by 2010 to 45,000 GWh by 2020 and introduced a 'solar credits' multiplier, to provide an additional incentive for the installation of solar photovoltaic systems (St John, 2014). The Solar Homes and Communities Program from previous Howard Government was extended until June 2009 and were to be superseded by the Solar Credits Initiative under this RET Scheme. See Appendix A1.

		B23=1	Refer to B22 above regarding the long-term policy certainty legislation.
	Market structural & regulatory reforms B3=(1+1+1)/3=1	B31=1	The government committed to improve efficient energy markets by maintaining its programme of reform, including the AMEC, AER and the establishment of the Australian Energy Market Operator (AEMO) in 2009 to be complemented by the development of a National Energy Customer Framework (IEA, 2012b).
		B32=1	The Connecting Renewables Fund (CRF) committed to invest $1 billion over the next decade in electricity networks to facilitate the transmission infrastructure (grid) to connect new large-scale renewable projects expected to come online in coming years. See Appendix A1.
		B33=1	A range of initiatives were also implemented to improve transparency, increase competition and regular reviews to enhance energy security (IEA, 2012b).
	Policies feasibility and effectiveness B4=(0+0.5+0.5)/3=0.33	B41=0	The battle of passing the main policy of Carbon Pollution Reduction Scheme (CPRS) throughout the year 2009-2010 had costed the prime-ministership of Rudd and the compromised version CPRS had never managed to pass the Senate to be implemented. Therefore, there was no carbon pricing policy in place (Durrant, 2010; Crowley, 2011, 2013a, 2017; Mcdonald, 2012, 2015).
		B42=0.5	The feed-in tariff (FiT) was not nationally mandated for all states and was only agreed in 2008 through the COAG on a set of four National Principles to increase consistency across the states' jurisdictions. These principles were aim to increase consistency across all state jurisdictions (IEA, 2012b). However, the result was still inconsistency across states' policy design that carried high public costs to some state governments and ultimately required significant changes to the policy (Zahedi, 2010; Martin and Rice, 2013).
		B43=0.5	The principal existing policies, the state and territory-based feed-in tariffs and the proposed Emissions trading scheme (ETS) were found to be ineffective to reach its 20% RET (Buckman and Diesendorf, 2010).
	Policies consistency and continuity B5=(0.5+1+0.5)/3=0.67	B51=0.5	Legislation of the Renewable Energy (Electricity) Amendment Act 2009 (refer to B22 above) and the failed attempt to pass the CPRS through the Senate (refer to B41 above) are considered as long-term oriented policy design. The score reflects a partially completed policy plan.
		B52=1	Under the Renewable Energy Act, the RET must be reviewed by the Climate Change Authority every two years; the review must examine the operation of the Act, its associated regulations and the environmental and economic impact of the scheme. The last review was undertaken in 2012; the review concluded

			that the RET did not require significant changes, and that there was no compelling evidence to alter the quantity or nature of the target. However, the Authority did flag that the uncapped nature of the SRES could prove problematic, and suggested policy measures to alleviate this. The Authority also noted that biennial reviews were damaging to investor confidence, and recommended that the RET should be reviewed every four years instead (Australian Government, 2012, 2014; St John, 2014).
		B53=0.5	There are 7 policies/measures still in force despite the changes of government. Refer to Appendix A1.
Implementation, tracking & reporting C=(0.5+0)/2=0.25	*Implementation institute capacity* C1=(0.5+0.5+0.5)/3=0.5	C11=0.5	The Department of Climate Change and Energy Efficiency (DCCEE) has primary responsibility for policy advice, policy implementation, programme delivery and regulatory oversight in four areas: • reducing Australia's greenhouse gas emissions; • improving Australia's energy efficiency; • adapting to climate change; and • helping to shape a global climate change solution. (IEA, 2012b). However, there was no strategic planning towards set target as illustrated at A33 the merit of the institute is being compromised.
		C12=0.5	Australian Centre for Renewable Energy (ACRE) was incorporated into ARENA on 1 July 2012. Refer to Appendix A1.
		C13=0.5	Average, based on funding for Australian Centre for Renewable Energy (ACRE) and ARENA in parameter B21 above.
	Robustness of tracking and reporting C2=0	C21=0	None
		C22=0	None
		C23=0	None

Table B 4-3 MCA ranking of Julia Gillard's climate actions performance

Tier 1 criteria	Tier 2 criteria	Tier 3 sub-criteria	**Julia Gillard –** ALP *(3 years)* 24/06/2010 – 27/06/2013 **Grade ranking rationale**
Total performance ranking = (A+B+C)/3 = (1+0.97+1)/3=0.99			
Political acceptability A=(1+1+1)/3=1	*Leadership support* A1=(1+1+1)/3=1	A11=1	Prime Minister Gillard (2012) defined climate change as ‘a broader global challenge with national security implications’. Her Labor Government’s conception of the threats posed by climate change as a threat multiplier with implications for both regional and national security (McDonald, 2015). Rather than expending her effort on advocacy for climate change action, her priority was pragmatic climate policy development (Chubb, 2015).
		A12=1	PM Gillard had succeeded what Rudd had failed with his CPRS by focusing her political strategy on gaining majorities where it counts in the Senate to get the Clean Energy Plan policies through the Senate that brought into law Clean Energy Act 2011 (Cth) (McDonald, 2012; Crowley; 2013a, 2013b)
		A13=1	The Low Carbon Communities program with funding of $330m aimed at supporting local councils to take actions on climate change and reduce their energy costs through energy efficient upgrades to street lighting, community facilities and council buildings as well as installation of cogeneration or new heating and air conditioning. Supported with funding of $6.8m, the Local Government Energy Efficiency Program (LGEEP) was a non-competitive grant program that will assists local governing authorities (LGAs) to install solar and heat pump hot water systems to drive smarter energy use in their buildings and community facilities. Refer to Appendix A1.
	International commitment A2=(1+1+1)/3=1	A21=1	As illustrated at A11 above.
		A22=1	Maintain the Kyoto commitments to reduce carbon emissions by 5–25% from 2000 levels by 2020 subject to the scale of global actions, and boosted a long-term target from 60% to 80% from 2000 levels by 2050 (Commonwealth of Australia, 2011b).
		A23=1	The Accelerated Step Change Initiative (ASCI) was to be managed and funded at the discretion of ARENA. The maximum funding is only constrained by the

			limit of available funds from ARENA. ASCI is open to Australian and international companies and research institutions with contribution of $5 million or more from ARENA to the total project cost of up to $20m. See Appendix A1.
	National targets & strategic planning A3=(1+1+1)=1	A31=1	Maintain the 20% RET set by her predecessor Kevin Rudd and boosted the long-term target from 60% to 80% from 2000 levels by 2050 (Commonwealth of Australia, 2011b).
		A32=1	The Treasury's climate change modelling team led by leading national and international climate change economists and with further collaborative work with Garnaut Climate Change Review updates had resulted with the Energy White Paper 2011 and Clean Energy Future Plan 2011 (Commonwealth of Australia, 2008, 2011b, 2011c).
		A33=1	The Clean Energy Future Plan has brought together existing policies and strengthen them with new initiatives and enabling legislation. The carbon pricing package was informed by the work previously undertaken by Garnaut (2008) for the CPRS and finalised and accepted through the Multi-Party Climate Change Committee (MPCCC). The Plan covered four main elements including carbon price, renewable energy, energy efficiency and action on the land (Commonwealth of Australia, 2011a; 2011b, 2011c).
Policy measures / instruments B=(1+1+1+0.83+1)=0.97	*Public funding for R&D and RE incentive* B1=(1+1)/2=1	B11=1	The **Clean Technology Innovation Programme** with funding of $200m was one of the many programs managed by ARENA to provide grants to support business investment in R&D in renewable energy, low pollution technology and energy efficiency. **National Carbon Dioxide (CO2) Infrastructure Plan** had provided $30m to accelerate the identification and development of sites suitable for the long term storage of CO2 in Australia that are within reasonable distances of major energy and industrial CO2 emission sources. It was to complement the work undertaken as part of the CCS Flagship program. Refer to Appendix A1.
		B12=1	Maintaining the Solar Credits Scheme under the national RET Act. The Clean Energy and Other Skills Package funded with $32m was to enable tradespeople and professionals in key industries to develop the skills needed to deliver clean energy services, products and advice to Australian communities and businesses.

			Low Income Energy Efficiency Program with funding of $55.3m was a competitive merit-based grant program established to provide grants to consortia of government, business and community organizations to trial approaches to improve the energy efficiency of low-income households and enable them to better manage their energy use. Refer to Appendix A1.
	Private investment inducement B2=(1+1+1)/3=1	B21=1	ARENA was legislated to manage $3.2 billion in supporting of research and development, demonstration and commercialisation of renewable energy. The national RET combined with other elements of the Clean Energy institutes and instruments including the CEFC and carbon price aim to drive $20 billion of investment in large-scale renewable energy by 2020 (Commonwealth of Australia, 2011b). Refer to Appendix A1.
		B22=1	The Clean Energy Finance Corporation (CEFC) was established with $10 billion in funding available over 5 years on 3 August 2012. The CEFC was setup as commercially oriented institute to support investments in renewable energy, low-emissions and energy efficiency technologies and innovation in clean energy. Funding is generally provided through loans on commercial or concessional terms. However, the CEFC is not restricted from using other structures / financial instruments to remove impediments to investment in the clean energy sector. Refer to Appendix A1.
		B23=1	The Clean Energy Act 2011 (Cth) encompasses the governing and implementation institutes of Climate Change Authority, ARENA and CEFC was aimed at providing and safeguarding the long-term stability and certainty of the RE policies which in term will induce capital investment for the sector (Commonwealth of Australia, 2011a, 2011b).
	Market structural & regulatory reforms B3=(1+1+1)/3=1	B31=1	The Energy White Paper (EWP) acknowledges a need to follow through on outstanding actions from previous energy market reviews, notably retail price deregulation (while empowering consumers and protecting vulnerable consumers), reducing government ownership in energy markets and furthering the transition to truly national markets by extending market governance arrangements and principles to all electricity and gas markets (Commonwealth of Australia 2011c; IEA, 2012b p.101).
		B32=1	The Energy White Paper (EWP) identifies the need for significant investment estimated to $240 billion in Australia's electricity and gas production, transmission and distribution sectors by 2030. Government proposes

			reinvigorating the energy market reform agenda to strengthen its work with the states and territories, through the established COAG ministerial councils to pursue greater market liberalisation and transparency measures, stronger customer protection measures and increased demand-side management reforms (Commonwealth of Australia 2011c).
		B33=1	EWP identifies a number of key actions that need to be taken including improving the investment and market competition, enhancing electricity network efficiency and productivity, development of a robust smart metering framework and the commissioning of an independent review by the Productivity Commission into the use of benchmarking of network businesses to improve efficiency (Commonwealth of Australia 2011c; IEA, 2012b).
	Policies feasibility and effectiveness B4=(1+0.5+1)/3=0.83	B41=1	IEA commended the range of proposals including the renewable energy sector in the Clean Energy Future Package and the most significant of these is the introduction of a carbon price which should provide investors with a strong incentive for the development of clean technologies, especially renewable energy (IEA, 2012b p.86). Associated with the introduction of carbon pricing an Energy Security Fund was setup to smooth the transition and maintain energy supply security through transitional assistance to highly emissions-intensive coal-fired power stations and to ensure the transparent information on the action taken by these generators to move to a cleaner energy future (IEA, 2012b p.103).
		B42=0.5	There is no nationally mandated programme on feed-in tariff (FiT). The FiT schemes was implemented on all state jurisdictions through COAG agreed set of four National Principles aimed to increase consistency across all the states and territories. However, the effectiveness of FiT schemes in inducing private investment are compromised as a result of different state's own agenda and plan (Martin and Rice, 2013). The initial phase of generous state-based FiT schemes was mostly funded from states' budget rather than from consumers which was proven to be unsustainable, hence being phasing out shortly when it was oversubscribed (IEA, 2012b).

		B43=1	The Clean Energy Plan policies are highly commended by the IEA (2012) as a relatively balanced package with strong elements of carbon pricing and annual pollution caps targets which encourages industries and households to find the most effective ways of reducing carbon pollution. The Australian carbon mechanism also fits well with lessons learnt from key emerging design issues from existing international emissions trading schemes (ETS) designs and experiences.
	Policies consistency and continuity B5=(1+1+1)/3=1	B51=1	The Clean Energy Act 2011 (Cth) had legislated the carbon tax, the governing and implementation institutes including Climate Change Authority (CCA), Arena and CEFC which aimed at safeguarding the long-term functioning and certainty of the RE policies against any radical change from future opposition government (Commonwealth of Australia, 2011a, 2011b). The overall policies package was highly commended by the IEA. See B43 above and B53 below.
		B52=1	The specific functions of the CCA include conducting reviews of: the operation of RET scheme; the Carbon Farming Initiative; the National Greenhouse and Energy Reporting System; the progress in achieving Australia's emissions reduction targets and national carbon budget; the Clean Energy Act 2011 (Cth) and associated provisions, carbon pollution caps, national emissions trajectory and national carbon budget. http://www.climatechangeauthority.gov.au/about-climate-change-authority
		B53=1	Despite the carbon tax being repealed, and the Coalition Government's attempt to disband the ARENA and CEFC, there are 11 policies still in force. The ARENA and CEFC are still carrying out their function originally designed for with the aid from carbon tax. Refer to Appendix A2.
Implementation, tracking & reporting C=(1+1)/2=1	*Implementation institute capacity* C1=(1+1+1)/3=1	C11=1	As stated in B23 and B51 above that the CCA as part of the Clean Energy Act 2011 (Cth) legislation was the dedicated institute to oversee the implementation, reviewing and reporting of the progress towards the RET (Commonwealth of Australia, 2011b).
		C12=1	The ARENA and CEFC were setup to stimulate and induce the private investment in the RE sector to achieve the RET (Commonwealth of Australia, 2011b).
		C13=1	Refer to B21 and B22 above that the ARENA and CEFC were funded with an aggregate of $13.2 billion in supporting to the R&D, commercialisation of RE technologies and inducing private investment in the RE sector.

	Robustness of tracking and reporting C2=1	C21=1	The Climate Change Authority's Legislated Reporting Obligations are well-defined as follow: 31 December 2012: First Renewable Energy Target review 28 February 2014: First review of progress towards national targets and budget 28 February 2014: Recommendations of pollution caps for 2015–16 to 2019–20, national trajectory and carbon budgets 31 December 2014: Second Renewable Energy Target review 28 February 2015: Annual review – progress towards targets and budget 28 February 2016: Annual review – progress towards targets and budget 28 February 2016: First annual recommendations on pollution caps http://www.climatechangeauthority.gov.au/about-climate-change-authority
		C22=1	A series of new reporting measures introduced under the Clean Energy Act 2011 (Cth) legislation required the target will be reviewed biennially. The first review took place in the second half of 2012 by the independent Climate Change Authority (CCA), which commenced operations on 1 July 2012 and must provide its report to government by 31 December 2012. A biennial National Energy Security Assessments (NESA) from 2014 and a regular four-yearly reviews of national energy policy strategies will begin in 2016 (Commonwealth of Australia, 2011a).
		C23=1	A series of the Progress Reviews and the outcomes of the reviews had been published by the CCA in these reports Australian Government (2012, 2014, 2015b).

Table B 4-4 MCA ranking of Tony Abbott's climate actions performance

Tier 1 criteria	**Tier 2 criteria**	**Tier 3 sub-criteria**	**Tony Abbott –** Liberal *(2 years)* 18/09/2013 - 15/09/2015 **Grade ranking rationale**
Total performance ranking = (A+B+C)/3 =(0+0.05+0)=0.02			

Political acceptability A=0	*Leadership support* A1=(0+0+0)/3=0	A11=0	Tony Abbott has always expressed scepticism about the science of climate change and his favour for coal in public (Readfearn, 2014; Grattan, 2015; Keane, 2015).
		A12=0	Within months of taking PM office, his Government had moved to repeal carbon pricing legislation, refused to send a Minister to UNFCCC talks in Poland, scrapped the Climate Commission, reduced funding for science and climate research, and was establishing the groundwork for walking away from both the 5% Kyoto target and the 20% RET which had raised uncertainty to the investment sentiment for the RE sector (Milman, 2013; McDonald, 2015; Crowley, 2017).
		A13=0	None
	International commitment A2=(0+0+0)/3=0	A21=0	As described at A11 and A12 above.
		A22=0	Refer to A12 above.
		A23=0	None. Refer to Appendix A1.
	National targets & strategic planning A3=0	A31=0	The Clean Energy Plan putting in place by the previous Labor Government was seemingly dismantled when the functioning carbon pricing mechanism was being repealed. Meanwhile, the carbon tax's designer, Ross Garnaut, has bemoaned the fact that Australia is now out of step with much of the rest of the world, while a new analysis of electricity data shows that carbon pricing was doing an effective job of cutting emissions (Whitmore et al, 2014). The Direct Action Plan (DAP) is the only policy plan being introduced which effectiveness were questioned and greatly criticized by many experts (RepuTex, 2013; Reputex Carbon, 2013; Burke, 2016; Hollo, 2016), hence, cannot be regarded as a fully formulated strategic plan as compared to the Clean Energy Plan.
		A32=0	No modelling for the purpose of introducing new plan had been conducted.
		A33=0	Refer to A31 above.
Policy measures / instruments **B=0.05**	*Public funding for R&D and RE incentive* B1=(0.5+0)/2=0.25	B11=0.5	The Abbott Government announced in the May budget that the government would axe the statutory organisation, grab its unallocated $1.3 billion project funding and roll any of its leftover functions into the Department of Industry (Sansom, 2014). However, with its failed attempt to repeal the ARENA, the Government had only succeeded a cut of funding to the $3.2 billion legislated for ARENA by $435 million and a bill to defer a further $370 million to nearly

			a decade (Parkinson, 2013). A new Research and Development (R&D) Program with $300m was introduced in place of the $805m cut. Refer to Appendix A1.
		B12=0	None. Only let the existing schemes established by the previous Labor Government to run their courses.
	Private investment inducement B2=0	B21=0	Refer to B11 above regarding the $805m funding cut to the ARENA operation which would have long-term negative impact to the RE sector.
		B22=0	In July, treasurer Joe Hockey ordered the CEFC to stop funding wind power projects, as well as small-scale solar projects, a move condemned by the industry, as well as environmental groups and the Federal Opposition (Keane, 2015; Keany, 2015).
		B23=0	The repeal of the carbon tax and the failed attempt to repeal the CCA, ARENA and CEFC and a talk of substantial reduction of the 20% RET were creating market uncertainty and significantly impacted the renewable energy investment grinding to a halt as reported by (Hannam, 2015).
	Market structural & regulatory reforms B3=0	B31=0	No new initiative in any sort of reform or enhancement.
		B32=0	None.
		B33=0	None.
	Policies feasibility and effectiveness B4=0	B41=0	The DAP was the only policy being introduced by the Abbott Government which provides neither complementary nor enhancing function to whatever policy measures that was left in place from the previous Labor Government. More importantly, unlike the repealed carbon tax which is paid by the polluters / energy consumers, DAP is being funded by taxpayers in rewarding the polluters (Denniss & Grudnoff, 2011; Jotzo et al, 2014).
		B42=0	None.
		B43=0	Negative impact to the overall policy effectiveness by dismantling an otherwise good plan (RepuTex, 2013; Reputex Carbon, 2013; Burke, 2016; Hollo, 2016).
	Policies consistency and continuity B5=0	B51=0	The four new policy measures including DAP are still in force. However, its short-term nature and viability is also seriously in doubt as stated in B41 above. The emission for the electricity sector had risen 3% for year 2014-2015 (Australian Government, 2015c)
		B52=0	None.
		B53=0	See B51 above.
		C11=0	Refer to B11, B21, B22 and B23.

Implementation, tracking & reporting C=0	*Implementation institute capacity* C1=0		In planning to repeal the CCA, ARENA and CEFC, a new Department of the Environment is taking over matters that include renewable energy target policy, regulation and co-ordination; greenhouse emissions and energy consumption reporting; climate change adaptation strategy; co-ordination of climate change science activities; renewable energy; greenhouse gas abatement programmes; and community and household climate action (Talberg et al, 2013).
		C12=0	Refer to B11, B21, B22, B23 and C11 above.
		C13=0	Refer to B11, B21, B22, B23 and C11 above.
	Robustness of tracking and reporting C2=0	C21=0	None.
		C22=0	None.
		C23=0	None.

4.10 Appendix C Australian population, GDP, emissions and electricity fuel-mix 1990-2014

Year	Population and GDP		Australian emissions and electricity generation by fuel type in GWh							
			National Emission inventory (mega ton CO2-e)	Non-renewable			Renewable			Total electricity including others
	Population	GDP $million		Black coal	Brown coal	Natural gas	Hydro	Wind	Solar PV	
1990	17,065,128	749,152	564.1	87,573.0	33,594.0	14,359.0	14,880.0			**154,708.0**
1991	17,284,036	745,960	530.4	89,511.0	36,048.0	10,772.0	16,103.0			**156,599.0**
1992	17,478,635	748,975	502.0	94,325.1	34,559.0	11,633.0	15,768.0		10.9	**159,328.0**
1993	17,634,808	779,286	489.8	97,872.7	33,248.0	12,295.0	16,953.0		13.3	**163,473.0**
1994	17,805,468	810,806	516.5	100,544.1	34,890.0	12,199.0	16,649.0	4.0	15.9	**167,292.0**
1995	18,004,882	842,275	500.4	102,522.1	35,832.0	14,913.0	16,239.0	7.0	18.9	**172,993.0**
1996	18,224,767	875,523	501.3	106,089.6	39,427.0	12,445.0	15,731.0	7.0	23.4	**177,456.0**
1997	18,423,037	910,048	523.4	109,452.2	41,893.0	11,426.0	16,852.0	7.0	27.8	**182,798.0**
1998	18,607,584	950,371	520.5	116,969.5	46,633.0	12,934.0	15,733.0	8.0	33.5	**195,161.0**
1999	18,812,264	997,930	535.5	118,586.3	49,703.0	16,001.0	16,563.0	28.0	37.7	**203,781.0**
2000	19,028,802	1,036,570	560.8	123,833.5	50,200.0	16,245.0	16,720.0	58.0	43.5	**210,018.0**
2001	19,274,701	1,056,561	567.8	134,264.0	52,223.0	17,271.0	16,933.0	210.0	50.0	**223,640.0**
2002	19,495,210	1,097,378	583.5	116,774.7	56,493.0	31,730.0	16,054.0	364.0	58.3	**224,870.0**
2003	19,720,737	1,131,168	557.6	115,296.6	55,160.3	29,375.3	16,490.0	703.1	58.3	**222,120.4**
2004	19,932,722	1,178,187	578.3	121,182.3	55,572.8	30,919.4	16,331.1	705.0	68.1	**229,784.4**
2005	20,176,844	1,216,083	611.9	127,788.5	53,377.8	23,802.9	15,612.2	885.0	77.8	**228,649.7**
2006	20,450,966	1,252,452	615.5	130,231.6	54,552.8	22,725.9	16,029.2	1,713.1	90.3	**232,829.4**
2007	20,827,622	1,299,545	597.8	132,368.5	54,375.8	31,849.9	14,517.0	2,611.1	104.7	**243,152.5**
2008	21,249,199	1,347,657	593.2	129,569.3	54,658.7	34,955.8	12,056.9	3,093.1	122.8	**243,217.1**
2009	21,691,653	1,370,998	594.7	127,270.5	56,981.4	37,660.4	11,869.4	3,823.8	155.6	**247,524.7**
2010	22,031,750	1,397,902	580.9	123,724.5	56,068.3	44,585.4	13,548.7	5,051.7	424.9	**252,279.2**
2011	22,340,024	1,430,354	552.7	116,948.8	55,298.1	48,996.2	16,806.7	6,084.9	1,530.4	**253,577.2**
2012	22,728,254	1,483,675	562.7	116,654.4	55,067.7	48,571.6	14,083.3	6,969.7	2,558.7	**250,740.1**
2013	23,117,353	1,520,945	550.4	111,491.1	47,555.1	51,053.4	18,269.6	7,959.6	3,826.3	**249,715.8**
2014	23,475,349	1,558,586	542.2	105,772.4	46,076.2	54,393.9	18,421.0	10,252.0	4,857.5	**248,297.1**

Chapter 5 – Chapter Introduction

This chapter comprises an article, currently undergoing final revisions, for the peer-reviewed *Journal of Energy Policy*:

Cheung, G., Davies, P. J., Bassen, A. 2019. In the transition of energy systems: what lesson can be learnt from the German achievement? Energy Policy, xxx, xx-xx.

Extending the investigation on the factors underlying Australia's progress, or lack thereof in energy transition (Chapter 4), this chapter details a parallel case study focusing on Germany. The same methodological approaches and MCA model were adopted to enable a comparative analysis of the ranking-scores of leaders from both countries to reveal any sensitivities within the model given the differing policy outcomes. The analysis focused on the energy policies and politics of three German Chancellors (Helmut Kohl,1982-1998; Gerhard Schröder, 1998-2005; Chancellor Angela Merkel, 2005-present) and their governments in Germany from 1990 to 2017.

Like Chapter 4, the role of this chapter was to uncover the factors underlying energy-transition performance and in this case was purposefully directed to Germany given its position as a widely acknowledged world leader in this area. Additionally, the aims of the chapter were to test the robustness and portability of the MCA model developed in Chapter 4 through this application to another state and in turn seek to enhance and advance the model's utility as a robust energy-transition analytical framework.

The comparative analysis of the MCA-model results of Australia and Germany uncovered new perspectives on causality of their contrasting energy-transition performance, as well as weaknesses of the model that could otherwise be missed in an isolated study. With the new insight on weaknesses, the MCA model was iteratively enhanced adding a time-weighted coefficient to overcome a limitation of the semi-crisp scoring ruleset. This scoring ruleset was otherwise unable to capture the short time-span phenomenon of Australia's leadership impacting the effectiveness and outcomes of the climate/energy policies.

The key contributions of this chapter to the aims of the thesis: *in gaining insights and new perspectives on the drivers, challenges and causal factors underlying the contrasting energy-transition performance between Australia and Germany* are highlighted below:

From an energy-transition research perspective, the findings of this chapter:

1. New insight reveals that the socio-political policy instability in Australia when compared to the stability in Germany, and thus the value of cross-partisan harmonisation of political differences and criticality of policy certainty to support capital investment needed for renewable energy development and deployment.
2. This new insight strengthens the work of other researchers in the energy-transition arena such as: (i) policy stability and consistency are important in providing long-term certainty and confidence to the capital-investment market (Geels, 2006; van Rooijen and van Wees, 2006, Verbong and Geels, 2007); (ii) analysis for motivations, barriers and causalities needs to be complemented by analysis of transition policies and their politics (Hill 1997); (iii) steering socio-technical structural changes is politically difficult (Grin et al., 2010; Meadowcroft, 2009; 2011); (iv) climate/energy policy formulation and implementation are found to be essentially a political process (Kern and Smith, 2008).
3. Offer new and supporting insights within the otherwise well-researched area of the German Energiewende on the significant impact of the anti-nuclear grassroots movements on the domestic energy policies and achievements (Hager and Stefes, 2016; Morris and Jungjohann, 2016), and the transition model and pathway of the socio-technical structural changes (Geels et al., 2016; 2017).

From a research methodological strategy perspective:

1. The nested case study enabled a comparative analysis of the parallel national-case results of Australia (Chapter 4) and Germany that uncovered new perspective (listed above) which would otherwise be missed in an isolated study.
2. A refined MCA model by incorporating a time-weighted coefficient to better assess the political and policy stability/certainty as a measurement of policy effectiveness.
3. Through testing in Germany's case, the MCA model has proven its utility in dissecting and quantifying the important socio-political factors and events that have contributed to the contrasting energy-transition performance.

Chapter 5: In the transition of energy systems: what lesson can be learnt from the German achievement? *

Grace Cheung[1], Peter J Davies[1], Alexander Bassen [2]

[1]*Department of Environment Sciences, Macquarie University NSW 2109, Australia*

[2]*Faculty of Business, Economics and Social Sciences, University of Hamburg*

Abstract

This paper assesses the energy transition in Germany from 1990 to 2017 with a focus on the politics and energy policies of the three German Chancellors. Its aim is to investigate the factors underlying the outcomes from a socio-political perspective and through this offer insight as to energy policy reforms that may be transferrable to other governments. We reveal the incremental and politically pivotal role of grassroots movements against nuclear power forming the catalyst and ongoing driver for Germany's energy transition - the Energiewende. Energiewende harbors a compelling socio-technical experiment based on government-led policy-driven structural changes to the energy system that has concurrently supported a heavily industrialized economy. Despite higher energy costs, borne disproportionally by residents, the energy vision and social experiment shared decadal and multi government cross-partisan political and community support. This socio-political policy stability provides a notable point of difference when comparing the energy transitions of lagging nations such as Australia that reveals the criticality of policy certainty to support investment towards new models of clean energy generation and distribution.

Keywords

Renewable Energy, Energy Transition, Climate and Energy Policy, Politics of climate change; Energiewende

* *This chapter was submitted on 18th April 2018 as a co-authored (authors listed above) paper and has been substantially revised based on peer-reviewed comments and resubmitted for publication on 19th February with the manuscript number of JEPO-D-18-01280.*

5.1 Introduction

In 2000, the German coalition government of the Social Democrats (SPD) and the Greens[36] introduced the Renewable Energy Act (Erneuerbare-Energien-Gesetz) (EEG) 2000 that committed to a phase-out of nuclear power and established ambitious greenhouse gas (GHG) emissions reduction targets and concurrent renewable energy targets (Jurca, 2014; Jacobs, 2012). This Act replaced the Electricity Feed-In Law (Stromeinspeisungsgesetz) (StrEG) 1991 that aimed to double the share of electricity produced from renewable energy by 2010. Through the EEG the government and utilities embarked on a targeted energy transition to progressively retire nuclear-power stations with a complete shut-down of all plants by 2021 (IEA, 2007; BMWi, 2000). In support of this reform, the Nuclear Energy Phase-Out Act (Atomausstiegsgesetz) 2002 limited the licenses of existing nuclear plants with regular reviews and prohibited the construction of new nuclear-power plants (Jurca, 2014). Concurrently, the EEG 2000 was amended in 2004 and 2009 (IEA/IRENA, 2018) to progress and meet further renewable energy (RE) policy targets and provide energy security to compensate the closure of nuclear power plants. These legislative pillars provided support for Germany's energy transition including a decentralized RE production and to facilitate more market competition through lowering the overall costs of RE deployment (Jurca, 2014).

Energy-policy landscapes are rarely straightforward. A newly elected (CDU/CSU and FDP) coalition government that aligned with pro-business policy introduced the Energy Concept (Energiekonzept) in 2010. This sought to extend the life-cycle of the nuclear power, in conflict with previous legal and policy directions (Jacobs, 2012), but reinforced an ultimate goal for Germany to become one of the first industrialised countries to base its electricity production, mobility, industries and households on RE (Greenpeace; 2014; BMWi, 2012). This push towards RE was further extended in 2017, when Germany committed to additional progressive targets of 35% electricity consumption from renewables by 2020, 40-45% by 2035, 55-60% by 2035 and at least 80% by 2050 (BMWi, 2017; 2015a). The delivery of these targets is based on three key principle energy-transition policies: security of supply; economic efficiency; and environmental sustainability (Jurca, 2014; Jacobs, 2012; IEA, 2002, 2007, 2013).

[36] The coalition of the Social Democrats (SPD) and the Greens was governing from 1998-2005 when the Greens were instrumental in promoting environmental policies and setting new environmental protection targets and the nuclear phase out was one of their main agendas.

Our study contributes to the crucial climate change and energy-transition research arena by revealing insightful causalities of the impactful socio-political factors underlying the achievement of Germany's RE transition and GHG emission reduction. The comparison of the German findings to the Australian study (Cheung & Davies, 2017) offers new perspectives and valuable lessons for governments, policy- and decision-makers. It highlights the criticality of stable and target driven political ideologies/stances that extend beyond individual governments to facilitate the necessary structural changes to energy generation and distribution systems and concurrently to minimising disruptive processes. The application of a simple and comprehensive semi-crisp scoring ruleset to evaluate a government's policies and actions offers an easily adaptable analytical framework applicable to similar review or comparative analysis within or between governments to advance energy transitions.

The remainder of the paper is made up of the following sections. Section 5.2 provides a review of the national context of Germany focusing on drivers and origins of the aspirations, progress and achievement, challenges and critiques of the Energiewende. Section 5.3 describes the application of the MCA energy-transition model and its ranking ruleset with an introduction of a new time-weighted coefficient as well as the mixed-method approach. Section 5.4 presents the performance results of the three German Chancellors' and their governments from the enhanced MCA model that assesses performance based on three criteria: political acceptability, policy measures/instruments and monitoring frameworks. Section 5.5 provides a discussion of the results at a broader perspective and with a comparative reference to Australian and German leaders' performance and finally the utility of the revised model. Section 5.6 concludes our study and identifies lessons to be learnt for global advantages.

5.2 Germany national context

5.2.1 Energy security and foreign dependency

Energy and economic growth are inexorably linked. Stern & Kander (2012) reported that without an increase in effective energy, no economic growth could have occurred in the industrial revolution and that future growth depends on sustaining energy-supply growth or augmenting energy-technological changes. This energy/economic nexus is critical to the sustainability of industrialized countries, like Germany, where energy intensive value-added industries contributed 30% of GDP in 2016 (World Bank, 2016). Energy security is defined as a secured availability of regular supply of energy at an affordable price (IEA, 2001). The definition has both long-/short-term social, economic, geopolitical and environmental dimensions for the European Union (EU) (European Commission, 2000).

Germany is an industrial and economic driver of the EU and one of the leading export nations in the world (Hager & Stefes, 2016; Morris & Jungjohann, 2016). In the 20th century, European industrial economies were driven by fossil-energy sources of coal, oil, and natural gas which were mainly imported from energy-rich countries in the Middle East and more recently from Russia and Norway (Eurostat, 2016; Hager & Stefes, 2016). For some countries, such as Germany, this was enabled through their own coal reserves. The EU is the world's single largest energy importer. In 2013, 53.2% of its energy supply was imported and for Germany this was even higher at 62.6% costing US$155.8 billion (Eurostat, 2016, UN-Comtrade, 2015).

The supply and prices of energy are subject to global energy supply/demand conditions and geopolitical stability in the oil-/gas-producing countries. Historically, numerous economic and political crises in energy-producing countries and regions have impacted on energy importing nations, effecting economic development and growth (Hamilton, 2011; Umbach, 2010). In recent decades, energy-supply security has become increasingly important in the domestic and international policy agenda in Germany and the EU. This has driven the diversification in both energy source and supply to lessen the reliance on foreign energy and concurrently reducing economic vulnerability (Umbach, 2010; Costantini et al., 2007).

5.2.2 Origin and development of Energiewende in Germany

This section provides an important discourse review of the climate/energy history and rationale of Germany's energy-policy trajectories as a background to understand the underlying concept of the Energiewende. The *Energiewende* has origins dating to 1973 from a local community-grassroots movement in protest to a proposed nuclear-power (Morris & Jungjohann, 2016). This community opposition culminated in a favorable court ruling in March 1977 against the proposal and set in train many other anti-nuclear movements and organizations. These organizations have since empowered local residents to participate in alternative energy-technological innovations that subsequently brought solar energy to fruition nationwide. This grassroots movement also founded green-alternative voting throughout West Germany that eventuated in the national Greens Party in 1980 (Hager and Stefes, 2016). The Greens entered the national parliament, the Bundestag, in 1983. This community led rejection of nuclear power paved the way for broader resistance to nuclear power and has served as a catalyst for the current energy transformation (Hager and Stefes, 2016).

In 1980, Öko-Institut, an independent research institute, published ‘Energiewende - *growth and prosperity without petroleum and uranium’*. The focus of the book was how Germany could achieve energy independence by lessening imports. It outlined an ambitious scenario of having 45 % RE and 55 % coal-based energy; the coal based energy reflecting the importance of the domestic coal reserves and reinforcing what has since been described as a blind spot in Germany’s energy-transition policy (Morris and Jungjohann, 2016; Morris and Pehnt, 2016). Concurrent to this publication there was a groundswell support for action on global climate change (Watanabe & Mez, 2004; Beuermann & Jäger, 1996; Cavender & Jäger, 1993). The 1986 Chernobyl nuclear-power catastrophe provided a critical tipping point in the energy transition debates focusing on the social and environmental risks of nuclear and more broadly the impacts of fossil-fuel power on climate change (Weidner & Mez, 2008).

Energiewende was officially introduced into legislation in 2000 as part of the Renewable Energy Act (Erneuerbare-Energien-Gesetz – EEG 2000). This act introduced new legislative reforms arising from the SPD/Greens coalition government led by Chancellor Schroder (Morris & Pehnt, 2016). The EEG 2000 was based on the Feed-in Act, 1991, which enabled the initial development of wind energy by incentivizing the deployment of onshore wind farms. The “Energiewende” was briefly paused after Chancellor Merkel overturned the nuclear-phaseout plan of the previous SPD/Greens coalition government. This short-lived decision was quickly overturned following the tsunami that caused the Fukushima nuclear-power accident in Japan that reinforced the broader community opposition in Germany to nuclear power. This exogenous influence of Fukushima led to an immediate shutdown of eight of the 17 nuclear plants, resumed the previous coalition government’s phase-out program of the remaining plants and concurrently heightened national and global interest and attention on the Energiewende (Morris & Jungjohann, 2016; Morris & Pehnt, 2016).

5.2.3 Progresses achievements and investments in the Energiewende

The objectives of the EEG 2000 were to establish Germany’s long-term plan for a sustainable and affordable power supply and create an economic policy to ensure an ongoing development of the RE industry (Morris & Jungjohann, 2016; Morris & Pehnt, 2016). Wind power grew rapidly under the EEG culminating in a third of all global wind-power generation (Morris & Jungjohann, 2016).

The capacity of Germany's wind-power installation increased from 1-gigawatt in 2000 to 3.2-gigawatts in 2002. Concurrently, Germany supported the growth of other renewables in its energy mix. By the end of 2002, the total RE supply increased by 70% to that generated the previous year and the goal of 4.2% minimum share of renewables in its total primary energy supply (TPES[37]) by 2010 was reached in 2007 (IEA, 2007). These achievements and ongoing socio-political support led to the amendments of the EEG in 2004 that set higher targets of 12.5% renewable-electricity generation by 2010 and minimum 20% by 2020. These targets were also achieved in 2010 with RE generation exceeding 17% and in 2014 grew to 26% (AGEB, 2018). As a result of the phenomenal growth of RE generation from 3.6% in 1990 to 29% in 2015, the 2020 target was revised again to 35% (Morris & Jungjohann, 2016). Concurrent with this policy reform was an acceleration in the progressive phasing-out of nuclear power whose share declined from 27.7% of total electricity generation in 1990 to 15.5% in 2014. In terms of energy mix, the decline in nuclear power was replaced by the rise in RE generation from biogas, wind, and solar power. The diversification of Germany's energy supply represented longer term structural changes to the energy sector, whereby fossil fuels, while still an important energy source, were at a 35-year low in the overall power mix (BMWi, 2016b). Notably, Germany has been a net electricity exporter since 2011 and posted record levels of net electricity exports nationally each year to 2015 (Morris & Jungjohann, 2016).

From a social and economic perspective, the Energiewende has had a positive impact on industrial growth and job creation, balance of trade and energy security (Hager and Stefes, 2016). From 2000 to 2014, €220 billion has been invested within the RE sector. It is estimated that around €15 billion of new investment per year is still needed to extend and upgrade the ageing electricity infrastructures (high-voltage grid system) and develop smart grids and energy-storage capacities for the next decade to harmonise the intermittent overcapacities of growing share of RE, such as the oversupply from wind generation during certain times of the year (Hager and Stefes, 2016; Agora Energiewende, 2015). Since the enactment of EEG 2000, there has been an increase in citizen-owned renewable-electricity generation enabled by public support schemes and technical developments in photovoltaics (Inderberg et al., 2018). By 2012, nearly half of the investments in new photovoltaics, wind-power and biomass were generated from household prosumers (small scale end-users who, in addition to using electricity from the grid, generate power for their own use, mostly solar photovoltaics and export back into the electricity system) and energy co-ops. This grassroots support for energy-system transformation has contributed to changes in business

[37] TPES represents the total amount of energy that is available to meet the demand in a country or region in a given period of time.

models and electricity markets, and established new political interest landscapes (Inderberg et al., 2018; Szulecki, 2018). The majority of the other investment has been through institutional investors such as banks, insurance companies, and municipal energy suppliers. Notably, the traditional big four utilities[38] contributed only 5.5% of the RE investment, reflecting a clear shift in importance of the traditional centralised fossil-fuel energy generators to a new diversified model (Morris & Jungjohann, 2016; Morris & Pehnt, 2016).

5.2.4 Challenges and critiques of the Energiewende

The Energiewende has brought about many social, economic and technological successes but not without some controversies and challenges. The long-term ambitious goal of Energiewende stipulates at least 80% of electricity from renewable sources by 2050 with progressive phase-out of the nuclear power by 2022. This has required a fundamental transformation of the entire energy system requiring a focus on both the supply and demand sides. While RE has concentrated on the supply side, managing demand though energy efficiency has been a focus across all sectors of the economy. This has been driven by a 20% primary energy consumption reduction target below 2008 level by 2020 in which an 8.3% reduction was reached by 2014 (BMWi, 2016d; Ringel et al., 2016; IEA, 2014d).

A tension point within the energy reform process has been the ongoing demands placed by carbon-intensive sectors, such as transport and buildings heating/cooling. This has had particular impact on the otherwise aging grid infrastructures that lacked a commensurate renewal program (Agora Energiewende, 2015). Arguably, the greatest areas of concern to many citizens and minor political parties have been rising electricity prices and employment-loss within the 'old' energy-generating and energy-intensive industries (Fischer et al., 2016).

At an energy market and policy perspective, the major challenges that have and continue to confront the Energiewende are fourfold. First, the need to invest in new distribution-network infrastructure to support the intermittency of RE supply (Chalvatzis and Hooper, 2009). Second, the need to further reform the energy market with increasing high capital sunk-cost and zero marginal costs RE that has shifted power-generation patterns and cost structures of electricity (Matthes, 2017a; BMWi, 2014, 2015b, 2016a; Jacottet, 2012). Third, the liberalisation of

[38] The Energy market reforms in Germany resulted, ironically, in a wave of mergers that consolidated the industry into four mega-companies (RWE, EnBW, E.On, and Vattenfall), with operations on a wider scale in Europe. See Rüdiger Mautz, "The Expansion of Renewable Energies in Germany between Niche Dynamics and System. Integration—Opportunities and Restraints," Science, Technology and Innovation Studies 3, no. 2 (2007): 114. Mautz noted that just two of the four remaining suppliers were responsible for 70 percent of supply by 2007.

electricity markets and the EU internal market for energy has contributed to overcapacities of RE that is compounded by low carbon prices driving down wholesale energy prices (BMWi, 2014). Four, is whether the cost effectiveness drivers of the twin-pillar policies of the feed-in tariff (FiT) of the EEG and EU Emissions Trading Scheme (EU-ETS) have been successful. These two policies were designed with intent to cost-effectively promote investments in RE generation technologies, energy efficiency and reduce GHG emissions (Grubb et al., 2012). While the FiT has been successful in supporting the market penetration and rapid development of RE and relevant technologies, it has also been criticised as being highly cost-ineffective in achieving RE transition (Andor et al., 2016; GCEE, 2011; IEA, 2007). The trading schemes and electricity pricing therein have received the greatest criticism. Through exemptions, they have enabled large energy-intensive industries to circumvent the EEG surcharge as to preserve the international competitiveness. This has created huge disparity in electricity pricing between the industries, small companies and household, with the latter subsidising the former (Fischer et al., 2016; Morris and Jungjohann, 2016; Wirth and Schneider, 2015). This price disparity between household and non-household,[39] illustrated in Figures 5-1 and 5-2, highlights the cost of household electricity across the EU and reflects the social inequity.

The EU-ETS (cap and trade mechanism) was designed to facilitate EU Member States in making progress towards their Kyoto Protocol commitments while minimising the impact of environmental policies on European industries' competitiveness (Butzengeiger & Michaelowa, 2004; Directive 2003/87/EC). However, since the commencement of the EU-ETS in 2005, there have been many reviews and critiques on its effectiveness caused by an over-allocation of the EU emission allowance units (EUAs) in the first trading period of 2005–07, creating windfall profits and overcompensating incumbents and how the carbon linkage through the Kyoto mechanisms[40] has caused instability and distortion of the EUAs' market price (Laing et al., 2013, 2014; Grubb et al., 2012; Martin et al., 2012; Spencer & Guerin, 2012; Lise et al., 2010; Helm, 2009; Jacobsson et al., 2009; Oberthür & Roche Kelly, 2008; Weidner & Mez, 2008; Weishaar, 2007). Therefore, at an EU level and within Germany there remains an ongoing debate among legislators about how best to implement various policies to strengthen the EU- ETS while concurrently providing the right price signals to the market. That energy policy is being perused positively at these two levels

[39] Household Annual consumption: 2 500 kWh < consumption < 5 000 kWh and non-household Annual consumption: 500 MWh < consumption < 2 000 MWh.
[40] The Clean Development Mechanism (CDM) and Joint Implementation (JI) allow the parties to the Kyoto Protocol to meet part of their emission target by financing emission reduction projects in countries outside the EU, including developing countries in the case of CDMs.

reinforces the leadership positions of both Europe and Germany, notwithstanding the challenges of implementation.

Domestically, Germany's energy transition remains dominated by policy tensions between electricity generation from renewable and fossil (hard-coal and lignite) sources. This reflects the socio-political hold of this indigenous energy source on government decision-making, and especially with government coalitions involving the SPD. The lack of reform in this sector is largely positioned as one of protecting a traditional employment sector that has been prosecuted successfully by the strong coal union and in turn supported by the more socially orientated political parties (Jungjohann & Morris, 2014; Otto et al., 2006). From a GHG-emissions perspective, hard-coal and lignite are envisaged to continue as a major national-emission contributor, as there remains no clear policy direction to phase out all fossil fuels from the energy mix if the 2050 targets are to be reached.

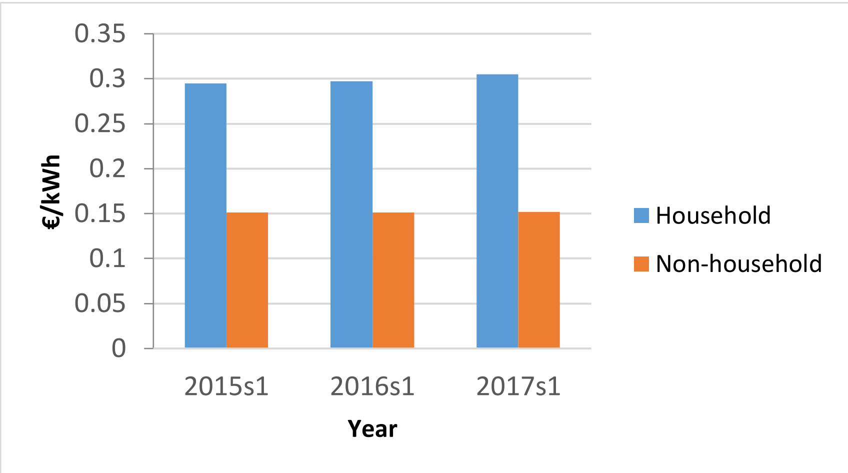

Figure 5-1 Comparison of household and non-household electricity prices in Germany (data based on first half of year)
Source: http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics

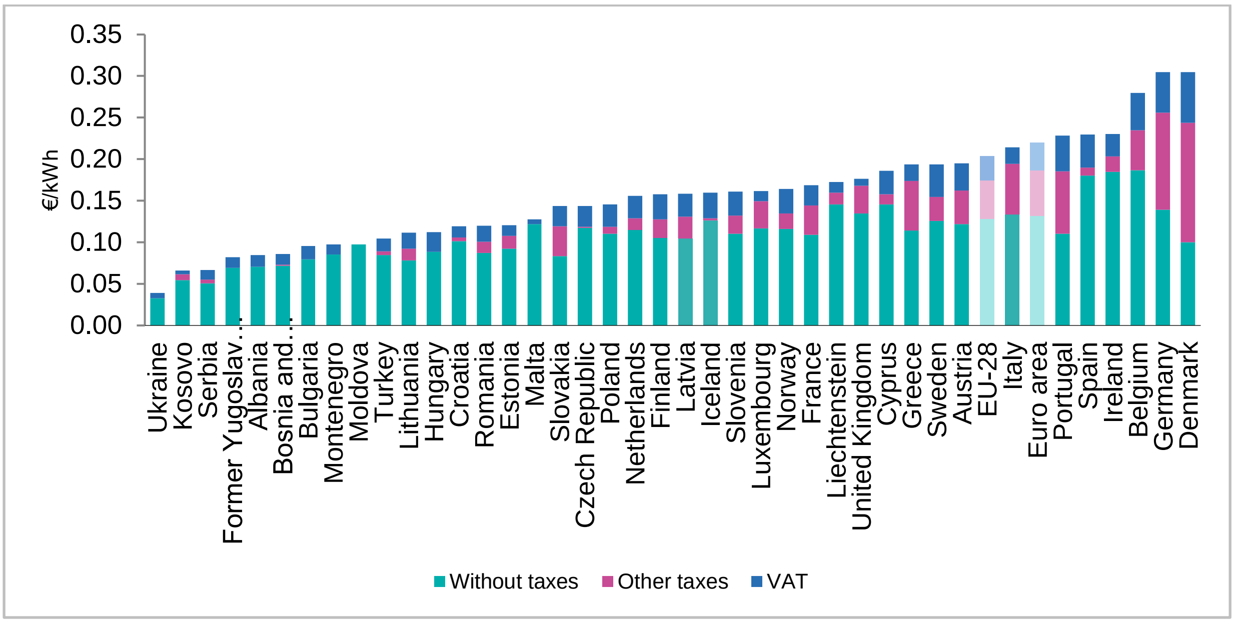

Figure 5-2 Comparison of EU household electricity prices (first half 2017)
Source: http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics

5.3 Methodology

The primary objective of this study is to examine, evaluate and rank the influence of the varying coalition governments led by three German chancellors on climate/energy actions and policy measures in energy transition in Germany. The Chancellors presiding over their coalitions include Helmut Kohl (1982-1998), Gerhard Schröder (1998-2005) and the incumbent Chancellor Angela Merkel (2005-present). A grounded theory approach (Glaser & Strauss, 1967) was adopted to investigate climate change mitigation and energy politics and policies from 1990 to 2017 in Germany. The choice of 1990 as a starting point was based on the historical political processes when the West Germany (Bundesrepublik Deutschland-BRD) and East Germany (Deutsche Demokratische Republik-DDR) reunited to form a single nation of Germany. The grounded theory approach is relevant to understanding complex interweaving relationships of social, political, economic and environmental processes (Charmaz, 2006, 2011; Halkier et al., 2011; Dey, 1999). The opportunities for RE transformation and their associated causal barriers were identified by applying a case-oriented research strategy combined with multi-criteria analysis (MCA) method (Konidari & Mavrakis, 2007; Rihoux & Grimm, 2006; Ragin, 1987). Analysis was performed chronologically on the climate/energy actions of each chancellor and respective coalition government. A constructed MCA energy-transition model from our previous study on Australia (Cheung & Davies, 2017) was adopted to systematically analyse actions and rank according to the same set of rules. The MCA model is also tested for its robustness, validity and adaptability in a different political context to explore its wider utility as an evaluation tool.

A mixed-methods approach can integrate various theoretical perspectives (such as Grounded Theory, Transition Theory and multi-criteria analysis) through qualitative data. This approach can enhance the understanding of processes in context and ability to identify emerging themes through influential events or conditions that have shaped the variables as revealed by the quantitative data. Hence, an integration of qualitative and quantitative data maximises the strengths and minimises the weaknesses of each type of data and enhances the scope and breadth of research analysis and results (Guest, 2013; Creswell et al., 2011; Creswell, 2003; Tashakkori & Teddlie, 2003; Greene et al., 1989; Smith, 1986).

5.3.1 Data collection and analysis

Quantitative data was sourced from the IEA/IRENA (2018) website for RE policies/measures of its member countries and German government's data sets including that of the Federal Ministry of Economics and Technology – BMWi and the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety – BMU. Qualitative data was drawn from a wide range of climate/energy politics/policy research literature. These data were matched chronologically with each chancellor's tenure and the UNFCCC COPs from COP1 in Berlin to COP23 in Bonn to reflect the political actions at the national and international level. This data was consolidated into the 'master table' presented in Appendix A. This master table forms the backbone data set was used to determine the extent and impact of the leaders' and their governments' actions on climate/energy policy frameworks. In turn this data was systematically analysed and ranked to reveal strengths and weakness in accordance with the ruleset of the MCA model (Table 4-1). The performance score was subsequently compared to identify the impact of climate/energy policies including achievement against national GHG emission reduction targets and RE transition achievements as the confirming indicators.

5.3.1.1 Multi-criteria analysis model

Our MCA model, based on previous work, systematically examines through evidence-based actions and the performance of each leader and his/her coalition government in setting national climate mitigation targets, formulating strategic plans and relevant climate/energy policy instruments and what is done in relation to reporting and monitoring. The MCA model (Table 4-1) is based on an Analytic Hierarchy Process (AHP) method (Saaty, 1977) designed as a three-stage approach; build the hierarchy, weight the criteria (indicators), then calculate the final value for the defined assessment goal. Within this approach a three-tier hierarchical criteria structure was constructed which encompasses three main Tier-1 criteria: ‘Political acceptability’; ‘Policy measures/instruments’; and ‘Implementation/tracking/ reporting’. The selection of these root criteria is based on a set of generic energy policies/instruments recommended by Intergovernmental Panel on Climate Change (IPCC) and IEA/IRENA for policy-makers gloabally on climate-mitigation and energy-transformation as effective tools to steering structural changes and governance of an ongoing transition. (IPCC, 2001; 2007; 2012; 2014). Each root criterion comprises of second and third tier of sub-criteria. The selection and application of these sub-criteria are also in line with IPCC guidelines to provide additional granular details to the efficacy of political, policy and implementation criteria (Table 4-1).

The strengths of the AHP method of the MCA are that complex evaluation process can be disaggregated into a hierarchical structure in order to reach a defined goal at the top of the hierarchy and the hierarchical structure is scalable to fit various problem perspectives (Beria et al., 2011). It is commonly adopted in analysing performance-type problems, resource management, public policy, political strategy and planning (Velasquez and Hester, 2013). Hence, the MCA method is increasingly adopted by governments and researchers in the field of climate/energy policy due to its strength in: assessing the dynamics of instruments and approaches to optimize their effectiveness (Matthes et al., 2005); verifying results and impacts of instruments and policies on emission reductions and energy transition (Neij and Astrand, 2006); selecting the most appropriate instruments and energy policies at a national level (IPCC, 2001; Mourmouris and Potolias, 2013); and evaluating instruments and policies that have complex socio-economic and environmental impacts which are hard to measure in monetary terms (Konidari and Mavrakis, 2007; Morris and Belton, 2011; Scrieciu et al., 2011). Our MCA model is framed at the macro social-technical and economic level of a nation and based on the premise that if the national mitigation targets are to succeed, the politics, policies and implementation dimensions have to go hand-in-hand. If any of these elements are missing, the long-term national goals of effective RE-transformation and GHG-reduction (as indicators towards the set goals) cannot be sustained.

5.3.1.2 Sub-criteria ranking scales and basic rules

The IPCC recommends the need for underlying political acceptability to address climate change through meaningful mitigation measures including having impactful carbon-reduction targets as an importance principle before the introduction of relevant policies/measures (IPCC, 2001; 2007; 2012; 2014). Based on this principle, the tier-1 criteria were assigned weighting factors including: 50% for ‘political acceptability’; 40% for ‘policy measures/instruments’; and 10% for ‘implementation/tracking/reporting’. This is consistent with the notion that climate/energy policies and measures have to be politically relevant in order to set target ‘mandates’ coupled with proper tracking and reporting mechanism to evaluate performance. However, equal weight coefficients are adopted for both the tier-2 and tier-3 sub-criteria (Table 4-1). This infers an equal contribution of each sub-criterion towards its higher-tier criterion. Thus, the value of each tier-1 criterion is an average of the total scores of its tier-2 sub-criteria and the same rule applies to each tier-2 criterion from tier-3 sub-criteria. The final total score of the tier-1 criteria is then calculated by applying the relevant weighting coefficients (elaborated above) in this formula (Ax0.5+Bx0.4+Cx0.1). The alphabet A, B and C are assigned to tier-1 criteria, whereas each tier-2 and tier-3 criterion would add its sequential sub-criteria number to the code inherited from its corresponding higher-tier criterion (see Table 4-1). A normal arithmetic rounding practice was adopted throughout calculation and a gradient scale is used in the interpretation of the value. As an example, a value below 0.5 would be interpreted as an insufficient response while a score above 0.5 would be regarded as sufficient.

As the MCA method is inherently subjective, both in terms of the criteria selection and their values chosen, this can lead to inconsistencies between judgement and ranking criteria. To minimize the inconsistencies in ranking processes, we design a parametric question for each tier-3 sub-criterion that requires an answer with a ‘Yes’ for definite positive outcome to obtain a score of 1, or a ‘No’ for definite negative outcome to obtain a score of 0. When there is a situation of either ‘Yes’ / ‘No’ from an uncertain/partial outcome that has a positive implied outcome, a score of 0.5 was assigned. This scoring mechanism is regarded as a semi-crisp ruleset aimed to minimize subjective bias of the researcher while still providing flexibility for occasional non-conclusive real-life situation during the assessment processes. The assessment score for each tier-3 sub-criterion was evidence-based drawing from official government sources, IEA/IRENA (2018) policies master table (Appendix A) and relevant literature in the field.

5.3.2 Evaluation processes and model enhancement

The evaluation processes of each ex-/Chancellor’s and his or her government were guided by the MCA model (Table 4-1) on their climate change political acceptability, mitigation actions and policies performance. The detailed evaluation processes and the awarded score rationale of each leader and relevant government with references to the sources are presented in Table B 5-1 to Table B 5-3 of Appendix B. The information sources include Appendix A, which contains summarised German Chancellors’ and relevant government climate policies chronology which is sourced from the IEA/IRENA member-countries' renewable energy policy database, the official documents from BMWi on energy policies and progress monitoring reports, the IEA policy review reports for Germany and other climate/energy policy, critical/evaluation study journal articles. The leaders' case-study tables were then consolidated and summarised into the case-table (Table 5-1) for comprehensive comparative analysis.

5.3.2.1 Model enhancement – time in office and policy impact

Many historical socio-technical transitions emerge autonomously, and full transition usually takes 40 to 120 years (Smil, 2016; Sovacool, 2016; Fouquet and Pearson, 2012). The urgency of global climate change and energy transition does not allow for a multiple generation time-step therefore requires enabling political actions, public policy measures and authoritative directives to steer structural changes (Hildingsson, 2014; Groba & Breitschopf, 2013; Van den Bergh & Bruinsma, 2008). Well-designed policy and regulations coupled with consistent political support are key factors for the successful deployment of RE technologies (Popp et al., 2011; Lipp, 2007; Kerr & Newell, 2003; Snyder et al., 2003). Disruptive forces, such as unexpected changes in policies and rapid turnover of leaders of government or the influence of coalition partners, can have negative impacts on investment decisions (White et al., 2013) and in turn stifle transformation and the efficacy of policy implementation. To this end, a time factor reflecting the stability of policy measures is an important consideration in the evaluation of a government's capacity to achieve targeted goals. To improve the evaluation result of the MCA model, a time-weighted coefficient was applied in this study to Criteria B – Policy measures/instruments. This was designed to recognise and weight policy effectiveness as a function of the tenure of a leader/government. Our model calculates the time-weighting coefficient as 'time coefficient = years in office / total years being assessed.' This time-in-office coefficient for the 'Policy measures/instruments' criterion reflects the reality of energy policies required time to achieve the set goals.

5.4 Results

5.4.1 Chancellor and their government's energy and climate action results

This section provides a summary of the analysis of each Chancellor and his or her government's energy and climate policies and actions. A description of the key initiatives and actions is provided in Section 5.4.2 with the granular level detail of the elements investigated, a comment on their impact and score is provided in Appendix B (Table B 5-1 to Table B 5-3). Table 5-1 provides a higher-level summary of the outputs of the MCA. As the tenure of a chancellor has bearing on the impact of a climate/energy policy, the model applies a time-weighting coefficient to the 'Policy measures / instruments' criterion as shown in Table 5-1 (explanation on this is provided in Section 5.3.2.1). For the government led by Chancellor Helmut Kohl we have applied the time-weighted coefficient over the 8 years commencing 1990 that begins from the reunification of Germany and the passing of the Electricity Feed-In Act 1990.

Table 5-1 Multi-criteria analysis of the performance evaluation scores of the three Chancellors and their governments

Criteria / sub-criteria	**Helmut Kohl** (CDU) (16 years) 1/10/1982–27/10/1998 (effective 8 years)	**Gerhard Schröder** (SPD) (7 years) 27/10/1998–22/11/2005	**Angela Merkel** (CDU) (12 years +) 22/11/2005–current incumbent
Criterion A Political acceptability	**0.83**	**0.94**	**1**
Leadership support	1	1	1
International commitment	1	1	1
National targets and strategic planning	0.5	0.83	1
Criterion B Policy measures/instruments	**0.7**	**0.97**	**0.97**
Public funding for R&D and RE incentive	1	1	1
Private investment inducement	1	1	1
Market structural and regulatory reforms	0.33	1	1
Policies feasibility and effectiveness	0.67	0.83	0.83
Policies consistency and continuity	0.5	1	1
Time-weighting coefficient *(years in office / total years evaluated)*	*0.3*	*0.26*	*0.44*
Criterion B Policy measures/instruments *(effective score with time-coefficient)*	***0.21***	***0.25***	***0.43***
Criterion C Implementation tracking and reporting	**0.09**	**1**	**1**
Implementation institute capacity	0.17	1	1
Tracking and reporting mechanism and clarity	0	1	1
Total performance ranking scores *(with policy time coefficient)*	**0.51**	**0.67**	**0.77**

Table 5-2 German chancellors' climate policies and funding

Leaders (Political party) Office term	**Conference of Parties (COP)**	**Federal Climate Policies still in force**	**Funding Provision** (€Million)
Helmut Kohl (CDU) 1/10/1982 – 27/10/1998	COP 1 (1995) – COP 3 (1997)	2	10,751*
Gerhard Schröder (SPD) 27/10/1998 – 22/11/2005	COP 4 (1998) – COP 10 (2004)	13	6,681
Angela Merkel (CDU) 22/11/2005 – incumbent	COP 11 (2005) – COP 22 (2016)	30	23,950
Total Federal climate policy funding provision			***41,382***

**: A DM100 million funding in this period is equivalent to €51 million based on conversion ratio of €562.4 million to DM1.1 billion used in the "1999 – 2003 100,000 Roofs Solar Power Programme" in Appendix A. The total amount also includes €10,700 (in loan 1990-2005) through the Reconstruction Loan Corporation (KfW) for the ERP-Environment and Energy Saving Programme.*

5.4.2 Analysis of leaders' performance ranking results

5.4.2.1 Chancellor Helmut Kohl – first leader for the reunified Germany

Chancellor Helmut Kohl is best known as the chancellor who presided over the German reunification in 1990 and became the first chancellor of a unified Germany since 1945 and holds the record as the longest-serving chancellor (Childs, 2017). During his tenure two critical events shaped his coalition government's action on climate and energy which contributed to his strong political-acceptability and policy-measures scores. First, the Chernobyl nuclear accident in 1986 highlighted the risk of the nuclear power and with this a need to explore alternative energy sources (Morris & Jungjohann, 2016; Morris & Pehnt, 2016). Second, the 1992 Earth Summit in Rio de Janeiro was a catalyst for broader political support and consensus to address the emerging concerns on climate change. These factors ultimately translated into policy and €10.7 billion fund (Table 5-2) which included the first Climate Change Action Plan adopted in 1990, the first plan to support RE in 1991 and Germany being a signatory to the Kyoto Protocol in 1997 with commitment to reduce its GHG emissions by 21% below 1990 levels by 2012 (Eloy et al., 2016). Since 1990, this government instigated transformative energy policies and programs including: Electricity Feed-In Act 1991 (Stromeinspeisungsgesetz - StrEG); 250 MW Wind Program; ERP-Environment and Energy Saving Program; tariff to support photovoltaic installations (Kostendeckende Vergütung), initiative to support rooftop solar installations and legislation to support the sale of green power to the grid outside the established national electricity feed-in scheme (Table B 5-1 of Appendix B).

Politically, reunification offered a brief window of opportunity for the retiring Christian Democratic Union (CDU) politician, Matthias Engelsberger, to gain an unlikely coalition of parliamentary backbenchers including the SPD and the Greens, to pass the Electricity Feed-In Act (StrEG) 1991. This Act was unopposed by anti-renewable politicians and utilities which were preoccupied with taking over energy sector in East Germany. Ultimately, the StrEG laid the foundations for the Energiewende and subsequent restructuring of the East German power sector by shutting down six nuclear-power plants and modernizing many of the coal-fired plants (Hager & Stefes, 2016; Morris & Jungjohann, 2016). The StrEG granted priority feed-in for RE sources and guaranteed a minimum price that encouraged new investment in and the growth of wind, biomass and photovoltaic energy supplies. The legacy of the StrEG has served as a foundation for the Renewable Energy Sources Act (EEG) 2000, established under Chancellors Schröder's government (Eloy et al., 2016; Hager & Stefes, 2016; Morris & Jungjohann, 2016; Morris & Pehnt, 2016; Blazejczak et al., 2011).

5.4.2.2 Chancellor Gerhard Schröder – social and regulatory reformist coalition government

The coalition government of the Social Democrats (SPD) and the Greens was led by SPD's leader Chancellor Gerhard Schröder from 1998 to 2005. The Greens had significant influence on the development of the energy policy during this period and integrated various economic approaches with the government's environmental platform (Eloy et al., 2016; Hager & Stefes, 2016; Morris & Jungjohann, 2016; Morris & Pehnt, 2016). The coalition government's success in bringing on a portfolio of RE-policy reforms was backed by €6.6 billion funding (Table 5-2) and what is revealed in the MCA as very strong political-acceptability and policy-measures scores. Policies included the landmark Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz – EEG 2000) that aimed to double the share of RE, the implementation of an eco-tax designed to reduce the emissions through energy efficiency, implementation of the 100,000 Roofs Programme to provide financial support for PV systems over 1kW and enactment of the Energy Industry Act 2005 designed to enhance competition, security of supply and sustainable energy production (Eloy et al., 2016; BMU, 2007, 2010; Büsgen & Dürrschmidt, 2009; Butler & Neuhoff, 2008). Collectively, these energy initiatives led to the achievement and exceedance of the national RE targets at the time and in-turn led an upward revision, reinforcing the government's commitment to energy reform (Bundesgesetzblatt, 2004, 2008). For example, the solar target for 2050 was achieved in 2012 and the 2010 wind power target was reached in 2005 (Morris & Jungjohann, 2016). Notable in this period was the exemption given to energy-intensive industries that were granted economic protection being key export industries facing international competition (Morris & Pehnt, 2016).

This industry exemption policy remains under debate. As a policy it unfairly burdens households and other industries and importantly impacts on the longer-term success of the socio-technological energy transition (Matthes, 2017b; Graichen, 2014).

The energy reforms during this period also had to contend with the introduction of the EU Emissions Trading Scheme (EU-ETS) that commenced in 2005. The objective of the EU-ETS was to reduce the GHG emissions across the EU and this also involved the liberalization of the energy market which aimed to remove market barriers for new energy players and improve competition. The energy market was not really liberalized until 2005 when the Network Agency (Bundesnetzagentur – BnetzA) was finally established to monitor competition, ensure security of energy supply and the infrastructure planning (Morris & Jungjohann, 2016; Matthes et al., 2015). This reform, albeit at the end of the term of the Schröder led government, demonstrated the strong commitment to liberalize energy market (IEA, 2007a). The coalition's achievement should not pass without a mention of the nuclear phase-out consensual agreement enacted into law in 2002 (Eloy et al., 2016; Morris and Jungjohann, 2016; Morris & Pehnt, 2016). This agreement was a major political accomplishment supported by 90% of German voters and the act constrained any future investment in nuclear from the utilities (Morris and Jungjohann, 2016).

5.4.2.3 Climate Chancellor Angela Merkel

Chancellor Angela Merkel was elected in 2005 as the first female Chancellor leading a grand-coalition government of CDU/CSU[41]-SPD as a leader of the CDU party. She has held the position of Chancellor across four different coalition governments (2005, 2009, 2013, 2017) and has successfully negotiated energy reforms accommodating a variety of ideological positions under the various coalitions including the left and centre-left (Greens and SPD) and liberal (pro-business Free Democratic Party – FDP) parties. Internationally, Chancellor Merkel has championed action on climate change within the EU and more broadly, this focus has earnt her title of the Climate Chancellor – Klimakanzlerin (Thalman and Wettengel, 2017). This international engagement, commitment and the domestic climate/energy actions supported by €23.9 billion funding provision (Table 5-2) has contributed to very strong ranking scores from all criteria for the governments she has led.

Her first grand-coalition government (2005-2009) is recognized as having maintained the momentum of the Energiewende, established by the former Schröder government, and raised

[41] CSU – Christian Social Union, sister party of the Christian Democratic Union in Bavaria.

international visibility of the German approach on climate/energy issues (Hager & Stefes, 2016; Morris & Jungjohann, 2016; Morris & Pehnt, 2016). During this period, Germany hosted the World Economic Summit of the G8 industrialized countries where she persuaded these leaders to accept the science of the IPCC and agree on the need for a binding GHG reduction targets. Her second term coalition government (2009-2013) was a partnership between the CDU/CSU and the pro-business FDP. Under pressure from the large energy utilities and a pro-nuclear faction within her own party, she briefly reneged on the nuclear phaseout in 2010 under the Energy Concept (BMWi, 2012; Jacobs, 2012) until the government returned to the nuclear phase-out plan following the Fukushima nuclear accident in 2011 (Thalman & Wettengel, 2017; Morris & Jungjohann, 2016). This dramatic reversal was unanimously supported in Parliament by the CDU/CSU, SPD and the Greens parties and had the support of 80% of the German population (Morris & Jungjohann, 2016; Morris & Pehnt, 2016). This about-face was accompanied by a full legislative Energy Package (Energiepaket 2011)[42] passed in the parliament in July 2011 and is often regarded as marking the beginning of Germany's energy transition – "Energiewende" (Eloy et al., 2016).

Chancellor Merkel's third term was a grand coalition of CDU/CSU – SPD. Under this coalition an agreement was reached on the key energy policies and objectives of the Energiewende including to: mitigate climate change by reducing GHG emissions; achieve greater energy security; reduce energy imports; boost the national economy; and maintain nuclear phaseout plan (Morris & Jungjohann, 2016). At the global stage, Chancellor Merkel made climate and energy policy a major focus of Germany's G7 presidency and pushed G7 leaders to commit to the concept of "decarbonizing" their economies by the end of the century. Germany simultaneously pledged to double its contribution to international climate financing by 2020 and engaged with the Paris Climate Agreement to push for ambitious, comprehensive, fair and binding agreements (Thalman & Wettengel, 2017). However, domestically this government, like its predecessors, retained its blind spot on reforming coal and lignite power sources, despite at a policy level striving to retain its focus on increasing RE generation (Hager & Stefes, 2016). In effect, these protected industries form a glass ceiling from which Germany will not be able to achieve its far more ambitious emission reduction goals of 55% by 2030 and by up to 95% by mid-century (Thalman & Wettengel, 2017).

Despite heavy losses in the September 2017 elections, Merkel has retained her role as Chancellor with a new collation involving the CDU/CSU and SPD parties after failing to form a coalition with

[42] Energy Package 2011 focused on growing RE, improving energy efficiency, upgrading electricity grid infrastructure and increasing investment in R&D notably in storage technologies.

the Greens and FDP (Chase, 2018). It is too early to assess the policy direction and actions of this new government although notably both parties in the coalition have no firm date or commitment to phase out coal-fired power generation (Wehrmann, 2017). As it stands, the path-dependency and socio-political hold of coal-based electricity generation remains and will almost certainly hinder the achievement of longer-term emission-reduction targets. This remains a socio-political hurdle Germany has yet to address.

5.5 Discussion

Energy transition is one of the most important political, economic, and social undertakings of our time that requires complex societal consensus and affects critical fossil-fuel entrenched and path-dependent institutions. Two key factors required to transform energy systems in industrialized countries are the goal setting and timeframes (*political acceptability*) and enabling viable pathways (*energy policies/instruments*) to achieve goals and interim targets (e.g. Polzin et al., 2015; Aguirre & Ibikunle, 2014; Cárdenas-Rodríguez et al., 2013; Marques & Fuinhas, 2012). Adopting these elements in our *MCA energy transition analysis model*, we first applied the model in analysing four political leaders and their governments in Australia to gain insight of the causes underlying Australia's slow energy transition (Cheung & Davies, 2017). In this study, we applied a modified model incorporating a time-factor coefficient to the 'Criterion-B Policy measures/instruments' across varying coalition governments presided over by three chancellors in Germany. This time-factor approach was subsequently applied to the previous Australian study to normalise the results for the purpose of comparison.

This section provides insights into the factors contributing to Germany's energy transition achievement through comparing the policy time-weighted results of Australia and Germany. The aim of this analysis is to identify key causative factors that can expedite or impede a nation's energy transition agenda. The strengths and weaknesses of the MCA model are also discussed with recommendations for its ongoing and iterative improvement.

5.5.1 Key factors for German energy-transition achievement

A distinguishing feature of Germany's energy transition has been its strong and positive policy consistency (Figure 5-3). This is clearly apparent when viewed over the 27-year period within which there has been multiple coalition governments. The data from the MCA reveals consistently high marks that underscores the value of political and policy stability shaped by the need to manage nuclear power and climate change risks through enabling the development of RE technologies and markets. This insight adds to the weight of evidence of the importance of political stability and regulatory continuity to provided long-term investment certainty and drive transformational change (Haas et al., 2011; Chalvatzis and Hooper, 2009). Importantly, its distinguishes Germany as a reforming outliner when compared to other nations within Europe (Jurca, 2014) and internationally.

Through the *Grounded Theory* approach, the MCA method was able to observe and capture the impact of the ongoing interactions of pre-existing and new socio-political ideas and practices (Strauss and Corbin, 1990; 1998). This section outlines three main reasons captured by the MCA that can explain Germany's RE success and in doing so provide insights and lessons for other nations attempting to decarbonise their energy sector.

Political stability and coordinated policymaking style

Germany is a 'coordinated market economy' which has a collaborative tradition for stakeholder interactions (Hall and Soskice, 2001). Citizens are empowered to participate in the decision-making process which in turn informs government decisions. Action on energy transformation post reunification is evidence of the impact of this deep democratic tradition. Critically, this democratic tradition has managed to circumvent the hold of incumbent energy utilities on policy inertia that existed prior to the SPD/Greens coalition government (1998-2005) (Geels et al., 2016). This socio-political disruption, rather than a path dependency of traditional technology, is recognised as critical to enable energy-market reform, policy establishment and long-term stability. In turn, this has provided market certainty for the private investment in RE technologies development and deployment. More importantly, this collaborative and consultative political tradition has facilitated political consensus within and across successive coalition governments to sustain energy-policy consistency reinforced by the iterative and upward review of RE targets. Arguably, the careful and deliberate use of the term "at least" in setting targets has meant these are uncapped or in other words serve as the minimum achievement levels which has circumvented attempts by opponents of the EEG to call for adjustment to the law and enabling policies as soon as the targets are reached (Morris & Jungjohann, 2016).

Grassroots support for alternatives to the nuclear power

The grassroots movements opposing nuclear power and a desire for alternative power from RE sources remain an ongoing and enabling factor supporting energy reform. Within Germany anti-nuclear grassroots movements led to the founding of the Greens Party in 1980 that was subsequently pivotal in creating and sustaining the Energiewende discourse (Hager and Stefes, 2016). Public interest on energy transition has been sustained and emboldened through exogenous-environmental catastrophes such as the Chernobyl and Fukushima nuclear disasters, serving as reminders of the social and environmental risks of nuclear power. The former incident, on Germany's doorstep, occurred at a time that galvanised support for the initial nuclear phase-out. The latter reignited public opinion against nuclear power and overturned the ruling coalition's political manoeuvre to extend the planned nuclear phase-out.

Critical junctures and the championship of renewable energy policies

Combined, the timing and impact of the socio-political alignment of endogenous and exogenous events provided the necessary catalyst and ongoing support for transformative change. Politically, critical junctures of the 1990 German reunification and the Greens participation in the Red/Green coalition government in 1998 offered windows of opportunities for a few astute German parliamentarians[43] to passing the first Electricity Feed-in Law (StrEG) in 1990 and its upward revision under the EEG in 2000 (Bechberger & Reiche, 2004). These laws shaped the early Energiewende in two ways. First, they led to the incremental decentralization of energy generation at the expense of the large incumbent utilities. Notable in the Germany experience, the existing power utilities, elected not to participate in the energy reforms and so missed the early RE investment cycle. They are now playing catch-up having to restructure their business models to ensure their ongoing value and relevance. Second, the Energiewende considerably improved the RE-investment climate and spread the profits due to an overwhelming grassroots support from small investors including citizens, farmers and communities (Morris, 2013). By the time the SPD/Greens coalition was replaced by the CDU/CSU/SPD coalition in 2005, the momentum of the Energiewende was well established. Economically, the RE sector had become a major growth industry and job creation engine that more than compensated the employment loss within traditional energy sectors. In 2013, the RE sector employed close to 380,000 workers and combined RE companies had a turnover of almost €23 billion (Hager and Stefes, 2016). As the Energiewende progressed and concurrently contributed to and sustained economic growth, the numbers of RE supporters continued to grow.

[43] An unlikely coalition of parliamentary backbenchers across party lines (the ruling CDU/CSU, the opposition Social Democrat and the Greens) managed to pass the StrEG (derived from the FIT system of Denmark) unopposed. Since the anti-renewable camp led by utilities was too preoccupied with the taking over of the East German energy sector to reject the StrEG as they did with the first proposals in late 1980s. In the late 1980s, the first proposals for FITs circulated in the federal parliament was sharply opposed by the Ministry for the Economy of the Kohl government (the ruling CDU/CSU) and the Free Democrats (FDP).

Other critical junctures, such as the oil crises, nuclear accidents (Chernobyl and Fukushima) and increasing environmental concerns on climate change, are exogenous factors that have played a significant role in bolstering the case for RE and weakened the arguments for established fossil and nuclear power (Hager & Stefes, 2016). From a political perspective, at each stage from the first environmental movements in the 1970s, the idea and implementation of the *Energiewende*, to the current situation, the roles of different governments in support of the energy transition discourse have each played an equally important role (Eloy et al., 2016). Successive chancellors/governments have framed the transition to RE as a way of improving national energy security by lessening import dependency and nuclear risks, concurrently carrying benefits of combating climate change, ensuring economic growth and industrial competitiveness (Morris & Jungjohann, 2016; Morris & Pehnt, 2016; Agora Energiewende, 2015).

5.5.2 Comparative analysis of German and Australian results

While this paper is centred on the energy transition of Germany, there is utility in comparing its performance with another country to offer insight on how leaders' actions and climate/energy policy frameworks impact on national GHG emissions reduction and socio-technical transition performance. A comparative study can also identify the strength and weakness of the MCA model for further enhancement as an innovative analysis tool. To this end, we have compared the results from the MCA of Germany (1990-2017) to Australia (1996 to 2015) (Cheung and Davies, 2017). The difference in time periods between reflecting the period from which energy transition first became an issue of national importance as evidenced in new policy and program funding.

The climate and energy policy frameworks and actions of both countries' were systematically analysed and scored against the MCA model and their total policy ranking scores are compared in Figure 5-3 and 5-4.

From cross-national perspective, the scores for Criterion-B '*Policy measures/instruments*' as shown in Figure 5-3, both Chancellor Schröder's and Merkel's scores are identical to that of PM Gillard in Australia. The scores are in spite of the differences in the term of office of these leaders and consequent impact of policy. For Germany, the discursive results (section 5.4.2.2 and 5.4.2.3) presents a notably different narrative on impact of the policies of these leaders and highlight the importance of the scaffolding effect of the policies of the previous government that impact directly on momentum, direction and speed of energy transitions. This policy continuity and scaffolding between governments are evident in the German leaders' MCA ranking scores and reflect the ongoing and iterative policy and legal reforms as discussed in section 5.5.1. This comparison also reflects that Criterion-B is less sensitive to intra-term government and intra-term leader policy change as noted by the decisions of Chancellor Merkel's second and third term coalition governments wavering it in nuclear power phase-out intention and the amendments to the EEG 2014 to favour the big utilities to re-centralize the RE generation (Geels et al., 2016). Variable policy reforms within the term of a leader and government, therefore, represent an 'averaging' and may not necessarily reveal the strength and impact of policy on energy transition. This reinforces the value of a time-factor to assess policy beyond an output (e.g. a new law or policy statement) to an outcome, reflecting what has changed over the long-term.

Figure 5-4 reveals the impact of a time-factor coefficient to Criterion-B. Germany had three chancellors between 1983 and 2017 presiding over 9 coalition governments. Within this 34-year period, political ideologies moved within the centre-right to centre-left positions, yet energy and climate policy remained broadly consistent. Australia, by contrast, had five in Prime Ministers between 1996 and 2017 and while these governments moved within a similar political spectrum from centre-left to centre-right, energy and climate policy was a divisive area and point of difference between the political parties. This resulted in policy uncertainty, inconsistency and change and these factors underscore the lack of energy transition in Australia.

Figure 5-5 illustrates the cumulative effect of energy policy and transition as a percent of generated RE between Germany and Australia. This data confirms the results of the MCA that clearly differentiate the two countries. Notable in this analysis is the low MCA ranking of the centre-right leaning Liberal/National Party coalition governments led by Prime Ministers Howard and Abbott respectively (Figure 5-4) and the corresponding decline in RE generation. The analysis between RE generation (Figure 5-5) and the MCA rankings (Figure 5-3 & 5-4) also reveal that while the governments of Rudd and Gillard of the Australian Labor Party (centre-left) governments were consistent with the rankings of German centre-left and centre-right coalition governments, their RE policy impact was not as effective. Again, this reinforces the positive value and long-term consistent focus needed for energy transition, as embedded in the Energiewende, to provide the enabling economic and technological support for both phasing out older coal-based technologies and phasing in RE infrastructure.

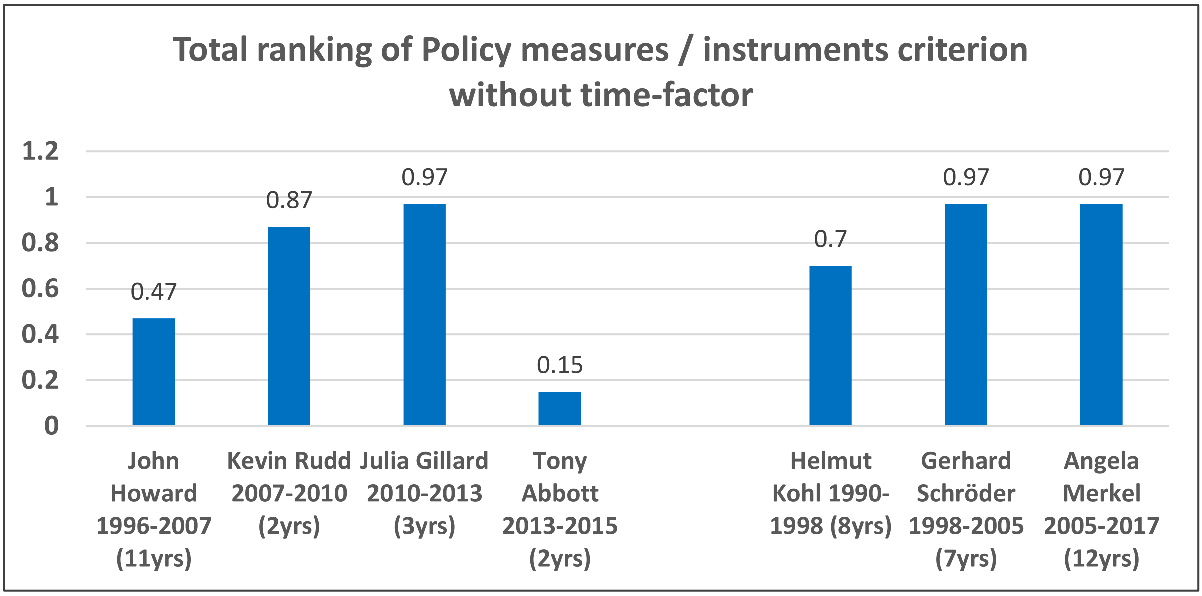

Figure 5-3 Australia Prime Ministers' and German Chancellors' energy and climate action ranking comparison without time-factor

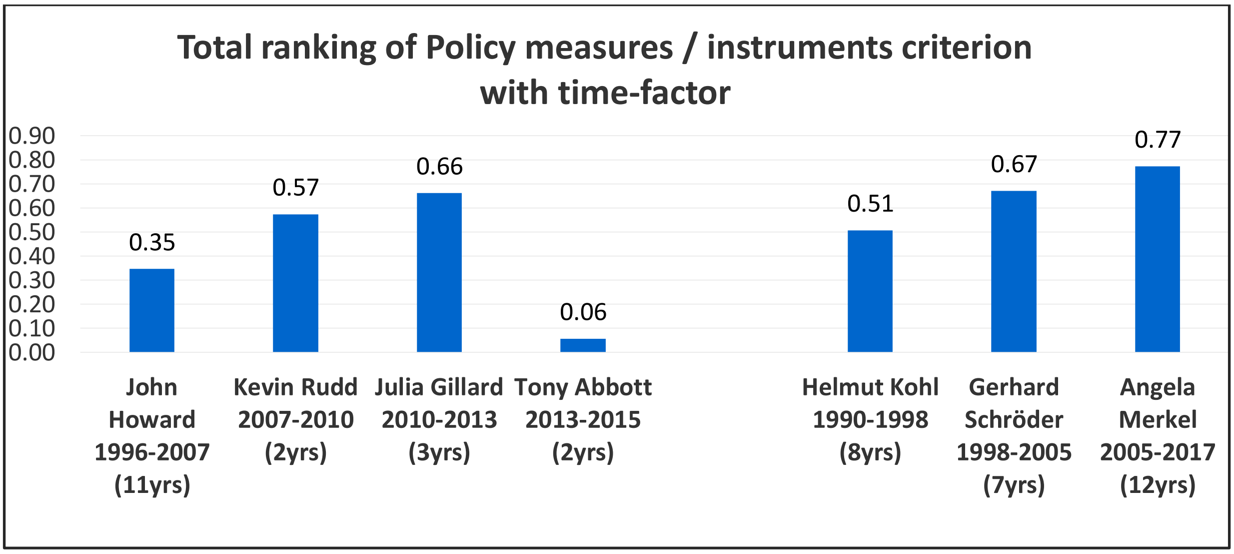

Figure 5-4 Australia Prime Ministers' and German Chancellors' energy and climate action ranking comparison with time-factor

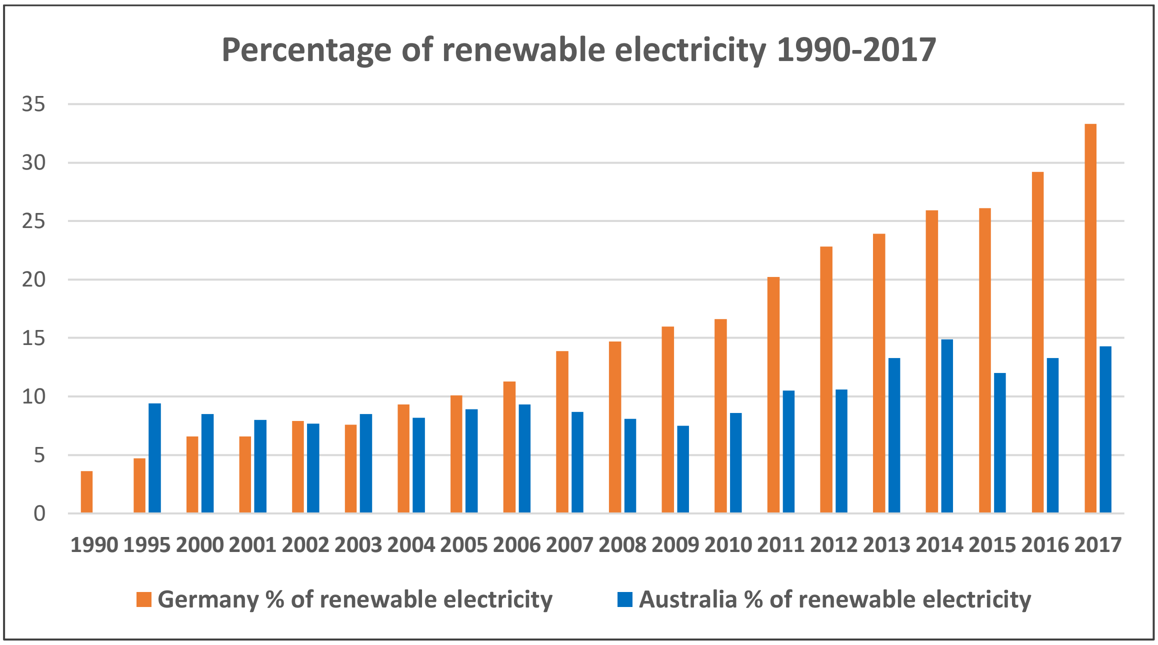

Figure 5-5 Comparing the share of renewable electricity including Hydro[44] in Australia and Germany

Source of data: https://www.energy.gov.au/sites/g/files/net3411/f/aes-table-o-2016-17_2017.pdf and https://ag-energiebilanzen.de/index.php?article_id=29&fileName=20171221_brd_stromerzeugung1990-2017.pdf

5.5.3 Strengths, weaknesses and enhancement of MCA model

5.5.3.1 Strengths of the MCA model

From a research-strategy perspective, the MCA methods used in the study have highlighted the contribution of policy analysis techniques and how they can reveal the impact of transition-specific politics, policies and governance frameworks. The MCA model was structured with an assumption of energy-policy developments are not simply technocratic processes devoid of politics. Rather, energy transition is an outcome of politically contested debates through contestation and sometimes harmonisation on perceptions and ideologies of energy and climate change. How these are reconciled through socio-political and technological responses including governance structures are critical to understand, measure, report and drive progress. Hence, the model was framed at an energy-system transition perspective focusing on the political direction and acceptability of energy policies and associated governance systems at a national level. Notably, the period of analysis and the model development was undertaken at a time when RE had not reached generation cost parity with coal-fired power, therefore this placed any transition towards renewables as reliant on government support, rather than simple market forces, to be economically effective.

[44] The notable fluctuations of the Australian RE percentage were a result of long draught impacting the Hydro power generation.

The semi-crisp three-point ranking-score system (see section 5.3.1.2) provided an effective method to score and compare the leadership actions as did the total scores in each of the criteria. This ruleset was designed to provide simplicity and repeatability to an otherwise large and complex review during the evaluation and analysis processes, as well as served to more easily compare government through a time-series longitudinal case study. By adding a time-series scoring it has also been able to quantify the impacts of climate/energy policy stability and certainty reflecting political agendas and ideologies. As discussed in section 5.5.2, instability and uncertainty were evidenced in Australia by the ratings comparing various PMs/governments, whereas, stability and certainty could be tracked over time through the time-series analysis of the chancellors/coalition governments in Germany.

5.5.3.2 Weaknesses of the MCA model

Due to the macro system-view nature and the semi-crisp ranking ruleset of the MCA model, certain weaknesses were also observed from the study. The model does not rank the effectiveness of the climate/energy policies, especially when subject to short time horizons due to policy backflips. It does not rank the significant impact of ground-breaking policies and consequent momentum, such as the StrEG 1990 and EEG 2000, and how these contribute to the energy transitions that are then attributed to successive leaders/governments. The model is not overly sensitive to assessing the impacts of long-serving leaders who within their tenure alter the transition speed and or policy course responding to the pragmatics of coalition-governmental negotiations and political compromises. Finally, the scores for Criterion-C may not be necessarily reflective of the foundational energy policies of leaders at the early stage of energy transition. The rankings of earlier leaders, Prime Minister Howard in Australian and Chancellor Kohl in Germany were notably lower than that of successive leaders that have been otherwise seen as energy champions such as Prime Ministers Rudd and Gillard, and Chancellors Schröder and Merkel. This reflects that energy-transition is a protracted process that requires an iterative development of policies, actions and governance frameworks that disadvantage the ranking of leaders at the earlier phase.

5.5.3.3 Enhancement of the MCA model and its implications

The weaknesses of the MCA, summarised above, reflect the high-level view of Criterion-B and Criterion-C that can be further enhanced. Firstly, a time-in-office coefficient can be incorporated with Criterion-B to reflect the lengthy time-cycle required for policy-making processes, implementation and consistency. Secondly, Criterion-C could be replaced with a criterion including a group of sub-criteria to assess in more detail the impact, effectiveness and significance of policies subject to the quantitative RE target achieved. This, however, must reflect whether a target is ‘soft’ or framed as a maximum, as often perceived in Australia, or a minimum level of performance as reflected by Germany laws. Lastly, a new Criterion-C could include a time-based evaluation to capture the effect of leaders’ short/long tenure as milestone marking any changes of policies and governance structures as an indicator of policies stability and consistency. These recommended enhancements to the MCA model, while not exhaustive, could improve its ability to better quantify policy effectiveness and impact within and between governments. These enhancements of the MCA model can easily be adopted and tested through application to other nations for further improvement of its robustness as an analysis tool.

5.6 Conclusion

This study aimed to uncover factors underlying the German energy-transition between 1990 and 2017 through a socio-political analysis of the chancellors who presided over various coalition governments. Our investigation revealed four interdependent high-impact factors that contributed to Germany’s energy-transition achievements:

1. The vision and social experiment of the Energiewende has remained a cross-partisan policy enduring many changes in coalition governments across the political divide and shares wide community support. This is despite the unequal burden of higher energy costs disproportionally affecting residents and smaller industries.
2. The political stability of leadership and the ability of successive politicians to champion long-term RE-enabling policies. Policy setting have, by and large, been cognisant of and complementary to the otherwise complex socio-economic and environmental expectations of a large industrial nation through which it has attracted, supported and emboldened private sector investment to the RE energy sector.
3. Bottom-up anti-nuclear grassroots movements established the foundation for and enabled the socio-political energy policy that was the genesis of Energiewende (energy transition). This sustained social movement and subsequent policies have framed energy transition towards RE on three pillars: improved energy security, sustained economic growth and climate change mitigation.
4. The Energiewende harbours a socio-technical experiment based on government-led, policy-driven structural changes to the energy system and a strong community-supported phasing-out of the nuclear power. This was driven through strategically decentralised power generation

with diversified ownership that broke the dependency and stronghold of the traditional centralised generators.

From an energy-transition research perspective, the finding 1 and 2 are new insights on the long-term policy stability through cross-partisan harmonisation of political differences on national climate/energy strategy in Germany. This is most valuable and can only be seen through a lens of a comparative analysis with the Australian case to uncover the contrasting policy instability resulting from political divides. These insights also add value to findings of other energy-transition literature such as: steering socio-technical structural changes is politically difficult (Grin et al., 2010; Meadowcroft, 2009; 2011); climate/energy policy formulation and implementation are found to be essentially a political process (Kern and Smith, 2008); analysis for motivations, barriers and causalities needs to be complemented by analysis of transition policies and their politics (Hill 1997); policy stability and consistency are important in providing long-term certainty and confidence to the capital-investment market (Geels, 2006; van Rooijen and van Wees, 2006, Verbong and Geels, 2007). The finding 3 and 4 provide additional support to the well-researched field of the German Energiewende on the impact of the anti-nuclear grassroots movements on the domestic energy policies and achievements (Hager and Stefes, 2016; Morris and Jungjohann, 2016), and the transition model and pathway of the socio-technical structural changes (Geels et al., 2016; 2017).

From a research-strategy perspective, the MCA model, despite limitations, has proven its ability to quantify the importance of socio-political factors and events that have contributed to the energy-policy success in Germany. The application of a time-weighted coefficient to better assess the impact of climate and energy policy has enhanced the model reflecting political and policy stability. Party politics and ideologies are not necessarily causative to a successful energy transition nor is a policy of least-cost energy provision. While this was the finding in the analysis of Australian actions on climate and energy, it has not been an underlying factor contributing to the German energy transition. In this respect, the MCA model when applied across differing nation states can play an important role in dissecting and identifying socio-political and economic nuance within otherwise complex systems.

The German experience represents one of the most important social, economic, and political undertakings of our time that offers valuable lessons for others looking to learn and adapt for their compelling paths to a sustainable energy future.

5.7 Appendix A – German Chancellors climate policies chronology table[45]

Leaders (Political party) Office term	Conference of Parties (COP)	Federal Climate Initiatives / Policies	Funding (€Million)
Helmut Kohl Christian Democratic Union (CDU) 1/10/1982 – 27/10/1998 CDU/CSU – FDP CDU/CSU – FDP – DSU CDU/CSU – FDP	COP 1 (1995) Berlin Mandate COP 2 (1996) Geneva Ministerial Declaration COP 3 (1997) Kyoto Protocol	1989 – ended **250 MW Wind Programme** This programme was initiated in June 1989 as a ''100 MW Wind Programme'' and was extended to the '250 MW Wind Programme' in February 1991. The programme provided grants for the installation and operation of wind turbines at suitable sites. The last grants were approved at the end of 1996 for turbines that had to be commissioned by mid-1998. A ''Scientific Measurement and Evaluation Programme'' (WMEP) was part of the support scheme. All turbines that received financial support were monitored for 10 years. The programme provided grants of DEM200 (€102)/kW, up to a ceiling of DEM100,000 (€51,300) for facilities larger than 1 MW. Grants up to 60% of the total investment to a maximum of DEM90,000 (€46,000) were provided. Alternatively, the programme provided operating subsidies of DEM0.06 (€0.031) – DEM0 .08 (€0.041) until 1991 for every kWh fed into the public grid. This programme promoted 1,560 wind turbines with a total installed capacity of 362 MW. 1990 – 2008 superseded ***ERP-Environment and Energy Saving Programme***	 €10,700

[45] The content of this Appendix A table serves as a data collected on Germany's climate/energy policies from IEA/IRENA climate/energy policy database website. The selection criteria of the extracted policies based on major policies from areas of climate change, renewable energy and energy efficiency, especially those with funding provisions. The aim of this table is to facilitate and streamline the MCA model evaluation processes of the three chancellors which are included in Appendix B. Following are the links for all policies and related details:
http://www.iea.org/policiesandmeasures/climatechange/?country=Germany
http://www.iea.org/policiesandmeasures/renewableenergy/?country=Germany
http://www.iea.org/policiesandmeasures/energyefficiency/?country=Germany

		The Reconstruction Loan Corporation (KfW) in place of the former 'Deutsche Ausgleichsbank' (DtA) provided low-interest loans for private companies, freelancers and public private partnerships to take suitable measures to save energy, or to use renewable energies (since 2003). Credit terms varied from 10-20 years with a redemption-free initial phase of two to five years with interest rates between 4% and 7% in 2006 depending on the credit rating of the applicant. A maximum of 50% of the total investment was eligible for funding. Loans taken out with this programme could be combined with loans offered under the KfW-Environment-Programme. Traditionally, the main beneficiary of the ERP Programme was the wind power sector. However, the support for solar photovoltaics grew towards the end of the scheme. This policy is superseded by: KfW Renewable Energies Programme (KfW-Programm Erneuerbare Energien) in 2009. 1991 – superseded **Electricity Feed-In Law of 1991 (Stromeinspeisungsgesetz - StrEG)** The 1991 Electricity Feed-in Law ensured grid access for electricity generated from renewable energy sources. It obliged utilities operating the public grid to pay premium prices (feed-in tariffs) for the electricity supplied from these renewable energy power plants. No public budget funds were involved, as the burden imposed by the law was exclusively borne by electricity suppliers and their customers. The premiums in the Electricity Feed-In Law were calculated annually as a percentage of the mean specific revenues for all electricity sold via the public electricity grid in the previous year, i.e., the average electricity price for all customers. In this way, the remuneration changed every year. Wind power plants and solar power plants received the highest remuneration with 90% of the mean specific revenues, followed by small hydro, biomass and biogas power plants smaller than 500 kW with 75%. 1993 – ended ***Full Cost Rates*** (Kostendeckende Vergütung) Under this legislation a tariff was granted to electricity from photovoltaic installations. The remuneration level was approximately 70-80 cents/kWh.	(in loan 1990-2005)

		Twenty-five municipal utilities introduced schemes under this programme by the end of 1999, often at the behest or even forced by local parliaments to do so. Approximately 1,000 photovoltaic installations with a total capacity of 4.5 MW were installed. The programmes became obsolete after the introduction of the 100,000 Roofs Programme and the enhanced remuneration according to the Renewable Energy Sources Law. 1995 – 1998 ended ***100 Million Programme*** This federal program, administrated by the Ministry of Economics and Technology (BMWi), encouraged increased use of renewable energy via capital subsidies (up to a limit varied by technology). Emphasis was given to: solar collectors and heat pumps; small hydropower installations; large wind turbines (450 kW to 2MW); PV installations greater than 1 kW; and biomass installations. Solar water heaters for swimming pools and geothermal applications were excluded. 1996 – in force ***Green Power*** To provide an opportunity to sell the electricity generated by renewable energy plants not operating under the German Feed-In Scheme (EEG) at a premium on the market. This ''green electricity'' entered the market as a new product which could be purchased in place of conventional electricity. Most utilities and electricity suppliers offered a choice between tariffs and between different sources of renewable energy (e.g. 100% hydropower) to their customers. Such programmes did not necessarily lead to the installation of new capacity due to the fact that the green power need to first enter the market with feasible conditions before the new capacity is installed. Prior to the liberalisation of the electricity market in 1998, the utilities pass on the financial burden of green power to customers with green tariffs surcharge aimed at building up funds for installing mainly new photovoltaic capacity. Post deregulation of the market, independent electricity suppliers could also market green power within their energy portfolio. In 2000, there were 132 companies offering green electricity with market share of less than 1% of the total supply.	 DM100

		The market functioned with certification schemes to ensure independent monitoring and control of the electricity's origin as well as the reinvestment of the funds to new plants. 1996 – 2004 superseded ***Fourth Energy Research Programmme*** This programme, established in 1996, set the framework for public RD&D support for energy technologies including hydrogen and fuel cells. Details of the program area available at www.iea.org/Textbase/pamsdb/renewable_table/table2.pdf. 1997 – in force ***Federal Building Codes for Renewable Energy Production*** The 1997 amendment of the federal building codes (Baugesetzbuch) granted the same legal status as nuclear power plants to wind- and hydropower plants by exempting them from the general ban on building in the undeveloped outskirts. The Infrastrukturplanungsbeschleunigungsgesetz (Infrastructure Planning Act) passed in December 2006 was in support of the offshore wind by mandating grid-operators to build the needed infrastructure for connecting offshore-wind parks to the grid and for transmitting the generated electricity on their own expense. Thus, making offshore-wind power feasible and encourage strong development in the sector.	
Gerhard Schröder Social Democratic Party of Germany (SPD) 27/10/1998 – 22/11/2005 SPD – Green	COP 4 (1998) Buenos Aires Plan of Action COP 5 (1999) Bonn Agreements COP 6 (, 2000) The Hague COP 7 (2001) Marrakesh Accords	1998 – 2005 ended ***Baltic Energy Efficiency Group (BEEG)*** Baltic Energy Efficiency Group (BEEG), was one of four working groups established by the Energy Ministers of the Baltic Sea at their Stavanger Ministerial on 2 December 1998. The BEEG was mandated to assess energy efficiency options and potentials. The programmes examined by the BEEG included combined heat and power (CHP) strategy, facility for financing small-scale energy efficiency projects, CHP and renewables, a Market Transformation Programme district heating (DH) initiatives CHP strategy. BEEG participants included the governments of Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Russia and Sweden. The European Commission was represented by DG TREN, the Directorate General for Transport and Energy. 1999 – in force ***Eco-Tax Reform***	

	COP 8 (2002) Delhi Ministerial Declaration COP 9 (2003) Milan COP 10 (2004) Buenos Aires	The ecological tax reform was introduced in 1999 and subsequently modified until its phasing out in 2012. It was aiming at setting taxes on conventional fossil fuels in order to support the RE market development and generation. The tax was incrementally amended to achieve its goals and also contained a provision to support energy intensive industries, commuters and low-income households. https://www.iea.org/policiesandmeasures/pams/germany/name-22079-en.php 1999 – in force ***Preferential Loan Programmes offered by the Reconstruction Loan Corporation (KfW)*** The Reconstruction Loan Corporation (KfW) offered several soft loans schemes to indirectly support renewable energy technologies. The KfW offered financing loans to replace conventional heating systems with RE sources enabled with interest rates of 1-2% below the market rate for 10-20 years term. Investment credits were granted for photovoltaic systems for new houses and refurbishment of old houses to achieve energy efficiency. In 2009, the KfW Renewable Energies Programme incorporated the Solar Power Generation Programme, the Environment Programme and the previous Renewable Energy Programme. The KfW had two elements: Mittelstandsprogramm for private companies and KfW-Infrastruktur- programm aimed at municipalities, public institutions and non-profit organisations. 1999 – 2003 superseded ***100,000 Roofs Solar Power Programme*** This programme expanded the 1000 Roofs Programme that commenced in 1991 to support the installation of PV systems larger than 1 kW. Loans with interest rates 4.5% below market rate applied to a maximum of EUR 500,000 with possible share of financing up to 100%. For installations < 5kW, the loans were limited to €6,750/kW and for > 5kW, the loans were limited to €3,375/kW. The programme aimed to develop 300 MW of additional RE generation capacity and by the end of the program in July 2003 it had achieved 55,000 installations and 261 MW of additional capacity.	€562.4 (DM 1.1 billion)

		1999 – in force ***Market Incentive Programme*** (Marktanreizprogramm) A successor of the ***100 Million Programme*** (1995-1998). Market incentive Programme was introduced in 1999 with an initial annual budget of €100 million allocated over 5 years. This programme was a part of the Eco-tax reform, with revenue from the eco-tax used to support the further development of the renewable energy technologies. The initial budget reflected an estimate of the eco-tax revenue. By 2005, approximately one third of the calculated tax €659 million had gone to support the programme. The Programme primarily served to expand heat generation from biomass, solar power and geothermal energy. Grants were provided to smaller installation through the Federal Office of Economics and Export Control (BAFA). Larger installations were supported with loans at reduced interest rates and partial debt release through the KfW - Kreditanstalt für Wiederaufbau. The programme was frequently adjusted to favour highly innovative technologies and large systems with applications of solar collectors, biomass boilers and heat pumps. 2000 – in force ***Renewable Energy Act*** The Renewable Energies Act, effective 1 April 2000, set a RE generation target of a 12% by 2010. This Act revised the 1990 Act on the Sale of Electricity to the Grid that enabled and supported a system of guaranteed sales prices for electricity from renewable sources such as wind, hydro, and solar energy. Producers of RE will be able to sell to the grid at a price guaranteed by law. The grid operators are obliged to connect the new RE installations (hydro, wind, solar, gas from biomass and geothermal) and purchase electricity in accordance with defined provisions. https://www.iea.org/policiesandmeasures/pams/germany/name-21295-en.php 2000 - 2005 superseded ***National Climate Protection Program*** The first National Climate Protection Programme in October 2000 set an aim of a 25% CO2 emissions reduction from 1990 levels by 2005. The programme included reduction objectives by sector and other provisions to achieve the aim, such as:	€100 x 5 (annual budget over 5 years)

<table>
<tr>
<td></td>
<td></td>
<td>an increase in energy production from combined heat and power plants; an Energy Savings Ordinance and a voluntary pledge by German industrial associations to reduce their emissions. Subsequent developments included tax breaks, an agreement with the automobile industry to support the widespread uptake of energy-efficient cars and consideration to a levy on air traffic. This programme was updated in 2005 (see separate entry).

2000 – 2004 ended Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz EEG)
This Act replaces the Electricity Feed-In Law of 1991 (StrEG) that had an aim to double the share of electricity produced from renewable energy by 2010. Grid operators were required to accept connections from renewable energy plants to the grid and purchase the electricity at a set tariff that was determined for individual technologies based on their actual generation costs. With the exception of wind power, the remuneration level remained fixed over 20 years for an individual plant or installation. Wind electricity received a higher tariff up to a capped initial total production after which lower amount was paid up to 20 years following the commissioning of the plant. The average remuneration paid for wind power was €0.084/kWh over a 20 -year lifetime without adjusting for inflation rate (which implied a decrease in the remuneration for the owner/operator in real terms).
From 2002 the nominal remuneration paid for newly commissioned plants was reduced by RE sector each year to incentivise the industry to reduce costs:
• Photovoltaic -5%
• Wind -1.5%
• Biomass -1%
The Act also stipulated requirements for grid compatibility and grid upgrades that affected both RE plant operators and grid operators. The Act also sought to solve the problem of unequal distribution of burdens (as in the EFL) by requiring all electricity suppliers to have the same share of electricity from RE in their fuel mix as averaged over a 3-month period. This ensured that all electricity suppliers</td>
<td></td>
</tr>
</table>

		operated on an equal playing field with respect to their purchase and sale of electricity and so doing shared the costs and benefits of the generated RE equally. 2000 – 2002 superseded ***Combined Heat and Power (CHP) Extra Law*** (Gesetz zum Schutz der Stromerzeugung aus Kraft-Wärme-Kopplung - Kraft-Wärme-Kopplungsgesetz) In 2000 new rules were built on emergency support for municipality owned CHP plants which were coming under increasing pressure from falling power prices in a newly liberalised electricity market and many were being closed. Having stabilised the market, the government wanted to ensure an increasing share of CHP-produced electricity, aiming at lowering carbon dioxide emissions by 23M tonnes by 2010. Half of this target is to be achieved by the CHP law, the other half by an agreement of German industry. The 2000 law offered CHP plant operators supplying electricity to the grid fixed prices above the market rate for up to ten years. Modernised plants built before December 2005 will benefit up to 2010 and plants built before 1990 will benefit up to 2009. Fuel cells, supplying CHP-produced electricity to the grid will benefit up to ten years from their installation on. The incentives were financed by a levy of EUR 0.1-0.15 Cent/kWh for households, and EUR 0.5 Cent/kWh for industry (consuming more than 100 000 kWh). 2000 – in force ***Federal ministry buildings*** In the National Climate Protection Programme of 13 July 2005, the federal government reaffirmed its self-imposed commitment of 18 October 2000 to reduce CO2 emissions in its sector by an average of 30 % during the period 2008 to 2012 compared to 1990. Following the announcement on 18 October 2000 of its self-imposed commitment the federal government is striving to achieve the additional target of a reduction in CO2 emissions for its sector of 50 % by 2020 compared to 1990. The Energy Savings Programme for Federal Government Properties were supported with €120 million funding. 2000 – in force ***National Energy Agency*** *(Deutsche Energie Agentur – DENA)*	€120 €9.1 (federal budget 2012)

		The German Energy Agency was established by the Federal Minister of Economics and Technology in September 2000 to implement the measures in the Climate Protection Programme. DENA was as setup a private company with various stakeholders including the Federal Republic of Germany (50%), the KfW (26%), the Deutsche Bank AG (8%), the DZ Bank AG (8%) and the Allianz SE (8%). DENA worked on projects, programmes and campaigns to promote: energy efficiency, environment-friendly transformation of energy distribution and use; renewable energies; climate protection; and sustainable development. DENA supported many pilot projects to advance new technologies in partnership with the industry, and developed various information campaigns on RE and related topics including a toll-free Energy Hotline to provide technical advice to companies and individuals on how to save energy in buildings and on co-generation and RE systems. 2001 – 2003 ended **Investing in the Future Programme (Zukunfts-Investitions-Programm, ZIP)** Special Funding Programme (2001-2003) to endorse specific energy research. This covered: fuel cells (stationary and mobile applications) €63million; alternative vehicle propulsion (e.g. high performance batteries) and regenerative fuel production (e.g. hydrogen, methanol) €15million; geothermal energy production (heat and electricity) €15million; offshore wind energy €15million; and renovation of existing buildings €15million. The total budget for this program over the period 2001-2003 was €123million (approx.. €41million per year). 2002 – in force ***Improving the infrastructure for using bicycles*** The aim of this program was to promote cycling through the implementation of projects identified under the National Cycling Plan. In support of this programme the federal government committed €100m in 2008 for the construction and maintenance of cycle paths on trunk roads and for various initiatives at the city an local level. 2002 – in force ***Law to Amend the Mineral Oil Tax Law and Renewable Energy Law***	€9.7 (private partners 2012) €123 €100

		The amended law raised the cap on total photovoltaic capacity from 350MW to 1,000MW eligible for premium payments under the 2000 renewable energy law (EEG 2000). The feed-in tariff was adjusted from EUR Cent 50.5/kWh to EUR Cent 45.7/kWh as part of the automatic annual -5% ratchet built into the law aimed at incentivising incremental improvements in technology and efficiency. The mineral oil tax exemption was also extended to cover all biomass fuels through to the end of 2008. The federal finance ministry was responsible for the bi-annual reporting and monitoring of the biofuels market and for making on-going policy adjustment recommendations to government. The Mineral Oil Tax Law was subsequently replaced by the Energy Tax Act to comply with the Council Directive 2003/96/EC of 27 October 2003 in 2006 which was then amended in 2009 by the Act on the Amendment of the Promotion of Biofuels (Gesetz zur Änderung der Förderung von Biokraftstoffen). 2002 – planned ***Renewables Technology Export Initiative*** According to a decision of the German parliament, an amount of €30 million was planned to be spent on a 'renewable technology export initiative' in 2003. 2002 – in force (amended 2008/2011/2012 ***Combined Heat and Power Law*** (Kraft-Wärme-Kopplungs Modernisierungsgesetz)) This replaces the 2000 law on the CHP (KWKVorschaltgesetz) in order to cover RE technologies excluded from the initial EEG. The aim was to promote large CHP plants affected by decreasing electricity prices because of market liberalisation (negative effects) and to boost the share of CHP-produced electricity (positive drivers) to lower CO2 emissions by 23 million tonnes by 2010. Half of this target was to be achieved by the CHP law with the other half by a voluntary agreement with industry. Included under the CHP law was co-firing of biomass in fossil-fuel power plants and biomass CHP larger than 20 MW. 2004 – in force ***Emissions Trading Law*** (Treibhausgas-Emissionshandelsgesetz) The Greenhouse Gas Emission Trading Law (TEHG) became effective on 15 July 2004. This law implements the Directive 2003/87/EC of the European Parliament	€30 €4450 (2002 – 2010)

		and of the Council of 13 October 2003 and established a trading scheme for GHG emissions within the European Community and amending Council Directive 96/61/EC. The law provided the legal framework for emission allowance trading in Germany. 2004 – in force ***Germany National Allocation Plan*** The German government has published its national allocation plan (NAP) for carbon dioxide emissions under the EU-Emissions Trading Scheme. The NAP is to allocate 499Mt CO_2 to installations covered by the scheme over the 2005-07 period. The allowances are to be allocated for free. The allocation is equivalent to a reduction of 5.2MtCO_2 annually compared to the reference period 2000-2002. The number of installations covered by the emissions trading scheme is around 1.850. New entrants will have access to 9 MtCO_2 of allowances. Allowances from plant closure will go to the New Entrant Reserve. However, this clause is not applied if the operator of the decommissioned installation commissions a new installation in Germany within a maximum of 3 months after decommissioning the old installation. 2004 – 2008 ended ***Solarthermie 2000Plus*** This programme was the successor of the 'Solarthermie2000' programme. It provided non-repayable grants of up to 50% of the investment cost of solar thermal collectors and focused on supporting pilot research and development systems and testing their market application. Funds were made available to public utilities, institutions, foundations and private companies and required the solar thermal collectors to be greater than 100 m². 2004 superseded ***Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz EEG 2004)*** The Act of 2004 replaces the Renewable Energy Sources Act of 2000 while maintaining the prior Acts' general principals. The EEG was amended on 1 August 2004 to increase the share of renewable energies in the total electricity supply to at least 12.5% by the year 2010 and to at least 20% by the year 2020. It also aims	€3.6 (2004)

		to further develop renewable technologies for the generation of electricity, thus contributing to a reduction in costs. The EEG amendment also assists the implementation of the September 2001 European Union directive on the promotion of renewable energies in the electricity sector, by ensuring that all the RE defined in the directive fall under the scope of the EEG. EEG REGULATIONS IN DETAIL Obligation to purchase and transmit. Grid operators must give immediate priority to connecting installations for the generation of electricity from RE or from mine gas to their grid. In addition, they are obligated to purchase and transmit all electricity available from these installations. Installation operators bear the costs of connection. Grid operators take on the necessary costs for upgrading the grid. They may incorporate these costs into the charges for use of the grid. However, to ensure the necessary transparency, the grid upgrading costs must be declared. This obligation aims, in the interests of consumer protection, to prevent costs being shifted unfairly to the electricity consumer. The amendment creates incentives for operators of RE installations to agree on the management of energy generation with grid operators. This is especially relevant for grid upgrading and stand-by energy. Such agreements may consider the occasionally fluctuating electricity supply in such a way that minimizes the costs for grid upgrades, reserves, and stand-by energy. To facilitate better integration of RE into the electricity system, the EEG amendment requires that installations with a capacity of 500 kW or more are measured and recorded 2005 – in force ***National Climate Protection Programme*** The 2005 National Climate Protection Programme updated the 2000 programme to ensure compliance with Germany's commitments to reduce GHG emission 21% below 1990 levels for the period 2008 to 2012. As part of this 5-year review it identified the effectiveness of federal climate protection policies and outlined a set of new measures. With the energy and industry sectors already covered by an emissions trading instrument, the 2005 Climate Protection Programme focused on the transport and private household sectors. 2005 – 2008 superseded ***KfW-Programme Producing Solar Power***	

		This programme offered low-interest loans for small investments in solar PV generation. Private investors with project investment up to €50,000 were the main beneficiary receiving finance up to 100% of the investment cost. The KfW provided interest rates ranging 3.6% - 4.15% p.a. with credit terms varying between 10-20 years with a redemption-free initial phase of two to three years. As of July 2006, more than 25,000 loans were provided at a cost of €784 million with an installed capacity of 199 MWp. 2005 – 2009 ended ***KfW Housing Modernisation Programme – Eco Plus (CO2 Building Redevelopment Programme)*** Interest rate subsidy and investment grants provided by the national budget designed to improve the thermal efficiency of current housing stock. Between 2005 and March 2009 the 'Housing Modernisation Programme' subsidised individual measures in the buildings sector with long-term low-interest loans. Funding was provided for the replacement of windows, thermal insulation, updating of heating based on E, combined heat and power generation or local / district heating. In 2009 the programme was rolled into the KfW Energy-efficient Redevelopment Programme. 2005 – 2011 superseded ***Fifth Energy Research Programme*** (5. Energieforschungsprogramme - Innovation und neue Energietechnologien) This programme was the successor to the Fourth Energy Research Programme (the Research Programme commenced in 1996). This is a rolling programme designed to provide a framework for public RD&D support for energy technologies. Institutional support, especially for centres of the Helmholtz Association and the promotion of networks of basic research, was given by the Federal Ministry of Education and Research (BMBF). The programme was superseded by the Sixth Energy Research Programme 2005 – in force ***Energy Industry Act (Energiewirtschaftsgesetz)*** (amended 2012) The Energy Industry Act established a framework to enhance competition, security of supply and sustainable energy production in Germany. The Act	 €784 (as loans to be disbursed in 2005 – 2006)

		required electricity labelling according to type of energy source and stipulates supplementary provisions for the access of electricity from renewable sources to the grid as well as the construction of intelligent grids including electricity storage. The law was amended in 2012 to speed up the expansion of offshore wind farms. A major focus was on enabling the upgrade and expansion of the grid, including the offshore grid, through the introduction of binding offshore grid development plans to improve the coordination of grid connections and offshore wind farms and a compensation scheme supporting the construction and operation of grid connections to offshore wind farms.	
Angela Merkel Christian Democratic Union (CDU) 22 November 2005 - Incumbent CDU/CSU – SPD (Grand coalition) CDU/CSU – FDP CDU/CSU – SPD (Grand coalition)	COP 11 (2005) Montreal COP 12 (2006) Nairobi Framework COP 13 (2007) Bali Road Map COP 14 (2008) Poznan COP 15 (2009) Copenhagen Accord COP 16 (2010) Cancun Agreements COP 17 (2011) Durban Platform	2006 – in force ***Coaltion Agreement: Target to Double Energy Productivity by 2020*** The target of the Coalition Agreement was to enhance energy efficiency and had 5 objectives: • To increase the energy efficiency of the national economy aiming to double energy productivity of 1990 level by 2020. • To boost funding to at least 1.5 billion Euros per year for the Building Modernisation Programme to improve its efficiency and attractiveness through grants and tax relief measures including rental accommodation. An introduction of 'energy passport' for buildings was also introduced with an aim to improve energy efficiency of 5% of buildings built before 1978. • To improve electricity sector by modernisation of the existing power plants, expansion of decentralised power plants and CHP systems, as well as review the funding criteria of the Heat-Power Cogeneration Act (KWK-Gesetz) in accordance to the regular monitoring reports. • To support European initiatives to improve energy efficiency and work towards a European top runner programme. • To intensify the DENA initiatives for energy conservation in the areas of buildings, electricity uses and traffic. 2006 – in force ***Funding for Solar Power Development Center*** Provide testing facilities and equipment resemble a modern industrial production line and the Photovoltaic Technology Evaluation Centre (PV-Tec) forms part of the	€5600 (2006 – 2009) €11.7

	COP 18 (2012) Doha Amendment COP19 (2013) Warsaw Outcomes COP20 (2014) Lima Call for Climate Action COP21 (2015) Paris Agreement COP 22 (2016) Marrakech Partnership for Global Climate Action	public-private Fraunhofer Institute for Solar Energy Systems. The PV-Tec is available to solar cell and solar systems manufacturers which are interested in testing their new products with goals for ongoing development and industrial production.	
		2006 – 2009 ended ***Klimazwei Research Programme*** The German Federal Ministry of Education and Research funded a research and development programme for technologies and strategies to mitigate and adapt to climate change, the Klimazwei - Research for Climate Protection and Protection from Climate Impacts. The Programme ran until 2009 and funded 39 projects targeting both adaptation and energy-related mitigation.	€35
		2006 – in force ***Energy Taxes: Coal, Biodiesel, Natural Gas*** In August 2006, Germany implemented a tax on coal, coke and lignite and rescinded tax breaks for biofuels. The tax fully exempts energy-intensive industries - glass, ceramics and cement - as well as domestic burning. The taxation law implements the European energy taxation directive as national law. Such implementation levies a tax on coal for the first time. Hard coal, lignite and coke are taxed when used for heating purposes. Taxes on natural gas are raised only as soon as the gas is delivered to the customer. Energy sources which are used for power generation are generally exempt from taxation, according to the federal Ministry of Finance. https://www.iea.org/policiesandmeasures/pams/germany/name-23849-en.php	
		2007 – in force ***Clean Truck Procurement Subsidies*** In 2007, the Ministry of Transport, Building and Urban Affairs provided subsidies to encourage a shift to the use of cleaner vehicles in the heavy goods transport sector. The fund was launched in 2007 with €100m with an addition allocation of €85m in May 2008. Vehicle buyers were able to choose between cheaper loans or direct grants of up to €4,250 per truck. Vehicles had to meet the EUs Euro V or EEV Class 1 emission standards. It is envisaged that additional incentives would be offered to buy even cleaner Euro VI vehicles once the latest standard is incorporated into German law.	€185

		2007- in force ***E-Energy – ICT-based energy system of the future*** This was a federal government programme designed to fund six RE pilot projects using information technologies such as smart metering in the energy sector. The program ran until 2013. Funding of the pilot projects was a cross-departmental partnership between the Ministry of Economics and Technology (BMWi) and the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMU). The BMWi provided €40m for four pilot regions and the BMU funded €20m for projects in two additional regions. 2007 – in force ***Integrated Climate Change and Energy Programme*** In August 2007, the cabinet of the German government adopted an Integrated Climate Change and Energy Programme to underpin the goals of the coalition treaty from the EU Spring Council meeting of March 2007, where the European Council of heads of state and government had set the parameters for an integrated European climate and energy policy. The Programme set its guiding principles in security of supply, economic efficiency and environmental protection and aimed to cut greenhouse emissions by 40% by 2020 compared to 1990 levels. As a result, a first package of fourteen draft laws addressing most of the priorities of the national climate and energy programme was approved in December 2007: 1. Amendment to the Combined Heat and Power Act. 2. Amendment to the Energy Industry Act (EnWG) on liberalised metering. 3. Report and draft amendment to the Energy Saving Ordinance (EnEV). 4. Amendment to the 37th Ordinance on the Implementation of the Federal Emission Control Act (BlmSchV) – clean power plants. 5. Guidelines on the procurement of energy-efficient products and services. 6. Amendment to the Renewable Energy Sources Act (EEG). 7. Renewable Energies Heat Act (EEWärmeG).	€60 (from government) €80 (from private companies)

		8. Amendment to the Gas Grid Access Ordinance. 9. Amendment to the Biofuel Quota Act. 10. Sustainability Ordinance. 11. Fuel Quality Ordinance. 12. Hydrogenation Ordinance. 13. Reform of Vehicle Tax to a pollutant and CO2 basis. 14. Chemicals Climate Protection Ordinance. https://www.iea.org/policiesandmeasures/pams/germany/name-23939-en.php 2008 – in force ***Climate Legislation Package Enacted under the Integrated Climate Change and Energy Programme*** In June 2008, the German government passed a second package of measures as an ongoing legal transposition of the Integrated Climate and Energy Programme with main targets to: reduce CO_2 emissions by 40% by 2020 compared to 1990; double electricity generated by combined heat and power technology (CHP) to 25%; increase share of renewable electricity to 20%, especially through subsidies to off-shore wind-farm development. Other elements include a requirement for all buildings built after 2008 to have a component of heating generated from renewable sources. The market for consumer energy consumption metering (smart meters) will also be liberalised. The second package of June 2008 included: • Reform of the Energy Saving Ordinance (EnEV); • Reform of the Vehicle Tax to a pollutant and CO2 basis; • Amendment to the Energy Industry Act to support expansion of the electricity grid; • Amendment to the Passenger Car Energy Consumption Labelling Ordinance; • Ordinance on the liberalisation of metering and implementation of the Energy Services Directive; • Amendment to the Heating Costs Ordinance; and	€3300 (2008)

		• Amendment to the HGV Toll Ordinance http://www.bmu.de/files/english/pdf/application/pdf/hintergrund_meseberg_en.pdf 2008 – 2014 superseded ***Special Fund for Energy Efficiency in SMEs*** The Special Fund was established jointly by BMWi and KfW to remove the barriers including the lack of information and costs for implementing energy efficiency initiatives from the small and medium-sized enterprises (SMEs). This was achieved through a maximum grant of €1,280 designed to fund an initial energy efficiency consultation. For SME wanting an in-depth energy analysis a maximum grant of €4,800 was available. Funding for energy-conservation measures arising from the consultations was assisted through a financing component which provided low-interest loans. 2008 – in force ***Minus 40 Per Cent Club for private households*** In order to demonstrate the achievability of a 40% emission reduction from 1990 level by 2020 target, the Minus 40 Per Cent Club involving 92,000 households was recruited and setup with the Online Energy Saving Account (ESA). The emission figures for the heating and electricity consumption for this club were monitored. The interim results identified participants were able to reduce their CO2 emissions by an average of 1.69 % p.a. In just under 2.5 years from September 2008 the number of ESAs had increased from 8,000 to 100,000 by means of partnerships with energy utilities, and media work. 2008 – in force ***National Innovation Programme for Hydrogen and Fuel Cell Technology*** (NIP) With the 'National Innovation Programme for Hydrogen and Fuel Cell Technology' (NIP) the federal government funded the development and implementation of hydrogen and fuel cell technology. The objective was to bring market readiness of this technology, creating value chains and value-added shares and contribute to the government's energy- and climate-policy targets. The programme includes	€500 (by BMVBS) €200 (by BMWi) €700 (co-financed by industry)

		both transport sector-related and stationary applications. The total programme budget was €1.4bn with €500m provided by BMVI (Federal Ministry of Transport and Digital Infrastructure), €200m by the BMWi, and the remaining co-financed by industry. 2008 – in force ***Stimulus Programme for Mini CHP Plants*** The objective of the fund was to increase the installation of mini-CHP plants of up to 50 kW in the heating market. The investment incentive funding was aimed at the SMEs, freelance professionals, individuals, municipalities, municipal regional authorities and special-purpose associations. The programme had a positive impact furthering the development of mini-CHP plants and creating forward-looking markets. 2009 – in force ***Funding Programme for Electromobility Pilot Regions*** The 'Electromobility in Pilot Regions' Programme provided subsidies totalling €130m to fund research and development for battery technology with an emphasis on everyday- and user-oriented demonstration and application projects. Funding was from the Second Economic Package which was the biggest stimulus package of €50bn approved by cabinet to tackle the country's deepest economic crisis since the second world war. 2009- in force ***Government Electromobility Programme*** The aim of the Government Electromobility Programme was to drive research and development of battery-operated vehicles and to create a suitable regulatory environment for electromobility. It set a target of a million electric vehicles on the German market by 2020. Funds totalling €500m were made available from the Second Economic Package for the electromobility sector. A further €1bn is being made available for R&D measures until the end of the legislative period aiming to secure and expand the leading role of the German automotive and supply-chain industry.	€130 €500 + €1000

		2009 – in force ***KfW Renewable Energies Programme*** (KfW-Programm Erneuerbare Energien) In 2009 the KfW consolidated their support programmes for renewable energy investments. This Programme superseded the following programmes: ***Producing Solar Power***, ***ERP-Environment and Energy Saving Programme***, ***KfW Environment Programme***, ***KfW-Programme Renewable Energy***. The new KfW Renewable Energies Programme consists of two parts - "standard" and "premium". The "standard" programme comprises loans for: - Electricity from solar (photovoltaics), biomass, biogas, wind, hydropower, geothermal energy; - Electricity and heat from renewable energies, generated in combined heat and power (CHP) stations. The "premium" programme offers loans and repayment bonuses for heat from renewable energies generated in large plants. In addition, the "Deep Geothermal Energy" programme was a financing facility for the development of hydrothermal, petrothermal and deep geothermal energy with more than 400 m drilling depth. With effect from 15 August 2012 the support guidelines in the premium part of the programme were modified, improving support for large solar collectors, large heat pumps, biogas pipelines for certain applications and deep geothermal plants.	
		2009 – in force ***Renewable Energies Heat Act (EEWärmeG)*** The Renewable Energies Heat Act (EEWärmeG) aimed to increase the share of RE for heating and cooling to 14% by 2020. The Act stipulated owners of certain categories of buildings must cover part of their heating and cooling supply with RE and provided funding up to €50,000 and penalty up to €50,000.	€5000
		2009 – 2009 ended ***Environmental bonus*** In January 2009, in the framework of the Economic Programme II, a once-off subsidy of an environmental bonus of €2,500 was granted through BAFA (The Federal Office for Economic Affairs and Export Control) to private car owners to scrap cars older than 9 years and replaced them with a new or one-year-old car. The objective of this bonus was to replace old passenger vehicles with high emissions of pollutants with new and more efficient vehicles. The funding was	

		increased to €5bn due to the very high level of demand and over the year approximately two million passenger vehicles were subsidised. 2009 – 2010 superseded 2009 ***Amendment of the Renewable Energy Sources Act -EEG 2009-*** On 1 January 2009 the amendment of the Renewable Energy Sources Act (EEG 2009) came into force. The amendment provided a higher feed-in tariff for wind energy, and other measures to stimulate the development of both onshore and offshore wind power. The Act also increased tariffs for hydropower, biogas facility and adjusted tariffs for geothermal and roof-mounted facilities. The new law also removed bonuses for building integrated facilities. Following link is for more details of tariffs: https://www.iea.org/policiesandmeasures/pams/germany/name-24289-en.php 2009 – 2013 ended ***Partnership for Climate Protection and Energy*** The BMWi and the BMUB (the Environment, Nature Conservation, Building and Nuclear Safety) together with the Association of German Chambers of Industry and Commerce (DIHK) initiated a joint project called ***'Partnership for climate protection, energy efficiency and innovation'.*** This partnership was designed to support company visits by members of the chambers aimed to support the SMEs to use energy consulting services. The fund required in 2010 as estimated by the KfW bank was EUR 12 million. 2009 – in force ***the national emission target for Germany under the EU Effort Sharing Decision (406/2009/EC)*** On 23 April 2009, the Effort Sharing Decision establishes binding annual GHG emission targets for EU Member States for the period 2013–2020. These targets concern emissions from most sectors not included in the EU Emissions Trading System (EU ETS), such as transport (except aviation), buildings, agriculture and	€12

		waste. The Effort Sharing Decision forms part of a set of policies and measures on climate change and energy – known as the climate and energy package of the EU. The national emission target for Germany under the EU Effort Sharing Decision is 14% reduction of greenhouse gas emissions in 2020 compared to 2005 level. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0136:0148:EN:PDF#page=12 2010 – in force ***National Energy Action Plan (NREAP)*** Under the EU Directive 2009/28/EC member countries of the European Union were obliged to draft and submit to the European Commission National Renewable Action Plans (NREAPs) outlining pathways which will allow them to meet their 2020 renewable energy, energy efficiency and GHG reduction targets. *Germany renewable energy 2020 targets:* • Overall target: 18% of energy generated from renewable sources in gross final energy consumption; • Heating and cooling: 15.5% of demand met by renewable energy sources; • Electricity: 37% of demand met by electricity generated from renewable energy sources; • Transport: 13% of demand met by renewable energy sources. These targets are supported by Germany's '2012 Amendment of the Renewable Energy Sources Act –EEG' for renewable energy development and supplemented by the 'Combined Heat and Power Act' and the 'Market Incentive Program (Marktanreizprogramm – MAP)' for the heating sector. http://ec.europa.eu/energy/renewables/action_plan_en.htm 2010 – in force ***Energy and Climate (EKF) Act, 2010*** The fund was designed to support the implementation of Germany's long-term climate and energy strategy through providing incentives for investments towards low-carbon/carbon-free energy. The fund was established in 2010 and commenced in 2011 to receive part of Germany's emission certificates auctioning	

		revenues and capital of the contract with the nuclear power operators. The operator's part capital flow stopped in 2012, and all auctioning revenues continued to be channelled into the EKF. The Fund provided finance to promote a reliable, affordable and climate-friendly energy system and electric mobility including renewable energy and storage, energy efficiency, grid technology, national climate action, international climate and environment action and development of electric mobility. Commencing in 2013, the Act also allows payments to electricity-intensive industries up to €500m in compensation for possible indirect effects from the EU ETS on electricity prices. 2010 – 2050 in force ***Energy Concept*** The Energy Concept draws together three interrelated policy goals: securing supply, protecting the climate and promoting the growth and competitiveness of German industry. It established a basic strategy for transition to renewable energy complemented by improved energy efficiency for a secured and sustainable future-proved energy supply while achieving the ultimate ambitious climate protection targets of 80% CO2 reduction by 2050. The goals included in the Energy Concept include: 1. Climate protection targets: 40% cut in GHG emissions by 2020, 55% by 2030, 70% by 2040 and 80% - 95% by 2050 from 1990 level. 2. Renewable energy in final energy consumption increase to 60% by 2050. 3. 20% reduction from 2008 level in primary energy consumption by 2020, and 50% reduction by 2050. 4. The rate of building retrofitting to be doubled from current level of 1% to 2% per year. The measures to meet these targets included prioritised action programs on the expansion of offshore wind power and upgrading of power grids, a solid plan for financing the necessary measures over long term and a three-yearly scientifically grounded monitoring process commencing from 2013 to be carried out by the Federal Government to review the implementation progress of the Energy Concept.	

		2011 – in force ***'Energy of the Future' monitoring process*** This long-term and fact-based monitoring process is part of the Energy Concept. Its aim was to closely observe, monitor and report on the implementation of goals of the Energy Concept and programs therein. The process was supported by four independent energy experts charged with responsibility to produce an annual Monitoring Report (beginning in 2011) and a three-yearly Progress Report (starting in 2013) to be provided to the Federal Economics Minister and the Environment Minister. The Monitoring Report is factual-based that shows the progress as compare to the targets, whereas the Progress Report is strategic-based and more extensive in identifying causes, obstacles and recommendations further actions as needed. 2011 – in force ***Energy Efficiency Fund*** The Fund was set up with €89m initially to be increased to above €100m in 2013. The aim was to support a large number of various measures to improve energy efficiency in SMEs, industries, private consumers and municipalities through better consumer information, product innovation, the market launch of energy-efficient products and innovative municipal energy efficiency measures. 2011 – in force ***KfW Programme Offshore Wind Energy*** To speed up the expansion of offshore wind energy in Germany, KfW supported the financing of offshore projects in Germany on behalf of the Federal Government. Financing was made available for the construction of up to ten offshore wind farms in the German Exclusive Economic Zone (EEZ) or in the 12 nautical-mile zone of the North Sea and the Baltic Sea for project companies regardless of the company background. Up to 70 % of the total debt capital required may be financed, but not more than EUR 700 million per project. Project financing may take place in the form of direct loan; a financing package composed of a loan on-lent through a bank and a direct loan from KfW; or a direct loan in the framework of bank consortia to finance unforeseen additional costs (cost overrun facility).	€100 €3400

		https://www.kfw.de/inlandsfoerderung/Unternehmen/Energie-Umwelt/index-2.html 2011 – in force ***Sixth Energy Research Programme*** 'Research for an environmentally sound, reliable and affordable energy supply' – this programme supersedes: Fifth Energy Research Programme This programme was a joint project of the Federal Ministry of Economics and Technology, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the Federal Ministry of Food, Agriculture and Consumer Protection and the Federal Ministry of Education and Research (BMBF). It established guiding principles and priorities of the German government's support policy for innovative energy technologies. **€3.4 billion** was allocated between 2011 to 2014 for funding research and development of energy technologies designed to support energy transformation inducing investment in RE, energy efficiency, energy storage, grid technologies and the integration of renewable energies into the energy supply system. This represented a funding increase of around 75% compared to the 2006 to 2009 period. 2012 – in force ***CHP Agreements with Industry (Vereinbarung zwischen der Regierung der Bundesrepublik Deutschland und der deutschen Wirtschaft zur Steigerung der Energieeffizienz)*** On 1 August 2012, a new agreement was reached between the German government and the energy industry. The agreement established an energy efficiency goal of 1.3% per year. 2012 – 2014 superseded ***2012 Amendment of the Renewable Energy Sources Act -EEG 2012-*** On 1 January 2012, the amendment of the Renewable Energy Sources Act (EEG) will come into force (EEG 2012). In agreement with the Energy Concept of the	

		government dating from September 2010, it aims at reaching the following minimum shares of renewable energy in electricity supply: •35% by 2020 •50% by 2030 •65% by 2040 •80% by 2050 The basic principles of the EEG, in particular priority purchase, transport and distribution of electricity generated from renewable energy sources as well as statutory feed-in compensation, remain unchanged. According to the growing share of renewables in the total electricity production, market integration, system integration and grid integration gain considerably in importance. Main mechanisms to improve integration are: • A market premium (optional for all renewables, from 2014 compulsory for new biogas facilities). • A flexibility premium (for new and existing biogas facilities). • A rebate in compensation payments for utility companies selling electricity generated at least 50% from fluctuating renewable energy sources, inclusion of photovoltaic plants in the feed-in management, as well as supporting instruments outside the EEG. With respect to the system and grid integration, a number of measures were adopted as part of the energy package of the Federal cabinet, among which an Act amending provisions of energy business legislation ("Gesetz zur Neuregelung energiewirtschaftsrechtlicher Vorschriften"), an Act on measures to accelerate the expansion of the electricity grid ("Gesetz über Maßnahmen zur Beschleunigung des Ausbaus der Elektrizitätsnetze"). The EEG 2012 supersedes 2009 Amendment of EEG and was superseded by 2014 Amendment of the EEG. http://www.iea.org/policiesandmeasures/pams/germany/name-24289-en.php http://www.iea.org/policiesandmeasures/pams/germany/name-145053-en.php	€4

		2013 – 2016 in force ***Richtlinie für die Förderung von Energie management systemen*** Energy and Climate Fund: EUR 4 million in 2015 and 2016 Funding Programme to increase energy efficiency in industry and services sectors. The aim was to promote a widespread implementation of energy management systems. Subsidises certification of an energy management system or an energy controlling system and the purchase of measuring equipment and software that is necessary for the introduction of such a system.	€14.5 + €19.5 + €27.5
		2013 – 2016 in force ***Richtlinie für die Förderung von energieeffizienten und klimaschonenden Produktionsprozessen*** Funding programme to increase energy efficiency in production processes. With this measure, we support companies to decide in case of investments for the most energy efficient and environmentally friendly solutions in the design of their production processes. We subsidize production process conversions to energy efficient technologies. The budget is 14.5 million in 2014, 19.5 million in 2015 and 27.5 million in 2016.	€2000 (soft loan) +€300/year to 2020 +€315 (2015-2018)
		2014 – in force ***3rd National Energy Efficiency Action Plan (NEEAP)*** The National Energy Efficiency Action Plan (NEEAP) is a requirement of the EU Energy Efficiency Directive (EED, 2012/27/EU). The Plan includes energy use and efficiency targets and reports on efforts and progress to date. **Targets:** •average annual increase of 2.1% in macroeconomic energy productivity from 2008 to 2020 •reduce primary energy consumption from 2008 levels by 20% by 2020 and by 50% by 2050 **Results to date**: •Energy savings of 2,246 PJ by 2016 (993 PJ between 1995-2007 and 1,253 PJ between 2008-2016)	+€6

		<u>**Measures and actions:**</u> **Quality control and optimisation of existing energy consultancy services** to support energy efficiency consulting for refurbishment plans of entire buildings, including groups of owners. Target savings: 4 PJ of primary energy consumption. **Tax incentives for energy efficiency refurbishment** targeted at improving energy efficiency and renewable heat usage in residential buildings (target date Q1 2015). Target savings: 40 PJ of primary energy consumption. **CO2 Building Refurbishment Programme** has been extended to increase funds available through the soft loan programmes to EUR 2 billion, with an additional EUR 300 million/year. The programme is now extended to commercial and communal properties, as well as residential. Target savings: 12.5-51.5 PJ of primary energy consumption. **Pilot Energy Efficiency Tenders "Step Up!"** is a pilot phase (2015-2018) for energy efficiency tenders to take place in a variety of sectors, e.g. IT servers, heat pump replacements. Total funding EUR 315 million from 2015-2018. **Increased guarantee provision for long-term energy efficiency contracting** to EUR 2 million over three years starting from 2015. Target savings: 5.5-10 PJ of primary energy consumption. **KFW Energy Efficiency Programme** has been extended to include two new levels of access to the programme ("Starter" programme at 10% energy savings, and the "Premium Standard" at 30%). The programme supports private sector energy efficiency improvements through soft loans. Target savings: 29.5 PJ of primary energy consumption. **Energy Efficiency Network Initiative** targets the creation of 500 "Energy Efficiency Networks" by 2020 to provide implementation frameworks and tools for the government's energy efficiency plan at a local level. Target savings: 74.5 PJ of primary energy consumption. **Top-Runner Initiative** plans to push for increased energy efficiency in supply chains and product development through the creation of higher standard at a	

		national level and the granting of EUR 6 million in research support. Target savings: 85 PJ of primary energy consumption. **Mandatory energy audits** require large companies to perform a full certified energy audit of their activities by the end of 2015. Target savings: 50.5 PJ of primary energy consumption. **National energy efficiency labelling for old heating systems** requires heaters and boilers to be given an energy efficiency grading during the existing mandatory chimney-sweep visits. Owners of boilers considered too old or inefficient under the scheme will receive advice on potential upgrades. Target savings: 10 PJ of primary energy consumption. http://ec.europa.eu/energy/efficiency/eed/doc/neep/2014_neeap_en_germany.pdf 2014 – in force ***2014 Amendment of the Renewable Energy Sources Act -EEG-*** The 2014 Amendment of the Renewable Energy Sources Act -EEG- entered into force on 1st of August 2014. The objective of the 2014 amendment to the EEG is to continue steady deployment of renewable energy in Germany in a cost-effective manner by integrating RE more to the market. **RES gross electricity consumption share is set to increase:** • to 40%-45% by 2025 • to 55% - 60% by 2035 • to 80% by 2050 **RES technology expansion corridors are:** • Onshore wind energy – 2.5 GW of net additions annually; • Offshore wind energy – 6.5 GW to 7.7 GW additions until 2020 (800 MW per year); • Solar PV – 2.5 GW annual additions;	

		• Biomass – 100 MW annual additions; • No expansion targets were established for other RE technologies. Tracking of the RE additions will be done through created for this purpose Register administered by the Federal Network Agency. **Mandatory direct marketing:** In order to better integrate renewable energy into the market, operators of new renewable energy plants are obliged to market their generated electricity directly, either independently or through a direct marketer. The EEG 2014 contains two ways of direct marketing: 1. direct marketing with the purpose of receiving a market premium (subsidised direct marketing) or 2. direct marketing without receiving a subsidy (other direct marketing). The ability to reduce the EEG surcharge (so-called green energy privilege, Sec. 39 EEG 2012) by way of direct marketing is no longer available. The possibility of a pro rata direct marketing of energy remains. **Market premium:** The payment of the market premium requires that the energy is direct marketed. The Market Premium consists of the fixed statutory tariff of the respective renewable energy plant minus its technology-specific monthly market value. Management Premium will be no longer granted for direct marketing for wind and solar generators. **Following plants are exempted from obligatory direct marketing:** • Plants with a capacity no larger than 500 kW commissioned before 1st January 2016 and • Plants with a capacity no larger than 100 kW commissioned before 31st December 2015. **Tenders:**	

		Starting from 2017 renewable energy generators will receive financial support via tenders. The rules of tenders are not yet agreed on. **Feed-in tariffs for small scale generators:** RE generators with a capacity up to 500 kW commissioned before 1st of January 2016 are supported via fixed feed-in tariffs. Plant operators may switch on a monthly basis between feed-in tariffs and a market premium or may benefit proportionately from the feed-in tariffs or the market premium. **Domestic consumption surcharge**: In contrast to the EEG 2012, according to which energy produced in generators owned by the energy consumer ("auto supply") did not pay the EEG charges, all energy generators have to pay the EEG charges. Existing self-sufficiency plants will be protected by far-reaching provisions from this fundamental system change. For new self-sufficient energy plants, a number of exceptions are intended from this new imposition of the EEG charges. http://www.bmwi.de/English/Redaktion/Pdf/renewable-energy-sources-act-eeg-2014,property=pdf,bereich=bmwi2012,sprache=en,rwb=true.pdf http://www.bmwi.de/EN/Topics/Energy/Renewable-Energy/2014-renewable-energy-sources-act.html	
		2015 – in force **Ground-mounted PV Auction Ordinance** As part of the reform of the EEG in 2014, renewable energy capacity is to be procured via auction system commencing 2017. To support the transition to this new system Germany introduced pilot version of the auction system for ground-mounted solar PV. The aim of the pilot auction for ground-mounted PV installations was to achieve the expansion targets for renewables in a cost-efficient manner. The pilot auction has ensured that new ground-mounted PV installations are being built while maintaining a high level of public acceptance and stakeholder diversity.	€30

		Auction system is open only for the ground-mounted solar PV installations with capacity no smaller than 100 kW and no larger than 10 MW per project. 2016 – in force **Subsidy for solar PV with storage installations (Programm zur Förderung von PV-Batteriespeichern**) This EUR 30M program commenced in March 2016 and will extent to 2018 to support investments into the battery storage of electricity generated from PV residential installations. The aim was to strengthen grid services of solar plants and help reduce costs. **The scheme provides:** •Soft loans[46] up to EUR 2,000 / kW for the solar PV system and •Capital grant covering up to 25% of the eligible solar PV panel The programme funding put in place an artificial cap on capital grants through to June 2016 in the event that the program was oversubscribed with a mechanism to progressively reduce the available funding every six months. A similar programme was available in 2012-2015 that offered a 30% rebate per project to help offset the cost of installing an energy storage system alongside their existing grid-connected PV installation. 2017 – in force **2017 Amendment of the Renewable Energy Sources Act (EEG 2017)** On 8th of July 2016 Germany adopted amendment to the Renewable Energy Act (further: EEG 2017). The amendment will enter into force on 1st of January 2017. The reform introduces public tender procedures for onshore wind, offshore wind, solar and biomass projects in country's efforts to shift from FIT support renewable energy deployment to market orientated price finding mechanism. With that, projects will no longer be eligible for statutory feed-in tariff remuneration but will have to bid for it in public auction organised and monitored by the Federal	

[46] Soft loan is an instrument of development financing policy supported by government to lower market interest cost of capital for investors.

		Network Agency (Bundesnetzagentur). Successful projects will receive contracts for duration of 20 years for sell of the produced electricity at the price that they bid during the auction process. Germany aims to increase its renewables share to 40%-45% by 2025, to 55%-60% by 2035 and to reach a minimum of 80% by 2050, as set in EEG 2014. EEG 2017 replicates those targets. The amendment **stipulates capacity corridors for technology deployment in order to control capacity volumes** commissioned each year, similarly as EEG 2014 did.	

5.8 Appendix B German chancellors' climate actions performance ranking

Table B 5-1 MCA ranking of Chancellor Helmut Kohl's climate actions performance

Tier 1 criteria	Tier 2 criteria	Tier 3 sub-criteria	**Helmut Kohl** Christian Democratic Union (CDU) 1/10/1982 – 27/10/1998 CDU/CSU – FDP CDU/CSU – FDP – DSU CDU/CSU – FDP **Grade ranking rationale**
Total performance ranking = 0.83*0.5+0.7*0.4+0.09*0.1=0.7			
Political acceptability A=(1+1+0.5)/3=0.83	*Leadership support* A1=(1+1+1)/3=1	A11=1	Domestic advocacy is evidenced through the establishment of *advisory panel* established by the Bundestag to address concerns about climate change. This responded to a published article in the Spiegel magazine on global warming that showed the Cologne cathedral half covered in water in 1986 (CLEW, 2015).
		A12=1	The following policies were introduced and their status (Appendix A): •1989 – *ended* 250 MW Wind Programme •1990 – 2008 *superseded* ERP-Environment and Energy Saving Programme •1991 – *superseded* Electricity Feed-In Law of 1991 •1993 – *ended* Full Cost Rates (Kostendeckende Vergütung) •1995 – 1998 *ended* 100 Million Programme •1996 – *in force* Green Power •1996 – 2004 *superseded* Fourth Energy Research Programmme •1997 – *in force* Federal Building Codes for Renewable Energy Production The policy-related total funding including loans was €10.75 billion (equivalent). Refer to Table 5-2 in Chapter 5.
		A13=1	The *Federal States (Länder) Support for Renewable Energy Policy* was introduced in 1985. This policy provided federal government funding to drive the deployment of renewable energy technologies and support initiatives from federal states (Länder). Refer to the following link: https://www.iea.org/policiesandmeasures/pams/germany/name-22071-en.php

	International commitment A2=(1+1+1)/3=1	A21=1	Recognition of the need to address climate change was reflected in a pioneering study and report in 1996 titled “Zukunftsfähiges Deutschland” translated as “Sustainable Germany in a Globalized World”. This report was authored by several German think tanks and set the course for the Energiewende and the sustainable transformation of Germany’s economy and society including the management of resources and how to tackle environmental challenges and globalization. This publication provided a reference for a follow-up study published 12 years later (CLEW, 2015).
		A22=1	Ratification of the national CO_2 emission reduction target of 25% below 1990 levels by 2005 was adopted by the federal government in 1995. Germany’s target within the EU Burden-Sharing Agreement under the Kyoto Protocol was to reduce its GHG emissions by 21% below 1990 level for the first commitment period of 2008-2012. Ratification of the Kyoto Protocol was approved in the parliament on 26 April 2002 (IEA, 2002b p38).
		A23=1	Germany was a key participant in the regional Baltic Energy Efficiency Group (BEEG) (Agora Energiewende, 2015).
	National targets & strategic planning A3=(1+0+0.5)/3=0.5	A31=1	In 1995, Germany established a demanding national CO_2 emission reduction target of 25% below 1990 level by 2005. Refer to criterion A22 above.
		A32=0	No evidence was available on modelling the cost and benefit of RE transitions
		A33=0.5	In 1990, the German government established the Inter-Ministerial Working Group on CO_2 Reduction (IMA CO_2) as a path to achieve RE transition and GHG emission reductions. This Inter-Ministerial working group comprised representatives from many federal ministries and headed by the BMU. While outside the term of office of Chancellor Kohl, the group issued its first National Climate Protection Programme in 2000 which was revised in 2005 (IEA, 2007a p45).

Policy measures / instruments **B=(1+1+0.33+0.67+0.5)/5=0.7**	***Public funding for R&D and RE incentive*** B1=(1+1)/2=1	B11=1	The “Fourth Programme on Energy Research and Energy Technologies” set out the basic plan and funding strategy for energy technologies R&D in Germany for the period 1996 to 2005. The primary objectives were to support R&D related to the national energy policy and concurrently support industrial development and economic growth (IEA, 2002b, p11). About €163 million was spent on developing wind power technologies during 1974-2000 (IEA, 2002b p126).
		B12=1	Various funding incentive programs were initiated by the Federal government positioned to meet a broad range of objectives including: energy R&D; increasing energy efficiency to reduce energy consumption; generating electricity from waste heat production; improving the efficiency of fossil fuels electricity (e.g. clean coal technologies); and improving the economics of renewables so that they can become alternatives to fossil-fuels and nuclear energy (IEA, 2002b p125). Refer to criterion A12 for policies listed.
	Private investment inducement B2=(1+1+1)/3=1	B21=1	Use of renewables and commercialisation of RE was promoted through the introduction of the Renewable Energies Act, the Market Incentives Programme and the *100 Million Programme*; this last programme provides assistance for investments in photovoltaic systems. The promotion of renewables is estimated to reduce CO2 emissions by 13 to 15 Mt by 2005 (IEA, 2002b p38).

		B22=1	The government introduced a range of financial instruments to support RE including: • The Electricity Feed-In Law of 1991 ("Stromeinspeisungsgesetz") ensured grid access for electricity generated from renewable energy sources. It obliged utilities operating the public grid to pay premium prices (feed-in tariffs) for the electricity supplied from RE plants. No public budget funds were involved, as the burden imposed by the law was exclusively borne by electricity suppliers and their customers. • The 1993 Full Cost Rates (Kostendeckende Vergütung) introduced a tariff for electricity from photovoltaic installations. • The 1996 Green Power law provides an opportunity to sell the electricity generated by renewable energy plants not operating under the German Feed-In Scheme (EEG) at a premium on the market. • The Federal Building Codes for Renewable Energy Production amendment in 1997. This amendment provided for the building of wind and water power energy sources on undesignated outlying areas. This placed the planning permissibility on RE sources in line with previous provisions enabling nuclear energy. Refer to Appendix A and Federal Building Code amendment 1997: http://www.iuscomp.org/gla/statutes/BauGB.htm#35
		B23=1	Three renewable energy policies introduced remain in force.
	Market structural & regulatory reforms B3=(0.5+0.5+0)/3=0.33	B31=0.5	The electricity sector has not been subject to intrusive government regulation or significant reform prior to 1998. Until 1998, the energy sector and agreements therein were exempt from competition law within the regulatory structure of the 1935 Act of the Reich to Promote the Energy Industry, which later became the federal Energy Industry Act. and within which, imposed maximum price controls only on electricity sold to small consumers, and the structure of ownership and local government involvement in the sector discouraged intrusive regulation (Van Siclen, 2004).

		B32=0.5	In 1987 the federal government established the independent Deregulation Commission to examine prevailing regulations of economic activities and to make 12 recommendations for the reduction of regulations which are inimical to market forces. It delivered its report, Marktöffnung und Wettbewerb ("Opening of Markets and Competition") in 1991 (Van Siclen, 2004) and provided subsequent direction for the reform of the sector and in particular opening up opportunities for new RE generators.
		B33=0	No action – noting that this period represented the early days in Germany's energy transition.
	Policies feasibility and effectiveness B4=(0+1+1)/3=0.67	B41=0	No carbon pricing mechanism existed.
		B42=1	The Electricity Feed-In Law (StrEG) of 1991 supported entry for new RE generators to the market (Hager and Stefes, 2016; Morris and Jungjohann, 2016).
		B43=1	The StrEG granted priority feed-in for RE sources and guaranteed a minimum price that encouraged new investment in and the growth of wind, biomass and photovoltaic energy supplies. The legacy of the StrEG also served as the foundation for its iterative amendments as the Renewable Energy Sources Act (EEG) 2000, established under Chancellors Schröder's government (Eloy et al., 2016; Hager & Stefes, 2016; Morris & Jungjohann, 2016; Morris & Pehnt, 2016; Blazejczak et al., 2011).
	Policies consistency and continuity B5=(1+0+0.5)/3=0.5	B51=1	Long term policies structured introduced as noted in comment at A12 above for policies introduced.
		B52=0	No monitoring mechanism of policy performance for ongoing improvement as it was still in its early phase.
		B53=0.5	2 policies still in force as at 2017
Implementation, tracking & reporting C=(0.17+0)/2=0.09	***Implementation institute capacity*** C1=(0.5+0+0)/3=0.17	C11=0.5	Up to 1998, the responsibility for all energy issues except the energy R&D were managed by the Federal Ministry of Economic Affairs (Bundersministerum fur Wirtschaft – BMWi) (Matthes et al., 2015) and all R&D for renewable energy technologies were managed and implemented by the Federal Ministry of Education and Research (IEA, 2002b p128).
		C12=0	None
		C13=0	None

	Robustness of tracking & reporting C2=0	C21=0	None
		C22=0	None

Table B 5-2 MCA ranking of Chancellor Gerhard Schröder's action performance

Tier 1 criteria	Tier 2 criteria	Tier 3 sub-criteria	**Gerhard Schröder** Social Democratic Party of Germany (SPD) 27/10/1998 – 22/11/2005 **SPD – Green** **Grade ranking rationale**
Total performance ranking = (A*0.5+B*0.4+C*0.1)/3 = (0.94*0.5+0.97*0.4+1*0.1)/3 = 0.96			
Political acceptability A=(1+1+0.83)/3=0.94	*Leadership support* A1=(1+1+1)/3=1	A11=1	Advocacy for a strong domestic mitigation target is reflected in Germany's achievement of its Kyoto obligation under the National Climate Protection Programme adopted on 18 October 2000. This encompassed 64 measures across seven sectors including: households, transport, industry, energy, renewables, waste management and agriculture. In 2005, Germany published its revised National Climate Protection Programme. The programme outlined measures to reduce GHG emissions primarily in sectors and areas that were not covered by the EU Emissions Trading Scheme including households and transport (IEA, 2007a p47).
		A12=1	The federal government's Energy Report (Sustainable Energy Policy to Meet the Needs of the Future) (November 2001) emphasised sustainable development within its energy policy. It defined three key objectives: supply security, economic efficiency and environmental compatibility (IEA, 2002b p19). In the seven years reigning of the SPD/Greens coalition government, 25 renewable energy related policies/measures were introduced with €6.68 billion funding provided. Refer to Appendix A and Table 5-2 in Chapter 5.
		A13=1	In the German political system, the Federal energy-reform policies need to be promoted through the acceptance of the 69 members of the German Bundesrat

			(upper house) who are not being elected, rather are being posted as a composition from the 16 state governments (Länder) (IEA, 2007a p15). The federal is primarily responsible for passing legislation on energy policy and the Länder are responsible for administrative implementation of national law alongside with the significant administrative powers of the federal. The ministerial conferences and a range of joint government and state committees and the recent national-energy summit working groups were established with objectives to involve all states in shaping and support of energy policies through the Bundesrat (IEA, 2007a p23).
	International commitment A2=(1+1+1)/3=1	A21=1	Germany committed to meet a number of RE and GHG reduction targets and objectives as part of its international, EU and domestic commitments (IEA, 2007a p11).
		A22=1	The government approved the ratification of the Kyoto Protocol in the parliament on 26 April 2002 (IEA, 2002b p38). This established the goal of a 21% GHG emissions reduction below 1990 level in 2012. Nationally, it also set a target of producing 12.5% of electricity from RE sources by 2010 and set an ambitious target to double energy productivity – a measure of economic output per unit of energy – between 1990 and 2020 (IEA, 2007a p11).
		A23=1	The federal government actively participated in setting up a testing ground for an emissions trading scheme for the Baltic Sea region (IEA, 2002b p43). It has also collaborated with international partners on EU R&D programmes and cooperated with non-OECD countries in RE technology transfer (IEA, 2002b p129). The Baltic Energy Efficiency Group (BEEG) was one of four working groups established by the Energy Ministers of the Baltic Sea and included the governments of Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Russia and Sweden. The BEEG formed on 2 December 1998 and established an action programme that included: CHP strategy, renewables and Market Transformation Programme. Refer to Appendix A.
	National targets & strategic planning A3=(1+1+0.5)/3=0.83	A31=1	In September 2001, the EU adopted a new directive (2001/77/EC) to promote RE. The German government subsequently set an indicative RE target 12.5% by 2010 (IEA,2002 p93). Refer also to criterion A22 above.

		A32=1	The 2001 report "Sustainable Energy Policy to Meet the Needs of the Future" published by the BMWi in 2001, presented two scenarios for the long-term development of energy markets. Scenario I was based on the 1999 PROGNOS/EWI study and Scenario II on the study "Assessment of a 40% Reduction Scenario in Terms of Energy Policy and Overall Economic Impacts" prepared by PROGNOS, EWI, Bremer Energieinstitut (BEI) and the German Institute for Economic Research (DIW, Deutsches Institut für Wirtschaftsforschung) for the federal government in 2001 (IEA, 2002b p23).
		A33=0.5	No specific plan or pathway was established. However, a new energy research programme with increased R&D budgets has also been released (IEA, 2007a p26) and agreed goals established the direction for Germany's energy transition plan.
Policy measures / instruments B=(1+1+1+0.83+1)/5=0.97	*Public funding for R&D and RE incentive* B1=(1+1)/2=1	B11=1	In 2000, €73 million was allocated to renewables R&D. This was divided between solar (67%), wind (21%), and biomass (12%) (IEA, 2002b p125). The estimated federal budget for non-nuclear R&D for 2001 was €165 million and the planned budget for 2002 was €150 million. This funding was in addition to that indicated in the ***Fourth Energy Research Programme*** And the federal government's ***Investing in the Future Programme*** (€153 million for 2001-2003). These funds were matched with industry co-contributions that increases the total budget to over €250 million (IEA, 2002b p127).
		B12=1	The ***100,000 Rooftops Solar Electricity Programme*** (built on an earlier rooftop program initiated in 1999) set an aim to install 300 MW of photovoltaic capacity by 2003 (IEA, 2002b p92). This programme linked to other initiatives to develop photovoltaics, through feed-in mechanisms and R&D (IEA, 2002b p97).
	Private investment inducement B2=(1+1+1)/3=1	B21=1	The federal government has established many joint projects with industry. This was aimed to support the introduction of new energy technologies to the market (IEA, 2002b p128).
		B22=1	The following policies/laws were introduced that were aimed at supporting the RE sector. The status is provided in italics: • 2000 – *ended* Emissions Trading Scheme. Its objective was to evaluate the possibilities and conditions for the implementation of an emissions trading scheme as recommendations for policy.

			•2004 – *in force* Emissions Trading Law. The Greenhouse Gas Emission Trading Law (TEHG) was effective on 15 July 2004. •2000 – 2004 *ended* Renewable Energy Sources Act (EEG). This Act replaces the Electricity Feed-In Law of 1991 aiming to double the share of electricity produced from renewable energy by 2010. The grid operators are obliged to accept the connection of renewable energy plants to the grid and purchase the electricity at a set tariff for each individual technology based on its actual generation cost. •2000 – 2002 *superseded* Combined Heat and Power (CHP) Extra Law. Effective in May 2000, the Co-generation Act guarantees temporary protection for existing CHP installations operated for the public grid. •2002 – *in force* (amended 2008/2011/2012 Combined Heat and Power Law). This replaced the 2000 law on the CHP to cover the renewable energy technologies excluded from the EEG. •2005 – *in force* Energy Industry Act (amended in 2012). This established a framework to enhance competition, security of supply and sustainable energy production. Refer to Appendix A.
		B23=1	The SPD-Greens coalition government adhered to the climate/energy policy targets set by the previous government and replaced some of their policies and introduced the new ones with long-term objectives. The continuity of policy is evidenced by 13 policies that remained in force. Refer to Table 5-2 in Chapter 5.
	Market structural & regulatory reforms B3=(1+1+1)/3=1	B31=1	The liberalisation of the electricity market in Germany began in 1998 (IEA, 2007a p122). However, the third-party access still needed to go through complex negotiation to reach a mutual agreement until the Energy Industry Act was enacted since 13 July 2005. The Act improved conditions for competition in Germany's electricity and gas markets. Electricity and gas grid operators are now subject to regulation by the newly established Bundesnetzagentur (BNetzA) and by regulatory authorities in the individual German states (IEA, 2007a p122). Among other things, grid operators are also responsible for ensuring non-discriminatory access to the transmission networks (IEA, 2007a p30).

			The IEA is pleased to see real progress on market reform since the last review in 2002, particularly in the electricity sector where a competitive market has begun to develop. The large and strategic location of Germany's electricity and gas markets make their success pivotal to the success of EU-wide electricity markets integration (IEA, 2007a p37).
		B32=1	The Bundesnetzagentur was established in July 2005 to regulate all network industries in Germany (including electricity, gas, telecommunications, postal and, since 1 January 2006 the railway markets). The initial focus of the regulator was to address and set grid fees, which were subject to ex ante regulation (IEA, 2007a p31). Refer to the criterion B31 above for more details. The term ex ante refers to strong "before the event" market intervention by a regulatory body and includes measures such as pricing regulation and placing obligations on a provider or providers to offer wholesale products. This is as opposed to ex post regulation which involves mechanisms such as competition law, arbitration and penalty processes.
		B33=1	The Bundeskartellamt, an independent competition authority was granted expanded powers to investigate and prosecute entities in the energy sector that limit competition. Investigations in 2002 and 2003 led to changes in procurement and accounting systems of some private energy companies (e.g. refer to Press release dated 19/08/2002: http://www.bundeskartellamt.de/SharedDocs/Meldung/EN/Pressemitteilungen/2002/19_08_2002_BEWAG_HEW_eng.html
	Policies feasibility and effectiveness B4=(0.5+1+1)/3=0.83	B41=0.5	The EU Emissions Trading Scheme (EU-ETS) as carbon-pricing mechanisms was designed to cap the CO2 emissions from carbon-intensive industries and energy sector. The German EU-ETS Trading Law and the national trading permits allocation were implemented in 2004 (Appendix A) before the launching of the trading market in 2005 as its first phase until the end of 2007 (IEA, 2007a p29). Installations included in the EU-ETS can meet their obligations either by implementing emissions reduction measures of their own, or by purchasing allowances from other installations covered by the EU-ETS, or by purchasing credits from the Kyoto Protocol's flexible mechanisms (Joint Implementation or the Clean Development Mechanism) (IEA, 2013b p57).

			The EU-ETS was criticised for a decentralised approach to the national allocation of over-generous allowances, the vague criteria used for guidance that had led to unequal treatment of comparable installations in different Member States that caused distortions of competition. As a result of low carbon price, the EU-ETS has failed to realise the full emission reduction potential anticipated in the first phase (Weishaar, 2007).
		B42=1	Feed-in tariffs are established and supported under the Renewable Energy Act (EEG 2000). The scheme guaranteed rates ranging from a low of 3.78 eurocents per kWh for biomass to a high of 56.8 eurocents per kWh for photovoltaics which are generally guaranteed for 20 years. The feed-in tariff rates were to enable all technologies to compete at a level playing field in terms of their profitability that is a technology-neutral approach. Annual degression rate was applied to incentivise incremental technology and process improvements between 1% and 5% (except for small hydropower) (IEA, 2007a p28-29). Under the terms of the EEG, RE were also guaranteed priority grid access, transmission and distribution. Further grid operators were obliged to purchase the electricity produced from these sources (IEA, 2007a p68-69).
		B43=1	The feasibility and impact of Germany's energy policy is evidence by being recognised as a world leader in wind power installations and the European leader in photovoltaic installed capacity (IEA, 2002b p96a).
	Policies consistency and continuity B5=(1+1+1)/3=1	B51=1	Collectively, the suite of energy policies was designed to achieve both short- to long-term goals reflecting its long-term commitment. The primary policy instrument EEG 2000 was to promote renewables in the electricity sector with Fit-in tariff fixed for 20 year and progresses were monitored with four-yearly reports. More importantly, the Act had been amended and enhanced in 2004 to upgrade the RE targets when initial targets were achieved early. The EU-ETS aimed at long-term climate mitigation through CO2 reduction, whereas the Eco-tax was designed to improve energy efficiency (IEA, 2007a p68-69). Refer to criterion B42 above for more details of the EEG and Appendix A for other policies.
		B52=1	The EEG 2000 guided the programme and mandated that the feed-in tariff programme be reviewed every four years in order to ensure that individual

			technology is not over-subsidised and the set targets are met (IEA, 2007a p28-29).
		B53=1	13 policies remain in force as at 2017 and many initiatives implemented under the governments presided over by Chancellor Schröder contained long-term objectives that established pathways for future initiatives.
Implementation, tracking & reporting C=(1+1)/2=1	*Implementation institute capacity* C1=(1+1+1)/3=1	C11=1	In 1998, the responsibilities for federal energy policies and energy R&D (e.g. programme-oriented energy research) were transferred to the Federal Ministry of Economics and Technology (Bundesministerium für Wirtschaft und Technologie (BMWi)) (IEA, 2002b p128, 2007 p158). The Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, (BMU)) oversaw the environmental policies including climate change mitigation, as well as the safety of nuclear facilities and the disposal of radioactive waste (IEA, 2002b p22).
		C12=1	Multiple government authorities play a role in renewables promotion and policy. The BMU has responsibility for Renewable Energy Sources Act (EEG) and the market adoption of renewable energy sources and incentive programmes and R&D (IEA, 2007a p24, p67). The German Energy Agency (DENA) created in 2000 was designed to promote energy efficiency and renewable energy providing additional support for the promotion of RE export (IEA, 2002b p22).
		C13=1	Since the last in-depth review in 2002, energy policy institutions and structure remained largely the same and retain a strong capacity for RE reform (IEA, 2007a p21). The main change to the energy industry legislation in 2005 established a network regulator Bundesnetzagentur (BNetzA) and the expansion of the use of renewable energy and the adoption of new energy efficiency targets (IEA 2007 p26).
	Robustness of tracking and reporting C2=(1+1)/2=1	C21=1	BMWi completed a report on the cost and competitiveness of renewables for Parliament, as required by the EEG. This is an important step for enhancing the economic deployment of renewables. The government also collected and reported up-to-date statistics on the progress of RE development (IEA, 2002b p97).

		C22=1	Data collection and reporting were undertaken (See also criterion C21 above.

Table B 5-3 MCA ranking of Chancellor Angela Merkel's climate actions performance

Tier 1 criteria	Tier 2 criteria	Tier 3 sub-criteria	**Angela Merkel** **Christian Democratic Union (CDU)** 22/11/2005 – Incumbent CDU/CSU – SPD (Grand coalition) CDU/CSU – FDP CDU/CSU – SPD (Grand coalition) **Grade ranking rationale**
Total performance ranking = (A*0.5+B*0.4+C*0.1)/3 = (1*0.5+0.97*0.4+1*0.1)/3=0.99			
Political acceptability A=(1+1+1)/3=1	*Leadership support* A1=(1+1+1)/3=1	A11=1	The grand coalition's governing agreement of November 2005 stipulated for Germany to continue to play a leading role in climate change mitigation activities. As set out in the agreement, one of the many Programme Domestic cornerstones and objectives for advancement of the National Climate Protection is to increase the share of renewable energy in electricity generation to at least 12.5% by 2010 and to at least 20% by 2020 (IEA 2007 p46).
		A12=1	During Chancellor Merkle's tenure from 2005 to 2017, there are 36 major policies/measures/instruments amended, enhanced and introduced with a total funding provision for the renewable energy up to €23.9 billion. Refer to Appendix A and Table 5-2 in the Chapter 5.
		A13=1	The Network Expansion Acceleration Act (NABEG) was introduced in order to facilitate network expansion linking the wind energy from the north with large centres of consumption in the south. The Act improves co-operation between the Länder (states) and the federal government

			enabling the Energiewende through streamlining the planning and permitting procedures for supra-regional transmission lines to be carried out by a single accountable source and on harmonised rules (IEA, 2013b p32).
	International commitment A2=(1+1+1)/3=1	A21=1	In August 2007, the federal government adopted the *Integrated Climate and Energy Programme* consisting of 29 separate measures for climate and energy policy aiming at 40% GHG reduction below 1990 level as a contribution towards global emissions reductions (IEA, 2013b p25).
		A22=1	Refer to the criterion A31 below for the ambitious national emission reduction and renewable energy targets set beyond the Kyoto Protocol.
		A23=1	In 2007, Germany held the presidency of the European Union (EU) and G8 (consists of Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States). During both presidencies, Germany has made energy matters top priority, particularly improvement of the functioning of the EU internal electricity and gas markets, expansion of cost-effective use of renewables, improvement in energy efficiency and the EU's international energy relations (IEA, 2007a p26).
	National targets & strategic planning A3=(1+1+1)=1	A31=1	Ambitious climate protection remains at the core of the Energy Concept with key goals to achieve 40% cut in GHGs by 2020, 55% by 2030, 70% by 2040 and 80% to 95% in 2050, compared to 1990 levels. The purpose of these targets is to send strong signals to encourage investment in innovations and RE technologies (IEA, 2013b p26). The share of gross final energy consumption targets: 18% by 2020, 45% by 2040, 60% by 2050 (BMWi, 2015b p7).
		A32=1	In 2007, an energy-policy roadmap was being prepared to guide Germany's energy policy for the coming decades (IEA, 2007a p26). Prior to the release of the energy-policy strategy roadmap, a series of three energy summits were held (with representatives from the energy sector, industrial and private consumers, trade unions, research institutes, environmental and nongovernmental organisations) to develop recommendations as building blocks in drawing up the energy roadmap. The aim of the roadmap was to provide comprehensive market and policy

			conditions for the market players to make their investment decisions on a long-term planning horizon (IEA, 2007a p 28).
		A33=1	The energy-policy roadmap is a comprehensive package containing policies for electricity, heating and transport sectors containing interim milestone targets for 2020, 2030 and 2040. Major policy actions, such as the expansion of renewable energy supply, an increase in energy efficiency, and the development of the electricity networks, are elaborated in the Energy Concept. It is based on scenario calculations produced by independent institutions, and studies underlying the concept mapping out how the energy and climate policy targets can be most efficiently achieved (IEA, 2013b p26).
Policy measures / instruments B=(1+1+1+0.83+1)/5=0.97	*Public funding for R&D and RE incentive* B1=(1+1)/2=1	B11=1	The federal government published its new Energy Research Programme in August 2011 which promotes R&D activities to achieve the policy targets in the Energy Concept. There is also a strong commitment from the federal government to boost its R&D and RE deployment budget funding from €1.9 billion over the period 2006-09 to €3.5 billion for the period 2011-14 (IEA, 2013b p11). The Energy Concept also supports the demonstration and deployment of CCS technology where it is appropriate (IEA, 2013b p107).
		B12=1	Refer to criterion B11 above for the funding budget aiming for the renewable energy deployment objective as well.
	Private investment inducement B2=(1+1+1)/3=1	B21=1	Germany's rapid development of its renewables sector has been driven by its renewables promotion policy, especially the differentiated feed-in tariff (FITs) as part of the Renewable Energy Sources Act (EEG) introduced since 2000. The FIT has proven very effective in deploying renewable energies; notably electricity generation from biomass, wind energy and solar photovoltaics (PV). This policy instrument has also proven successful in bringing costs down, as reflected in particular in the decrease in FIT for PV as a response to the rapid growth in take up of the technology over the past four years (IEA,2013 p10).

		B22=1	In September 2010, the federal government adopted the Energy Concept (Energiewende) as an elaboration of an ongoing energy policy until 2050. It set out a series of measures and targets for the expansion of renewable energy sources, transmission and distribution grids, and improving energy efficiency (IEA, 2013b p137).
		B23=1	The 2010 Energy Concept is a comprehensive new strategy which established the principles of a long-term, integrated energy pathway to take the country to 2050 and determined the renewable energy as the cornerstone of future supply. The Energy Concept built on the success of previous policies, notably the Integrated Energy and Climate Programme of 2007, but adopted more ambitious goals (IEA, 2013b p9).
	Market structural & regulatory reforms B3=(1+1+1)/3=1	B31=1	An amendment to the Energy Industry Act (EnWG), which entered into force on 4 August 2011, was to strengthen requirements for fair network access and thus to improve competition in the electricity and gas markets (IEA, 2013b p152). The four TSOs are required to prepare a joint network development ten-year plan – Electricity Grid Development Plan 2012 (NEP 2012) which was subject to the approval by the Federal Network Agency. The plans would reinforce approximately 2,900 km of lines and construct a further 2,800 km of new power lines which was estimated to be costing around €20 billion to €30 billion over the next ten years. Additionally, more capital investments of between €27.5 billion to €42.5 billion are required over the next ten years for the distribution systems (IEA, 2013b p13).
		B32=1	The German electricity market is in the midst of a significant transition as the volume of renewable energy grows while at the same time large volumes of nuclear capacity are being decommissioned (IEA, 2013b p150). Therefore, the newly amended Energy Industry Act (EnWG) is to ensure a reliable and predictable policy environment, promoting demand response, facilitating market entry and setting locational incentives, and improving energy and balancing markets. The network operators are also required to grant non-discriminatory third-party access to their infrastructure. Access can be denied only where granting it would be

			impossible or unreasonable for operational, capacity, technical or commercial reasons (IEA, 2013b p151-152).
		B33=1	Liberalisation of the German electricity market is an ongoing process that currently all customers are free to choose their own suppliers with price control only for the small consumers and households. Under the Network Access Ordinance (Netzzugangsverordnung), the BNetzA has considerable authority to establish market design features. For legal as well as practical reasons, decisions concerning the design of Germany's electricity market are made after consultation with market participants (IEA, 2007a p122-123).
	Policies feasibility and effectiveness B4=(0.5+1+1)/3=0.83	B41=0.5	The EU-ETS since its launch in 2005 has not realised the full emission reduction potential as originally designed and required a reform to harmonise its excess supply of tradable allowances before it could play an effective role in capping emissions from the Germany's industrial and energy sectors in transitioning to a low-carbon economy (IEA, 2013b p64). The Reuter's analysts had recently trimmed the EU carbon price forecasts as the supply swells from the third-phase auction to an average €5.25 per tonne in 2017 (Twidale, 2017). This may have implications for the achievement of the German 40% reduction target in 2020.
		B42=1	The Renewable Energy Act (EEG) which has been amended since its enactment in 2000 has provided stability of the feed-in tariffs which helps lowering the cost of project finance by reducing risks and making entry attractive for potential institutional investors. This effectiveness is evidenced by the 88% of renewable energy investments in 2011 stemmed from power generation installations qualifying for assistance under the EEG (IEA, 2013b p164).
		B43=1	The German energy policies as a whole are aiming to achieve their long-term goals by providing long-term predictable political and regulatory framework. As elaborated at the criterion B42 above that the FIT as a cornerstone market instrument which has provided long-term capital investment confidence. The fact that Germany is one of the few OECD countries that has successfully decoupled economic growth and GHG

			emissions over the past decade has proved the effectiveness of the adopted policies and measures (IEA, 2013b p54).
	Policies consistency and continuity B5=(1+1+1)/3=1	B51=1	Refer to the criteria B41-B43 above for detailed description of the policies design and long-term objective nature of the policies.
		B52=1	The Energy Concept adopted in 2010 established strategic targets for Germany's climate and energy policy for the long term (IEA, 2013b p50). It contained a wide variety of specific measures to meet these targets to be reviewed every three years from 2013 on monitoring the status of implementation. The necessary measures of the Energy Concept were also financially supported by a sustainable special Energy and Climate Fund (IEA, 2013b p26).
		B53=1	Overall, the main Renewable Energy Act – EEG was amended in 2004, 2009, 2011 and 2012 (IEA, 2013b p115), and more recently, in 2014 and 2017 (refer to Appendix A). The consistency of the policies is evidenced with the 33 policies still in force despite the changes of coalition makeup of government. Refer to Table 5-2 in Chapter 5.
Implementation, tracking & reporting C=(1+1)/2=1	*Implementation institute capacity* C1=(1+1+1)/3=1	C11=1	Multiple government authorities oversee the implementation of RE policies and national mitigation plan: • BMU[47] – responsibles for administering the Renewable Energy Sources Act (EEG), Market Incentives Programme and adoption of RE sources and research on renewables, and the environmental regulation that affects the energy sector (e.g. regulations relating to pollution abatement, climate change mitigation, nuclear safety and radiation protection) (IEA, 2013b p24). • BMWi[48] – responsibles for primary energy policy, such as funding for overall programme-oriented non-nuclear energy technologies research along the entire energy chain, ensuring the security of supply in

[47] BMU – Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.
[48]BMWi – Federal Ministry of Economics and Technology.

			electricity and gas, and for supply in times of oil crises (IEA, 2013b p24, p33).
		C12=1	In addition to the governing and implementing institutes mentioned in criterion C11 above, the German Energy Agency (DENA) is an institute jointly owned by the German government and the KfW Bank with responsibility in promoting energy efficiency and RE deployment, improving the integration of wind power into the network and RE export (IEA, 2007a p25, p146).
		C13=1	The sufficiency of supporting institutes' capacity is evidenced by Germany's considerable progress in reducing the carbon and energy intensities of its economy over the past two decades. It has decoupled GHG emissions and economic growth in the recent years and domestic GHG emissions have declined more than required by the Kyoto target. Energy efficiency improvements and the rapid development of renewable energy sources were among the key drivers of this decline (IEA, 2013b p30-31).
	Robustness of tracking and reporting C2=(1+1)/2=1	C21=1	The Energy Concept stipulated long-term financing plan complemented with a wide range of specific measures towards the set targets. These measures will be monitored and progresses reported by BMWi every three years. The monitoring process is supported by an independent commission of four experts who will examine and comment on the federal government's report. The first monitoring report "Energy of the Future" for the reporting year 2011 was published jointly by the BMWi and BMU in December 2012. The report confirmed that the Energiewende was making progress, but was also confronting with many challenges (IEA, 2013b p28).
		C22=1	The aim of the Progress Report was to provide an overview of the energy transition for deeper analysis over the long term to recognise and track possible trends towards the goals and targets set out in the Energy Concept, and to identify what additional measures might need to be taken. The annual monitoring report is also incorporated into the Progress

			Report in addition to its annual reporting cycle. The monitoring and reporting frameworks are comprehensive and robust based on energy-related statistics data sourced from the Federal Network Agency, the Federal Environment Agency, the Federal Motor Transport Authority, the German Institute for Economic Research, Statistik der Kohlenwirtschaft[49], the Working Group on Renewable Energy Statistics, and the Working Group on Energy Balances. Refer to the following webpage: http://www.bmwi.de/Redaktion/EN/Artikel/Energy/monitoring-implementation-of-the-energy-reforms.html

References[50]

Clean Energy Wire [CLEW] 2015. Milestones of the German Energiewende – factsheet. Paul Hockenos,16 Jun 2015. Available at: https://www.cleanenergywire.org/factsheets/milestones-german-energiewende accessed on 5/11/2017.

van Siclen, S. 2004. Germany - Regulatory Reform in Electricity, Gas and Pharmacies. OECD Regulatory Reform Programme Reports.

Twidale, S. 2017. Analysts trim EU carbon price forecasts as supply swells. Reuters London, January 9, 2017. Available at: https://www.reuters.com/article/us-eu-carbon/analysts-trim-eu-carbon-price-forecasts-as-supply-swells-idUSKBN14T19O accessed on 17/11/2017.

[49] Statistik der Kohlenwirtschaft – an organisation tasked with providing the Government with statistics from the coal industry.
[50] The references supplied are only used in this Appendix B. All other references in the tables that are not listed here can be found from the reference list in the main chapter, so as to avoid duplication.

Chapter 6 – Chapter Introduction

This chapter contained an article that was submitted for publication to the peer-reviewed *Journal of Energy Policy*

Cheung, G., Davies, P. J., 20xx. From a multi-level perspective, what is underlying the contrasting performance of energy transition in Australia and Germany? Energy Policy, xxx, xx-xx.

The investigations of Australia and Germany in the two previous chapters (Chapter 4 & 5) reveal that both countries have differing socio-technical and political positions that impact on their energy-transition performance. To understand more deeply on the underlying factors that have shaped their differing political positions, a big-picture view from the multi-level perspective (MLP) has been adopted in this chapter. The aim was to identify the interlocking technological, institutional and social forces within the landscape, regime and niche dimensions of MLP through the prism of national dynamic socio-economic activities and socio-political interactions.

Extending from the tested concept of the MCA model applied in Chapter 4 & 5, the role of this chapter/paper was also to construct a combined MLP and MCA analytical model applied as a framework to the comparative investigation of Australia and Germany. The MLP-MCA model comparative-analysis results highlighted below are the key contributions relevant to the main objective of the thesis*: to gain insights and new perspectives on the drivers, challenges and causal factors underlying the contrasting energy-transition performance between Australia and Germany*.

From an energy-transition research perspective, the new insights uncovered in this chapter:

1. The static landscape of Australia and Germany, including national fossil-energy endowment and economic structure (resource-based or industry-based) is a crucial determinant on the national climate/energy policy positions (decision-making) driving socio-political agendas and techno-economic pathways.
2. The degree of development of rich fossil-energy resources, as part of a static landscape, can reinforce carbon lock-in as a result of embedded large capital investments irrespective of rich renewable-energy endowments.

3. Mitigation costs are highly dependent on the timing (immediate or delayed actions) of implementing climate/energy mitigation policies and pathways. This timing was found to be of considerable relevance to many countries that the industrialised countries will benefit from early adoption of RE, whereas well-endowed energy/resource-based countries would likely lose (Bauer et al., 2012; Garnaut, 2008; Gerlagh et al., 2009; Sorrell and Sijm, 2003). This factor offered a feasible rationale for Australia's delayed adoption versus Germany's early adoption which has partly shaped their contrasting transition performance.
4. In the absence of national government leadership on climate/energy policy and direction, state and territory governments in Australia are likely to lead the transition motivated by their dynamic-landscape factors, including the compelling economics of RE technologies over fossil-power, regional development and local energy-supply security.
5. Energy transitions are non-linear with ebbs and flows of advances and setbacks in shifting pathways shaped by dynamic landscape factors, such as coalition partners in governments, energy crises, natural disasters and regime-/niche-level interactions. This finding is consistent to and has strengthened the MLP theory of Geels et al. (2016).
6. Coal miners in Australia and big utility companies in Germany were found to be incumbent regimes with dominant forces shaping the energy transition trajectory in both countries.

From a research methodological strategy perspective:

1. Central to the investigation of energy transition is an understanding of the interactions between different levels of scale, particularly regime and niche interactions, as well as their enactments to the changing landscape. None of these can be analysed in isolation. Hence, the methodological approaches (combined MLP-MCA analytical framework, comparative analysis of longitudinal national case study) provided an integrated multi-disciplinary, multi-dimensional and multi-scale analysis with system thinking. The research strategic approaches demonstrated in this chapter can be adapted, tested and expanded to gain new perspectives on socio-technical transition of other nation states.
2. An innovative MLP–MCA analytical framework has proven its ability in uncovering new insights listed above. The model can be further tested and improved to provide finer granular tapestry-view of motivations and causalities that underly national decision-making on setting energy-transition agendas, policies and pathways which affecting their respective achievement in RE deployment and emission reduction.

Chapter 6: From a multi-level perspective, what is underlying the contrasting performance of energy transition in Australia and Germany? *

Grace Cheung, Peter J Davies

Department of Environmental Sciences, Faculty of Science and Engineering, Macquarie University NSW 2109, Australia

Abstract

Australia and Germany have adopted differing socio-technical and political positions to decarbonise their energy systems that underly their current trajectories. Applying a combined multi-level perspective, multi-criteria analysis and comparative case-study approach for the period of 1990–2017, this research uncovers five impactful factors underlying the two countries' energy-transition performance. First, the static landscape, including energy-endowment and economic-structure configurations, is a crucial determinant on the national climate/energy policies driving socio-political agendas and techno-economic pathways. Second, rich fossil-energy resources can reinforce carbon lock-in irrespective of renewable-energy endowments. Third, the national energy-transition decision is influenced by the static-landscape factors which affected an early adoption by the industrialised economy of Germany and delayed in the well-endowed energy/resource-based economy of Australia. Fourth, in the absence of national government leadership on energy and climate policy, the state and territory governments are likely to lead the transition motivated by dynamic-landscape factors including the economics of renewable technologies, regional development and energy-supply security as evidenced in Australia. Lastly, consistent with the MLP theory, energy transitions are non-linear, with ebbs and flows of advances and setbacks in shifting pathways shaped by changing landscape factors.

Keywords

Renewable Energy, Energy Transition, Climate and Energy Policy, Politics of climate change; *Energiewende*

---

* *This chapter was submitted on 21/09/2018 as a co-authored paper Dr Peter Davies to the Journal of Energy Policy.*

6.1 Introduction

Energy transitions can be triggered by a diversity of forces. Historically, socio-technical transitions emerged spontaneously and autonomously through entrepreneurs exploring commercial opportunities of new technologies for niche advantages (van den Bergh and Bruinsma, 2008). Under pure market-based conditions, new technologies generally took a longer time[51] to reach maturity until their price became competitive over the incumbent technologies (Elzen et al., 2004; Fouquet and Pearson, 2012; Kern and Markard, 2016). The current low-carbon energy transitions are driven by energy-security and climate-change concerns (IEA, 2012a). Thus, it is steered and driven by governments within a complex combination of market-based instruments and governance frameworks designed to ensure secured supply while transitioning to clean energy. Decarbonising energy systems carries socio-economic and political challenges and risks on the one hand linked to addressing immediate and critically future concerns of climate change but also the past and present inertia to overcome locked-in infrastructure and path-dependent socio-technical systems (Geels, 2018; Unruh, 2000). This requires multi-dimensional structural changes across the energy-resource sector to supply industry and consumer demands and be reflexive in social-economic structures, institutions, policy and legal concerns (Elzen et al., 2004, 2011; Geels et al., 2017; Groba and Breitschopf, 2013; Smith et al., 2005; van den Bergh and Bruinsma, 2008). Simultaneously, these changes need to ease the tensions between the inertia of the incumbent regimes with an implicit commercial advantage founded on maintaining the status quo in order to protect their vested interests and the niche-technology innovators/entrepreneurs developing and seeking market penetration of new commercial opportunities (Elzen et al., 2004, 2011; Geels, 2014b; Mattauch et al., 2015).

The catalyst for climate-change energy transitions arose in 1992 from the first Earth Summit of the UNFCCC in Rio de Janeiro and has been the subject of ongoing Conference of the Parties (COP) meetings. The COPs review the national commitments of the climate change convention and decision-making on effective implementation of national carbon-emission reduction and renewable energy targets (RET). The pledge and speed of nation states' response to the climate change convention has been the subject of many studies (Cheung and Davies, 2017; Cheung et al., 2018 in review; Climate Action Tracker, 2015a, 2015b; Lins et al., 2014; REN21, 2013, 2018; Smil, 2016). There remains, however, an underlying concern that the rate of energy transition and targets therein, are insufficient to mitigate climate change risks (Smil, 2016), despite an acceleration in investment in and installed capacity of renewable energy (REN21, 2017).

[51] It was generally taking 40–120 years to reach technological maturity and complete the transition.

Energy transitions are socially disruptive[52] and politically contested[53], hence the adopted policies, intended technological pathways and targeted speed of progress are often non-linear[54] and varied (Geels et al., 2017). Many energy-transition studies have demonstrated that its success cannot be driven solely by techno-economic approaches with climate/energy policies focusing merely on financial incentive and regulation-dimensions drivers (Berkhout et al. 2009; Cohen et al. 2010; Stephens et al. 2008; van Vuuren et al., 2012). To achieve a speedy, sustained and effective transition, a system-wide understanding of implicit and explicit contextual interactions and complex relations between institutions, technologies, energy-suppliers and consumer practices is paramount (Bergek et al., 2006; Cherp et al., 2018; Child and Breyer, 2017; Geels, 2004a, 2004b; Kern and Markard, 2016). Hence, the multi-level perspective (MLP) can be applied to provide a ‘big-picture’ view that provides an explanation of both stability and changes caused by the central conflicts of disagreement and contestation among various social stake-holding groups (Geels et al., 2017). However, the discursive analysis of MLP does not quantify the complex impacts and interactions at the socio-political and socio-technical levels. By incorporating a quantifiable multi-criteria analysis (MCA) technique, the MLP concept can be enhanced to investigate energy transitions. In this article, a MLP–MCA model has been developed and applied to Australia and Germany as a comparative case study.

The aim of this article is to construct a new analytical framework that combines the system-wide view of the MLP and a quantifiability of MCA to provide a tool to measure temporal responses to national energy-transitions. The study applies a combined mixed-methods, longitudinal case-study and comparative analysis approach based on ex-post historical data from government reports and studies. The MLP–MCA model will assess the positive/negative enactments of regimes and niches as forces for or against energy transitions within a broader national landscape configuration. The focus of the analysis covers the tenure of four Australian prime ministers and their governments between 1996 and 2017 and three German chancellors and their governments between 1990 and 2017.

[52] Disruptive, because they threaten the economic positions and business models of some of the largest and most powerful industries (e.g., utilities, coal miners), which are likely to protect their vested interests (Geels, 2014b).
[53] Contested, because actors disagree about the desirability of different low-carbon solutions and often resist their implementation (e.g., onshore wind turbines, carbon capture and storage) (Geels et al., 2016, 2017).
[54]Non-linear, because climate change policies and low-carbon innovations can experience setbacks, accelerations, or cycles of hype and disappointment (e.g. this is reflected, for example, in recent fluctuations in current climate policies of the UK, USA, and Australian governments) (Geels et al., 2016).

6.2 Interlocking technological, institutional and social forces

Energy transition has been defined 'as a change in the state of an energy system as opposed to a change in individual energy technology or fuel source' (Grubler et al., 2016 p. 18). The wider scientific consensus in mitigating the climate change risks and addressing other sustainability challenges requires deeper transitions involving many different technologies and pathways encompassing national and global scales (Cherp et al., 2018; IPCC, 2014; Krey et al., 2014). The inherent complexity and scales involved in energy and the wider sustainability transitions will by virtue of these characteristics take a longer time to achieve their desired outcomes (Grubler, 2012; Marchetti and Nakicenovic, 1979; Smil, 2016; Sovacool, 2016). At a national level, the availability of resources is dynamic and often constructed and shaped by constantly shifting socio-economic, technological, and political landscapes (Burke, 2010; Cherp et al., 2018; Meadowcroft, 2011). To investigate the complex dynamics of energy transitions, analysis needs to be based on understanding the governance frameworks/theories beyond technologies, pathways, scenarios or sectoral systems driven solely by techno-economic approaches focusing merely on financial incentive and regulation dimensions (Bergek et al., 2006; Cherp et al., 2018; Jacobsson and Bergek, 2004; Jacobsson and Johnson, 2000; Krey et al., 2014).

Energy transitions are being caught within a techno-economic paradox. Existing 'locked-in' infrastructure in itself has created an inertia to new investments (Unruh, 2000; Unruh and Carrillo-Hermosilla, 2006). Seemingly, many existing unsustainable systems are stabilised through various lock-in mechanisms, such as scale-of-economies, perpetuating sunk investments in power plants and infrastructures, institutional commitments, shared beliefs and discourses, power relations and political lobbying by the established incumbents (Unruh, 2000). These lock-in mechanisms create path dependences that pose as barriers to dislodge the entrenched systems and otherwise serve as obstacles to mitigating climate change and addressing socio-economic issues linked to energy poverty, accessibility and affordability (Child and Breyer, 2017). This points to a need to better understand what and how the various and multi-dimensional and structural elements such as resources/inputs (supply), consumer lifestyles/preferences (demand) and institutions/policies (legislation) can be managed to support transition and transformation (Child and Breyer, 2017; Geels, 2018; Unruh, 2000). Framing within the MLP can help to understand and identify the impacts and levers of contestations from interactive politics and power-struggle dynamics. These dynamics include an inertia of incumbent regimes (utilities and fossil-fuel industries) in maintaining the status quo to protect their vested investment-interests and socio-political power and the technology innovators/entrepreneurs operating at a niche level to explore and push the boundaries for new commercial opportunities to complement and compete in the supply of energy (Elzen et al., 2004, 2011; Geels, 2014b; Mattauch et al., 2015; van den Bergh and Bruinsma, 2008).

To examine the factors underlying a nation's performance in energy transition, it is crucial to have a system-wide understanding of multi-dimensional dynamics of socio-technical changes from complex interactions between policy/power/politics, economics/business/markets and culture/discourse/public sentiment perspectives. The mainstream analytical framework of MLP offers a 'big-picture' view that is particularly useful to analyse long-term dynamics, shifts from one socio-technical system to another, and the co-evolution of technologies and society, as well as explain both stability and changes caused by the central conflicts of disagreement and contestation among various social stake-holding groups (Geels et al., 2017; Geels, 2004a, 2004b). The MLP analytical framework combines theoretical concepts from evolutionary economics[55], science and technology studies[56], structuration theory and neo-institutional theory[57].

The MLP views transitions as non-linear processes that result from the interplay of developments at three analytical levels: innovative *niches*, sociotechnical *regimes* and sociotechnical *landscape* (Geels and Schot, 2007; Geels, 2002, 2004b). Each level embodies a heterogeneous configuration of elements and characteristics. *Niches* refer to the locus for radical innovations from R&D laboratories, subsidised demonstration projects, or small market niches where users have special demands and are willing to support emerging innovations. Such terms as entrepreneurs, start-ups and spinoffs are considered to be niche actors working on radical innovations which might eventually be taken up by the regime or even replace the regime over time (Geels, 2011). *Regimes* refer to the locus of established practices and associated rules that stabilise existing socio-technical systems (Geels, 2004a). From the multi-level perspective, transitions are defined as shifts from one regime to another regime, therefore the niche and landscape levels are considered as 'derived concepts' in relation to the regime, such as practices or technologies that deviate radically from the existing regime and an external environment that influences interactions between niches and

[55] Evolutionary economics is the field of economics that focuses on changes over time in the processes of material provisioning (production, distribution and consumption) and in the social institutions that surround those processes. It also explores the processes and resources that affect a company's development and transformations including trajectories, regimes, niches, speciation, path dependence and routines.
[56] Science and Technology Studies (STS) is a newly emerged research field over the last 4–5 decades that focuses on sense making, social networks, and innovation as a social process shaped by broader societal contexts.
[57] Structuration theory and neo-institutional theory are two of the main theoretical perspectives used to understand organisational behaviour as situated in and influenced by other organisations and wider social forces—especially broader cultural rules and beliefs, rules and institutions as 'deep structures' on which knowledgeable actors draw in their actions, duality of structure, i.e. structures are both context and outcome of actions, 'rules of the game' that structure actions.

regimes. In this light, the *landscape* level represents the external developments or exogenous factors[58] that have overall influence on trajectories of both niches and regimes and their alignment.

While the levels within the MLP provide a framework to differentiate the interests and scales impacting on transition, there remains lesser focus on quantifying the relative impact of these actors and agents and how they either enhance or impede the direction and speed of transition. This can limit the heuristic learning of governments, industry and the community as to the overall socio-technical drivers that support or oppose transition. At a system level, there is a lack of measurement and evaluation dovetails within a reflective and evidence-based analysis of transition processes for ongoing improvement. It is in this context that we see the synergy of extending MLP with MCA as an analytical framework that could measure those positive and negative contesting forces at play that in turn affect the performance of energy transition.

6.3 Methodology

Applying our multi-criteria analysis (MCA) energy-transition model to four Australian prime ministers[59] (Cheung and Davies, 2017) and three German chancellors[60] and their coalition governments (Cheung et al., 2018 in review), political acceptability was found to be the key factor underlying the contrasting energy-transition performance between Australia and Germany. To further shed light on system-wide determinants to the political-acceptability dynamics, this study developed and applied a combined MLP and MCA to the temporal energy transitions in Australia (1996–2017) and Germany (1990–2017). This temporal perspective is deemed important as energy transitions are long-term processes within which the ensuing outcomes are often shaped by preceding conditions and developments, struggles and balances of various social stake-holding groups (Geels et al., 2016). The two countries selected were based on their contrasting energy-transition achievements. Both are democratic, developed and signatory countries to the Kyoto Protocol with carbon-emission reduction commitments.

6.3.1 Research strategies and theoretical frameworks

The case studies used a mixed-methods strategy. Quantitative energy/economic data was used in combination with qualitative information pertaining to motivations, events and social interactions.

[58] External developments or exogenous factors include elections, crisis/accidents, macro-economic trends, commodity price developments.
[59] The prime ministers included in the analysis are John Howard (1996–2007), Kevin Rudd (2007–2010), Julia Gillard (2010–2013) and Tony Abbott (2013–2015).
[60] The chancellors included in the analysis are Helmut Kohl (1982–1998), Gerhard Schröder (1998–2005) and the incumbent chancellor, Angela Merkel (2005–present).

Data and information were sourced from official government statistics, reports, newspapers and a wide range of climate/energy, politics/policy literature from both countries[61]. Both longitudinal cases are divided into three periods defined by a dominant political leader or coalition government. For Australia the periods were 1996–2007, 2007–2013, 2013–2017, and for Germany were 1990–1998, 1998–2009, 2009–2017. For each period, we assessed conditions, developments, social interactions on endogenous/exogenous (landscape) events/factors and struggles among various stake-holding groups (regimes and niches) that impacted and shaped the speed and direction of the energy transition.

A *Grounded Theory* approach (Glaser and Strauss,1967) was adopted to observe climate change mitigation and energy politics and policies chronologically to the relevant period demarcations for each country to understand the complex interweaving relationships of social, political, economic and environmental processes (Dey, 1999; Charmaz, 2006, 2011; Halkier et al., 2011) The MLP–MCA model framed an investigation focus on the interactive forces between MLP dimensions of *landscape*, *regime* and *niche* (Geels, 2002, 2010, 2011, 2014). These dimensions were evaluated through MCA for their negative/positive impacts and results (Konidari and Mavrakis, 2007; Ragin, 1987; Rihoux and Grimm, 2006). The mixed-methods approach enhanced the scope and breadth of research analysis and results (Guest, 2013), since both quantitative and qualitative data sources were integrated and synthesised to provide an aggregated (big-picture) comprehensive interpretation (Creswell, 2003; Greene et al., 1989; Smith, 1986; Tashakkori and Teddlie, 2003).

6.3.2 Multi-level perspective and multi-criteria analysis model

The MLP–MCA energy-transition model was constructed as a hierarchical tree structure based on the MLP concept of the three domains of landscape, regimes and niches as the tier-1 criteria. The landscape contains three sub-criteria to provide the 'big-picture' view of the national energy profile, climate/energy targets and policies, and citizen sentiment on climate/energy mitigation. The regimes domain contains two sub-criteria to provide insights to the actions and inclinations of the incumbent utilities and fossil-fuel industry. The niche domain contains two sub-criteria to provide insights to the conditions and actions of the RE technologies R&D and commercialisation and RE industries and flow-on effects. Each of these tier-2 sub-criteria are further supported by

[61] Official data of Germany from the Federal Ministry of Economics and Technology (*Bundesministerium für Wirtschaft und Technologie* (BMWi)), the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (*Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit* (BMU)).
Official data of Australia from Australian Bureau of Statistics for national economic statistical data, Bureau of Resources and Energy Economics, national communication reports to UNFCCC, IEA/IRENA member-country RE policies website and a wide range of climate policy literature.

two tier-3 sub-criteria to provide finer granular insights into relevant impactful actions and developments as shown in Table 6-1 below.

6.3.2.1 MLP–MCA energy-transition model sub-criteria ranking scales and conditions

Evaluation frameworks, such as MCA, are inherently subjective in what they purport to measure and evaluate. For our study we have sought to minimise the subjectivity and improve the transparency of the analysis through a three-tiered criterion framework of increasing detail through which a five value Likert scale (-1, -0.5, 0, 0.5, 1) was applied with negative and positive values reflecting a retreat from or progress towards energy transition. The assignment of a score for each tier-3 sub-criterion was based on a well-defined combination of a set of conditions as laid out in Appendix A. For easy reference to all the criteria, the letters A, B and C are assigned to the tier-1 criteria, whereas each tier-2 and tier-3 criterion would add its sequential sub-criteria membership number to the code inherited from its corresponding higher-tier criterion (see Table 6-1). Each sub-criterion carries equal weight in its contribution to the value of its higher tier criterion.

6.3.2.2 Evaluation processes

The MLP–MCA model (Table 6-1) was used to assess the negative/positive inclination against or for RE transition in each demarcated period in Australia and Germany. The evaluation processes were evidence-based drawing on data from official government sources of both countries, IEA reports, Bloomberg New Energy Finance reports and relevant literature in the field. Appendix B and C provide the detailed evaluation processes and assessment scores of each period for Australia and Germany correspondingly. The assessment results are summarised in Table 6-2 and Table 6-3 in the following result section.

Table 6-1 Multi-level perspective and multi-criteria analysis model

Tier 1 criteria	Tier 2 criteria	Tier 3 ranking parameters and scales *Scale values: -1=strong negative; -0.5=negative; 0 = neutral; 0.5 =positive; 1 = strong positive*
A – Landscape	*A1 – National energy profile*	**A11 –** fossil-fuel resources and production trend
		A12 – energy demand for economy and dependency on imports
	A2 – Climate/energy targets and policies	**A21 –** CO_2 emission reduction and renewable energy target sufficiency
		A22 – climate/energy policies' effectiveness and consistency
	A3 – Citizen sentiment on climate/energy mitigation	**A31 –** citizen recognition of climate change and attitude on energy
		A32 – events/factors as catalysts of changes in public attitude/action on energy
B – Regimes	*B1 – Incumbent utilities inclination*	**B11 –** market regulation and competition conditions and inertia of incumbents
		B12 – investment trend of incumbents
	B2 – Fossil-fuel industry inclination	**B21 –** production and investment trends of fossil-fuel industry
		B22 – government subsidies and R&D funding conditions
C – Niches	*C1 – RE technologies R&D and commercialisation*	**C11 –** public R&D funding in the renewable energy technologies
		C12 – public institutional support in commercialisation of R&D innovation
	C2 – RE industries and flow-on effects	**C21 –** investment trend of the RE technologies and development of RE industry
		C22 – flow-on effects from development and deployment of renewable energy

6.4 Results

This section provides a summarised results and analysis of political-acceptability scores affecting the energy-systems transitions of Australia (Table 6-2) and Germany (Table 6-3). The analysis incorporates temporal scores of the three MLP criteria, *landscape*, *regimes* and *niches*, aggregated through two lower tiers of their relevant sub-criteria (Table 6-1 in Methodology section). Granular-level details of the data analysis and comments on the rationale for awarding scores are provided in Appendix B for Australia and Appendix C for Germany. Details of the defined conditions for awarding the Likert scores are included in Appendix A.

Our MLP–MCA model views the MLP as flat ontologies with horizontal elements of *landscape*, *regime* and *niche* that intertwine in overlapping relations through circulatory interactions. This approach differentiates from early work on the MLP that characterises the levels as vertically nested hierarchy (Geels, 2011). Thus, the levels in the MLP–MCA model are defined as different degrees of structuration and differences in relation to the scale of local practices of the regimes and niches within an overarching context of the socio-technical landscape.

6.4.1 Analysis of Australia's renewable energy transition

The results of the political-acceptability assessment of Australia for the three distinctive periods are summarised in Table 6-2 and Figure 6-1. The scores reflect a highly varied response to national energy transition.

Table 6-2 MLP–MCA political-acceptability assessment result of Australia 1996–2017

Criteria / sub-criteria	**Period 1996–2007** Liberal/National PM Howard	**Period 2007–2013** Labor Party PM Rudd (2007–2010) PM Gillard (2010–2013)	**Period 2013–2017** Liberal/National PM Abbott (2013–2015) PM Turnbull (2015–2017)
Criterion A – Landscape	**-0.33**	**0.17**	**-0.42**
National energy profile	-1.00	-1.00	-1.00
Climate/energy targets and policies	-0.25	1.00	-0.75
Citizen sentiment on climate/energy mitigation	0.25	0.50	0.50
Criterion B – Regimes	**-0.38**	**0.13**	**0.00**
Incumbent utilities inclination	0.00	1.00	1.00
Fossil-fuel industry inclination	-0.75	-0.75	-1.00
Criterion C – Niches	**-0.13**	**0.88**	**0.00**
RE technologies R&D and commercialisation	-0.25	1.00	-1.00
RE industries and flow-on effects	0.00	0.75	1.00
Total assessment scores	***-0.28***	***0.39***	***-0.14***

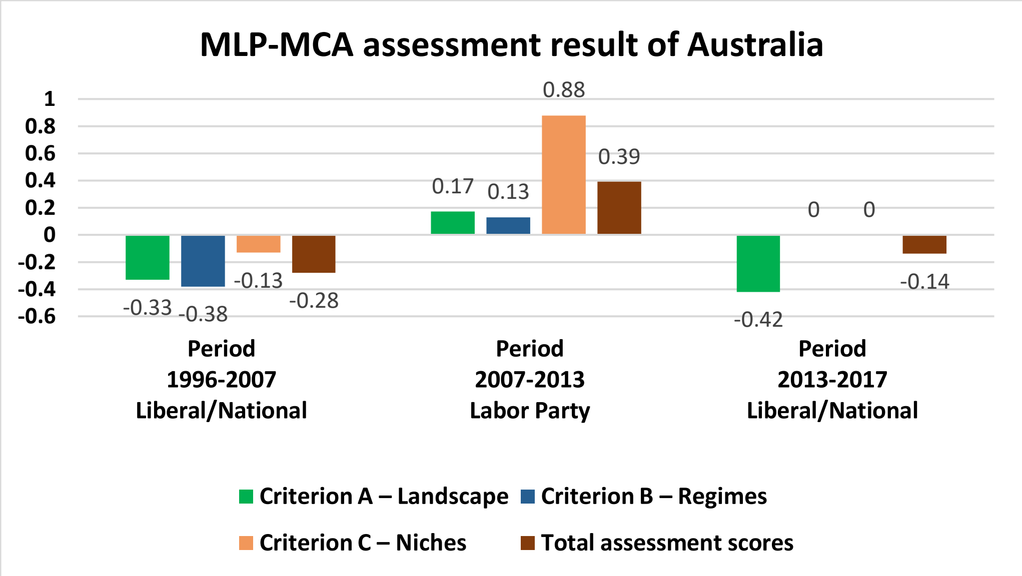

Figure 6-1 MLP–MCA assessment result of political acceptability of Australia[62]

6.4.1.1 Landscape: carbon lock-in, policies and citizen dynamics

From the static-landscape perspective, Australia is resource-rich and remains a major energy-exporting nation. At the macro level, Australia's economy is dominated by and locked-in to massive resource and fossil-energy[63] investments and developments, while the manufacturing sector is in decline. The share of RE generation grew from 0.5% in 1996 to 2.7% in 2007[64] with fossil electricity remaining above 90%. The most recent decade to 2017 has seen the RE share grow to 9.2%[65] with the share of fossil-fuelled[66] electricity falling to but remaining at a high of 84.4%, reflecting the historic dominance of coal-based energy (DEE, 2018). Politically, Australia's energy landscape has a dynamic impact on personal/political ideologies of leaders and political parties and is buoyed by varying citizen sentiment on energy and climate change.

The period 1996–2007 was a decade of climate/energy inaction (as illustrated in Figure 6-1), within which there was early citizen awareness of energy-related climate-risk issues. The absence of an emission-reduction target was symbolic of the political indifference and, arguably, recalcitrance towards global climate concerns by the government of the day. During this period climate and energy policy was subordinate to and more importantly seen as in competition with

[62] In the Australian context, the Liberal/National Coalition Party is considered as carrying a centre-right (conservative) political ideology, whereas the Labor Party is carrying a centre-left political ideology.
[63] Consistent growth of significant investments in coal and LNG development and infrastructures.
[64] This percentage accounted only for wind and solar, excluding the hydro-electricity, which ranged from 6% to 9.2% during this period.
[65] The 6.4% of hydropower was excluded.
[66] Including black coal, brown coal, gas and oil.

domestic economic growth, job creation and international competitiveness (Beeson and McDonald, 2013; Crowley, 2010; McDonald, 2015; Riedy and Diesendorf, 2003). RE policies and measures delivered in this period included the liberalisation of the National Electricity Market (NEM), the setting of a rather unambitious 2% mandatory renewable energy target (MRET) and a A$2.9 billion allocation for the 'Securing Australia's Energy Future' program within which energy R&D was biased towards fossil-fuel industry (only A$26.9M was allocated to RE) (IEA 2005; 2018; Talberg et al., 2013).

Early in this period a global survey report revealed that 50% of Australians perceived global warming as 'serious' and less than 50% were willing to pay 10% more for renewable electricity (GlobeScan, 2000, 2001). A subsequent study in 2006 revealed a marked change in community attitudes, reporting that more than 70% of Australians agreed that global warming was a serious and pressing problem and that action should be taken now even if this involves significant costs (Leiserowitz, 2007). This heightened public sentiment toward climate and energy politics and policies contributed to the election of a new Labor government with a mandate on climate/energy actions, leading to the Clean Energy Plan (Curran, 2011; Hetherington and Soutphommasane, 2010; IEA, 2012b; Pietsch and McAllister, 2010; Tranter, 2011).

During the period 2007–2013 of the new Labor government, several new climate/energy initiatives were implemented. These included the ratification of the Kyoto Protocol with an unconditional emission-reduction target of 5% below 2000 level by 2020, setting long-term emission-reduction targets of 60% below 2000 levels by 2050 and later revised upwards to 80% (Chubb, 2015; Commonwealth of Australia, 2011a, 2011b; Crowley, 2013; Durrant, 2010), and the passing of key legislations to expand the MRET to 20% by 2020 and enable investment in clean energy through strong elements of carbon pricing and feed-in tariffs (St John, 2014; Durrant, 2010; Commonwealth of Australia, 2008; Parliament of Australia, 2007; Cheung and Davies, 2017). Whether imbued by these actions or in response to global concerns, a 2012 community study reported 91% of Australians believed that climate change was caused by human activities and 78% agreed that 'if nothing is done to reduce climate change in the future, it will be a "very serious" problem for Australia' (Reser et al., 2012).

This wave of heightened public sentiment on climate change was short-lived. The Liberal/National Party successfully won over voters by raising concerns on the impact of carbon tax on the cost of living. This shift in social consciousness contributed to a change in government in 2013 whereby the newly elected coalition in its first years in office repealed the carbon-tax and dismantled and lessened targets and funding that had been set up by the previous government. This backflip highlighted the unstable and polarising nature of climate/energy politics at the national level (Climate Action Tracker, 2013; Commonwealth of Australia, 2014; Crowley, 2017; DOE, 2014; Hannam, 2015; McDonald, 2015; Norman, 2015; Parkinson, 2013; Sansom, 2014; UNEP-BNEF, 2014).

6.4.1.2 Regimes: dynamics of utilities and fossil-energy industries

The dynamics of electricity generation in Australian has been subject to disparate and often conflicting forces. There was an overarching theme of incremental neo-liberalism instigated National Electricity Market (NEM) reforms in 1998 that aimed to gradually privatise and corporatise majority of state-owned monopolised systems into the generation, transmission, distribution and retail sectors (ABARE, 2004; Penny et al., 2008). However, the nuances motivating and leading to investment in RE projects were less clear and certainly not linear nor iterative from a ‘rational’ transition perspective. When viewed through a quantitative lens from the MLP, the actual proportion of renewables between 1996 and 2017 grew only 8.7%[67], reflecting a reinforcing techno-economic lock-in of the incumbent fossil-based generation of 84.4% (DEE, 2018). Since 2008, the investment pattern of the incumbents in power generation has contributed to a rise in renewables. This has responded to the government’s more ambitious targets and favorable policies in 2008–13 (Australian Government, 2015e; Penny et al., 2008; UNEP-BNEF, 2014), albeit with a brief setback due to the policy reversal in 2014 (UNEP-BNEF, 2015), and investment confidence linked to ensuing policy stabilisation most notably during 2015–2017 (UNEP-BNEF, 2016, 2017, 2018). Arguably, this reflects the adaptive, agile and more strategic approach to investment of incumbent utilities demonstrating resilience to the otherwise unstable and variable policy positions of government. This is particularly notable in the 2007-2017 period that has witnessed a change in the dominant energy investment from new fossil-fuelled generation projects[68] to more RE projects (BREE, 2012; Penny et al., 2008; Australian Government, 2015e; UNEP-BNEF, 2018)[69]. From a business and economic perspective, this suggests investment in RE

[67] Excluding hydro-power.
[68] The more stimulating climate/energy policies of the Labor government 2007–2013 attracted investment in 2008, adding a total new generation capacity of 6,285MW, of which 86% (A$6.41 billion) were non-renewable (67% gas-fired generators), with renewables adding merely 899MW (A$1.88 billion) (Penny et al., 2008).
[69] The investment pattern of incumbent utilities witnessed a slow transition in 2011 to more renewable (A$3.025 billion) than fossil-generated technologies (A$1.765 billion) (BREE, 2012). This trend continued into 2015 with a total investment of A$41.76 billion in new capacity of 28,968MW, of which only 6,268MW was non-renewable energy (mostly gas power) costing A$5.02 billion, while renewable energy (mostly wind and solar) contributed 22,700MW, costing A$36.75 billion (Australian Government, 2015e).

technologies has passed a tipping point where it has become more viable than coal-fired generation.

Notwithstanding the broader industry transition towards renewable energy leadership, the fossil-energy industries (as dominant regimes) welcome and continue to receive government subsidies and favourable taxation policies. This highlights a dualistic system and policy structures that on the one hand continues to support the incumbent and embedded fossil-energy sector while concurrently seeking to enliven renewable R&D leading to commercialisation. As an example, in the period 1996–2007, fossil-energy industries received A$6.54 billion/annum as incentives to expand exploration and production activities[70] through tax concessions and direct energy R&D funding bias towards coal and LNG[71] (Crowley, 2010; NIEIR, 1996; Riedy and Diesendorf, 2003). In 2009, the federal government continued its explicit support for the dominant regimes through Low Emission Technologies for Fossil Fuels (LETFF) with A$2.5 billion R&D funding encompassing the Carbon Capture and Storage (CCS) Flagships program[72], the National Low Emissions Coal Initiative (NLECI)[73], the Low Emission Technology Demonstration Fund, and the Coal Mining Abatement Technology Support Package (ABARE, 2010).

From an economic perspective, coal and LNG have attracted massive investments[74] in the past decade and contributed significantly to the Australia's economy (ABARE, 2006, 2008, 2010; BREE, 2012). Additionally, for the period 2013–2018, the outlook for coal-mining and infrastructure investment has remained high with an estimated value of US$13 billion (IEA, 2013a). Thus, the domination of the fossil-energy industries in Australia's climate/energy politics is clearly evident with the current federal government's plan to publically fund the Clean Energy Finance Corporation (CEFC) for the CCS and Northern Australia Infrastructure Fund to help build new coal-fired power plants in the state of Queensland (Fabri, 2017; Long, 2017; Reuters, 2017). Ideologically this position of support for coal remains current within the elected coalition government (Perrigo, 2018).

---

[70] Such as the A$360 million in deductible company tax reported in 1994/1995 and A$720 million in deductible exploration costs for petroleum in 1999/2000.

[71] Of A$180 million to energy research in 1994, only A$27 million (15% of the total) was for RE and energy efficiency.

[72] The CCS Flagships program was announced as part of the Clean Energy Initiative in the 2009 Federal Budget with A$2 billion with additional funding from state governments to support the construction and demonstration of large-scale integrated CCS projects in Australia.

[73] The NLECI program was announced as a A$500 million election commitment in November 2007 and was established in the 2008 Federal Budget with the aim of accelerating the development and deployment of low emission technologies and carbon dioxide (CO2) transport and storage infrastructure.

[74] Major new black coal-mine and infrastructure projects reached A$13.58 billion in 2006 and increased to A$24.43 billion in 2011. The major new and committed LNG and infrastructure projects attracted around A$158 billion plus US$62.9 billion in the period of 2004–2017 (ABARE-BREE, 2014).

6.4.1.3 Niches: dynamics

From the landscape perspective, the underlying landscape and regime factors[75] have controlled the development of RE innovative niches. Energy transitions at the niche level have been dominated by a high penetration of small-scale residential/commercial rooftop solar-PV systems. These have been buoyed by Australia's natural solar resources and economic factors including falling solar-PV prices and rising electricity prices (CEC, 2016). The impetus for small-scale solar-PV investment began with generous feed-in tariffs circa 2009/10 that led to a 74% increase in investment from 2009 to 2010 and a 105% annual increase in 2011 with a total value of US$3.8 billion (UNEP-BNEF, 2011; UNEP-BNEF, 2012). In 2015, Australia had 1.4 million household PV systems, equating to one in six households being a stakeholder in distributed solar-power generation (UNEP-BNEF, 2016) that represents one of the highest uptakes by country (UNEP-BNEF, 2018). This in itself represents a significance of socio-technical transition from an energy distribution perspective shifting in part away from centralised generation towards a decentralised, although largely household model (Geels et al., 2016).

Larger-scale solar- and wind-generation systems have taken longer to gain traction. This is attributed to policy uncertainty at the national government level. Notably, in July 2014 through to the end of 2015, the newly elected federal government imposed a ban on the use of federal-government funding for large-scale wind projects that has severely impaired this industry (Hannam, 2015; Parkinson, 2013). Since the ban lifted, there was an industry rush to secure solar and wind projects under the large-scale RET program coupled with high electricity prices and complementary policies of state/territory governments. Combined, these factors have seen the large-scale RE investment in Australia increase to $8.5 billion in 2017 (UNEP-BNEF, 2018). The niche level transitions also highlight the important role of state and territory governments that have acted to fill the national energy policy void.

6.4.2 Analysis of Germany renewable energy transition

The results of the political-acceptability assessment of Germany for the three distinctive periods are summarised in Table 6-3 and Figure 6-3. The scores reflect the underlying strong national energy transition trajectory.

[75] A combination of declining manufacturing sector (no supporting RE manufacturing industry) and almost three decades of successive government funding ideologically oriented to fossil-energy R&D such as clean-coal and CCS technologies over the niche RE technologies (lack of government R&D funding support).

Table 6-3 MLP–MCA political-acceptability assessment result of Germany 1990–2017

Criteria / sub-criteria	**Period 1990–1998** Chancellor Kohl coalition CDU/CSU/FDP	**Period 1998–2009** Chancellor Schröder (1998–2005) coalition SPD/Greens Chancellor Merkel (2005–2009) coalition of CDU/CSU/SPD	**Period 2009–2017** Chancellor Merkel (2009–2013) coalition CDU/CSU/FDP (2013–2017) coalition CDU/CSU/SPD
Criterion A – Landscape	**1.00**	**0.92**	**1.00**
National energy profile	1.00	1.00	1.00
Climate/energy targets and policies	1.00	1.00	1.00
Citizen sentiment on climate/energy mitigation	1.00	0.75	1.00
Criterion B – Regimes	**-0.25**	**0.13**	**0.38**
Incumbent utilities inclination	-1.00	0.00	0.75
Fossil-fuel industry inclination	0.50	0.25	0.00
Criterion C – Niches	**0.25**	**1.00**	**1.00**
RE technologies R&D and commercialisation	0.25	1.00	1.00
RE industries and flow-on effects	0.25	1.00	1.00
Total assessment scores	**0.33**	**0.68**	***0.79***

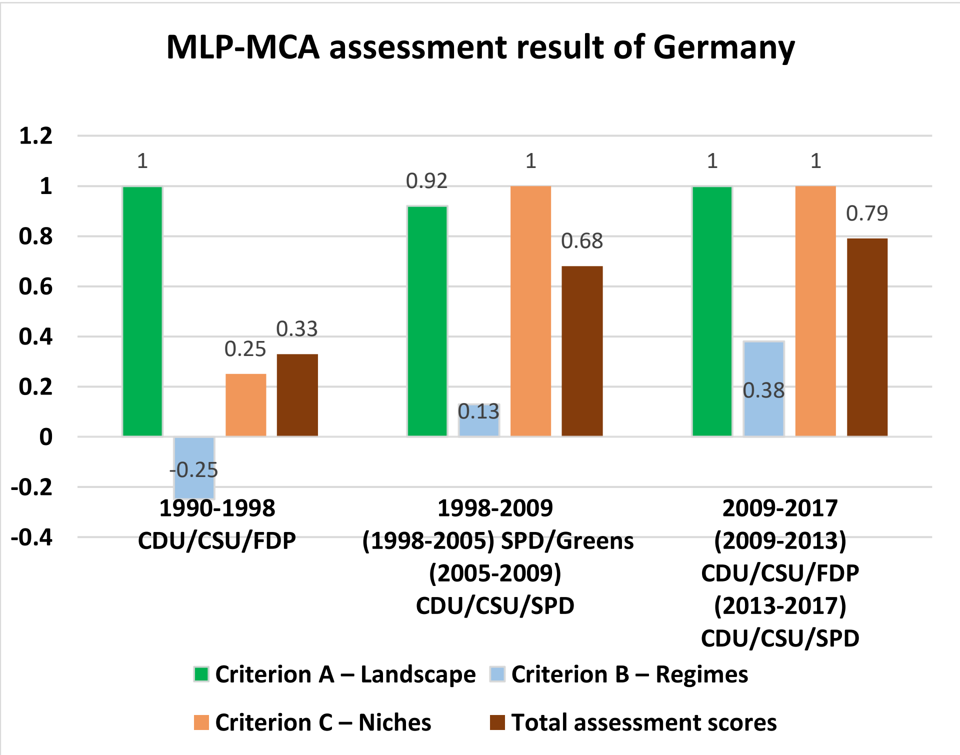

Figure 6-2 MLP-MCA assessment result of political acceptability of Germany

6.4.2.1 Landscape: energy dependency, policies and citizen dynamics

From a static-landscape perspective, with limited indigenous-energy resources[76], domestic energy-supply security remains a core element of Germany's energy and economic policies. As a highly industrialised manufacturing-based nation, it has and continues to remain dependent on energy imports[77] to power its economic growth. Industrial and commercial enterprises consume around 45% of the total electricity (EIA, 2018; BMWi, 2015c). This has contributed to the protective policy for domestic fuel sources (mainly lignite) and over recent decades the significant investment in R&D of RE technologies (wind and solar) and end-use energy-efficiency programs (IEA, 2002b). Despite significant achievements in transitioning to RE (14% of installed generational capacity), the concurrent phasing-out of nuclear power has sustained the need for coal and lignite electricity which remains a major contributor to the national generation capacity, falling slightly to 40.2% in 2016 from 48% in 2007 (BGR, 2009; BGR, 2016; AGEB, 2009).

The socio-political landscape of energy transition in Germany has both deep and influential roots. This can be traced back to the grassroots movement against nuclear power in the 1970s that continues to the present. The anti-nuclear movement was the foundational policy of the Greens Party and their entry to the German Parliament in 1983 (Steentjes et al., 2017). Coupled with this movement was an early and heightened social and subsequent political awareness of climate change. In 1990, this resulted in one of the earliest national climate change action plans. This plan instigated transformative energy policies and programs that has to this day positioned Germany as a world leader in wind power. There has also been many economically integrated energy initiatives and policies including: the gazettal of the Electricity Feed-In Act (*Stromeinspeisungsgesetz*: StrEG) in 1991; establishment of the 250MW Wind Program; legislation enabling the sale of green power to the grid; the Renewable Energies Act (EEG 2000); the 100,000 Roofs Programme; the Energy Industry Act 2005 and many amendment policy updates (BMU, 2007, 2010; Büsgen & Dürrschmidt, 2009; Butler and Neuhoff, 2008; Eloy et al., 2016; Hager and Stefes, 2016; Morris and Jungjohann, 2016; Morris and Pehnt, 2016). Above all, Germany has committed to long-term progressive emission-reduction targets below 1990 levels of at least 40% by 2020, 55% by 2030, 70% by 2040 and 80%–95% by 2050. As for the RE share of gross electricity-consumption, targets are set at least 35% by 2020, 50% by 2030, 65% by 2040 and 80% by 2050 (BMWi, 2015a).

[76] The 2015 energy statistics showed that Germany produced no nuclear fuel, only 2% of crude oil, 10% of natural gas, 11% of hard coal and 100% of lignite, and the shortfalls were covered by imports.
[77] Historically, from 1990 to 2009, its import dependency on oil ranged between 96.3% and 96.6%, and on gas between 74.9% and 84%.

Collectively, these targets and policies have contributed to many significant step changes in energy transformation.

From a social perspective, the level of environmental awareness has been traditionally high among German citizens and this has contributed to the socio-political motivation for transition towards renewable energy (Geels et al., 2017; Morris and Jungjohann, 2016; Morris and Pehnt, 2016). Social surveys have consistently reported high concern (between 70% and 90%) regarding global warming and support for greater actions in mitigation (BMWi, 2014a; Brechin, 2003; Leiserowitz, 2007; Steentjes et al., 2017). Environmental concerns linked to energy security and social support for transition have also been shaped by exogenous events, including the Chernobyl nuclear disaster (instigating energy-transition policy to phaseout nuclear power), the global financial crisis in 2008 (providing a focus for domestic energy and economic security), and the Fukushima nuclear-power disaster (returning to socio-political commitment to nuclear phaseout) (BMWi, 2012; Geels et al., 2017; Jacobs, 2012; Morris and Jungjohann, 2016; Morris and Pehnt, 2016).

6.4.2.2 Regimes: dynamics

Before 1998, the gas and electricity sectors were fragmented and mostly municipally owned. This discouraged any intrusive government regulation and the market functioned through various associations agreements amongst industries and electricity generators, dominated by coal-fired power stations. Within this era, utilities were assigned exclusive territories with the Länder (state governments) regulating households and small-business contracts, whereas the larger industrial consumers were largely unregulated. The federal and Länder governments oversaw investment, but access to the rights-of-way was regulated by communities and often discouraged entry of new generators (van Siclen, 2004).

The liberalisation of the German electricity and gas market in 1998 was aligned with European single-market objectives and national energy objectives for energy-supply security, economic efficiency and environmental protection. However, the liberalisation has led to market consolidation to just big-four utilities[78] retaining distribution assets in defending their pre-liberalisation positions that also produced more than 80% of the total generation in 2002 (van Siclen, 2004). This high concentration of market power of both horizontally and vertically

[78] The 'big four' German utilities, RWE, EnBW, E.ON and Vattenfall, are involved in primary power production, distribution and sales.

integrated utility regimes has formed de facto regional-based monopolies[79] that discouraged new entrants of significant scale (van Siclen, 2004).

The dominant energy generation and distribution regimes did not face significant disruption until the German government adopted the new European directives[80] on electricity and gas in 2002–2003 and amended the Energy Industry Law and Act against Restraints of Competition in 2004 (van Siclen, 2004). Subsequent regime changes impacting on their business models included: the national nuclear energy phase-out policy[81]; increased market share and competition from renewables[82] directly impacting revenue[83]; and declining demand from households and companies which generated 11% of the total national power demand in 2012 (CLEW, 2015; Wigand and Amazo, 2017). Collectively, these factors contributed to a shift in capital investment of the big four utilities towards renewables (mainly offshore-wind mega-projects at US$5.1 billion in 2016) (UNEP-BNEF, 2016, 2017) although on balance, their business models remain locked-in to mostly coal power. Going forward, despite there being only one last new hard-coal power plant scheduled for construction by 2022, 10 hard-coal power plants will be retired in 2018 and remaining lignite plants will be transferred into the so-called security reserve by 2019, noting that the lignite plants comprise seven out of Europe's 10 biggest polluters and 55.3% of ETS emissions in Germany (CLEW, 2017).

Hard-coal power had fuelled the post-war economic boom that also helped spawn the Social Democratic Party (SPD) in Germany. Thus, just as the Greens party has a foundational opposition to nuclear power, the SPD has a long history of protecting the traditional coal/lignite sector. This has included their support for formal national agreements linking the supply of domestic hard coal to German power stations (van Siclen, 2004) and enabling subsidies under the hard-coal mining financing law[84] (*Steinkohlefinanzierungsgesetz*) (CLEW, 2017). From 1960 to 1980, the domestic hard-coal production was in steady decline with dwindling resources so that only four hard-coal

[79] Monopoly at the regional structure of the RWE in the northwest, EnBW in the southwest, E.ON in a north-south strip in the middle of the country and Vattenfall in the new Länder of Hamburg and Berlin.
[80] These directives (Directive 2003/54/EC and Directive 2003/55/EC) mark further progress toward electricity and gas market liberalisation in Europe. They include general rules regarding public service obligations, universal service, customer protection, and monitoring security of supply, and set deadlines for liberalisation of all customers (1 July 2004 for commercial customers and 1 July 2007 for household customers). Of particular interest is the strengthening of the rules regarding unbundling, regulatory bodies, and third-party access.
[81] The most impact was from the simultaneous closure of eight nuclear-power plants in the aftermath of the Fukushima nuclear disaster in 2011.
[82] The domination of the big-four utilities continued with 67% of the conventional power market in 2013.
[83] The big-four utilities recorded a fall in their company profits, where E.ON reporting a loss of €1.9 billion after presenting €6.3 billion of profits in the previous year (2011).
[84] According to Green Budget Germany (FÖS), the sector has received €337 billion in subsidies between 1970 and 2016.

mines remained open in 2012. There are expected to be closed by the end of 2018 (BMWi, 2018a; CLEW, 2017; DW, 2007). Notably, almost 90% of hard coal (54.1Mt) was imported in 2016 (BGR, 2016; BMWi, 2018a). Lignite, however, continues to be self-sufficient, contributing 23% to electricity generation (AGEB, 2018).

6.4.2.3 Niches: dynamics

The oil crises in the 1970s stimulated R&D programs in wind and solar photovoltaics, but during this decade the deployment remained limited as it was not yet cost effective. During the 1980s, small wind turbines were adopted by environmentally motivated citizen groups, farmers, and smaller utilities. While numbers of installations were modest, their impact is best measured by the shift in energy transition discourse and the role of green energy solutions (Geels et al., 2017). Since the enactment of EEG 2000, R&D funding for RE technologies increased substantially from €399 million in 2006 to €604 million in 2009 (BMWi, 2017b).

The energy R&D programme and funding in Germany has been focused towards industry within which it has sought to bring to market new research designs and innovative technologies (BMWi, 2011). The Federal Ministry for Economic Affairs and Energy is responsible for ensuring successful transfer from research laboratories and workshops to industrial production (BMWi, 2016c). With this integrated and enabling approach, Germany has become a market leader and since the 1990s it has been a major exporter of wind and solar technologies that has contributed significantly to the global energy-transition discourse (Greenpeace, 2014; Morris and Jungjohann, 2016). Ongoing R&D funding remains an important national strategy evident by incremental increases from €604 million in 2009 to over €1 billion in 2017 (BMWi, 2014a, 2018b). This integrated R&D strategy, combined with the StrEG 1990 legislation, has been foundational to an ongoing growth and transformation of the German wind industry[85] (AGEE-Stat, 2011). The subsequent EEG 2000 and green-stimulus program in 2008[86] have further expedited the phenomenal growth of wind and solar industries[87] (IEA, 2007a; UNEP-BNEF, 2010, 2011, 2012). Collectively, the share of all RE sources in gross electricity consumption grew from 4.5% in 1998 to 32.3% in 2016, which was mirrored with an annual investment growth from €4.7 billion in 2000

[85] The wind industry experienced a significant growth boosted by the share of RE electricity (mainly from wind) in gross electricity consumption from 3.1% in 1990 to 4.7% in 1998.
[86] The German RE industries were further boosted by the US$15.3 billion green-stimulus program for 2008–2009 as a result of the global financial crisis.
[87] Under EEG 2000, wind-power capacity grew from 1GW in 2000 to 3.2GW in 2002 and added some 18GW of wind power between 1995 and 2005. Solar was adding 7.4GW new capacity, which was well above the government's annual target of 3.5GW to reach an ambitious 52GW goal by 2020. The growth of RE industries investment also surged 132% on the previous year in 2010, driven by feed-in tariff subsidies.

to €27.9 billion in 2016 and with strengthened economy through the increased employment of some 370,000 people in RE industries (BMWi, 2014a, 2016a, 2016b; UNEP-BNEF, 2010, 2011).

6.5 Discussion

Our constructed MLP–MCA analytical model for a decadal-scale comparative analysis of Australia and Germany focused on the static and dynamic landscape characteristics, developments and changes affecting energy transition. Landscape developments comprise both slow-changing trends and exogenous shocks. The slower trends included shifting demographics, ideology, spatial structures and geopolitics, while the exogenous factors comprised economic crises, major accidents, political upheavals and wars. The model revealed static structural differences between the two countries. This reflects differences in their underlining economic and constitutional structures, policy styles, ideologies and natural-energy endowments. These aspects combined have shaped different enactments and decision patterns that have contributed to the sum of static-landscape structures and therein provide different affordances and action possibilities (Geels et al., 2016). Landscape changes, such as elections, accidents, macro-economic trends and commodity prices affect complex dynamics of national political struggles, social acceptance and governance systems. These complex dynamics factors serve as both constraints and catalysts for shifting pathways and accelerated/stalled transitions (Cherp et al., 2018). Our investigation and analysis uncovered insightful factors that shaped the political acceptability for/against the energy transition in both countries that explain their contrasting achievements as discussed in this section.

6.5.1 Contrasting static-landscape characteristics

The two most distinctive contrasting static-landscape characteristics between Australia and Germany are their natural-energy endowment and economic structures. Australia is rich with natural energy and mineral resources, and this is reflected in its resource-based economy. Over the last three decades, Australia has consumed only one third of its total energy production the remainder being exported (ABARE-BREE, 2014). In contrast, Germany has limited natural-energy resources (except lignite) and has established a heavily industrialised economy, which inescapably depends on imported energy (BGR, 2009, 2016; BMWi, 2015c). For these reasons, energy security carries different meanings and priorities to both countries (IEA, 2012a) and similarly impact differently on the dynamic-landscape changes informing energy transition.

In the last two decades in Australia, the massive perpetuating sunk investments in both mining and infrastructures of coal and LNG combined with the resources super-cycle boom[88] has deepened carbon lock-in of its economy (ABARE, 2006, 2008, 2010; Australian Government, 2018; BREE, 2012, 2014; DEE, 2017; IEA, 2013a). These lock-in mechanisms have created an economic path dependence and underlying entrenched political-power relations and lobbying persuasion from the fossil-fuel industries to the governments. These dynamic-landscape factors offer an explanation for the long-term climate-mitigation inaction and policy backflips in the climate/energy politics of Australia. The mild-negative to below-average assessment scores presented in Figure 6-3 for Australia reflect fundamental different political ideologies and thus varying actions between the Liberal/National coalition and Labor parties in the context of the nation's rich energy endowment (static-landscape), along with its dynamic-landscape developments of the super-cycle resources boom.

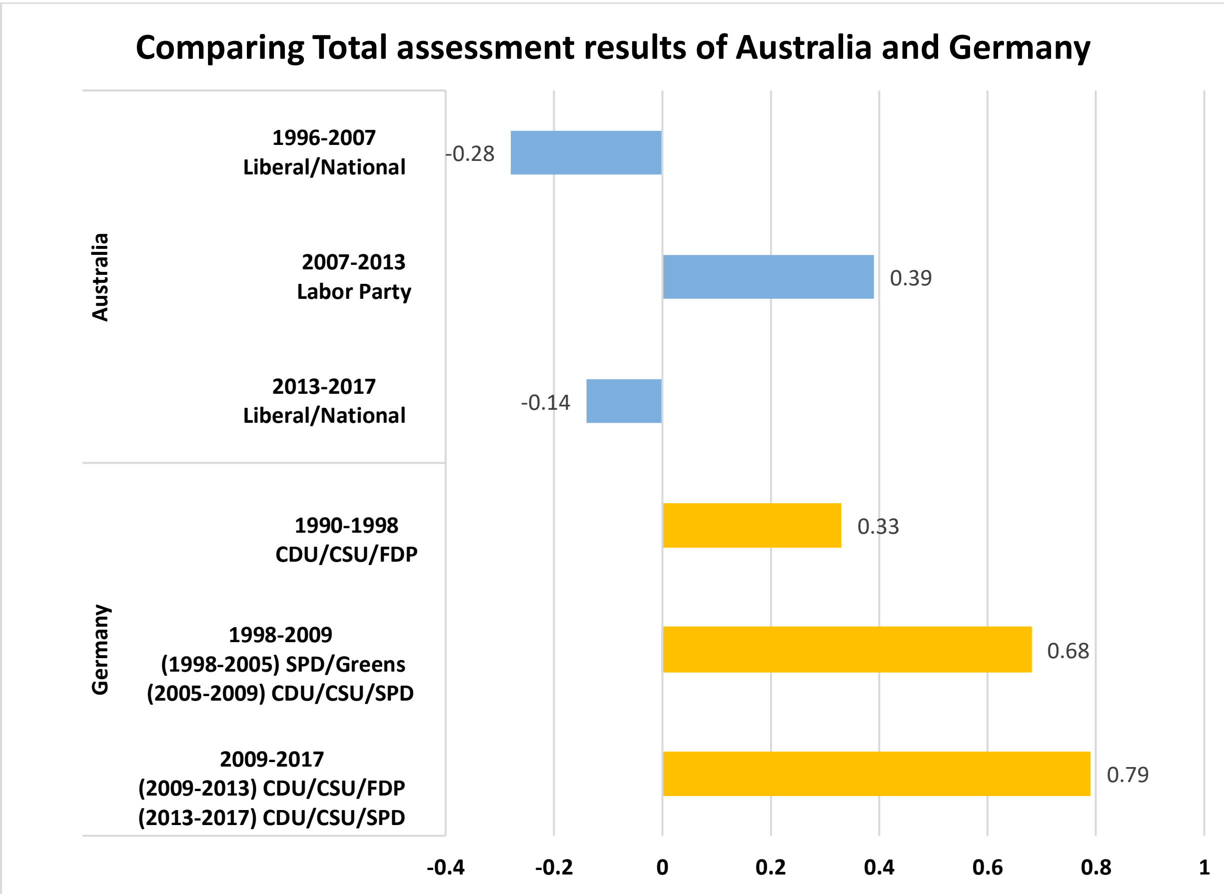

Figure 6-3 Total assessment results of political acceptability of Australia and Germany

[88] Emerging countries such as China and India in Asia have contributed to a long resources cyclical boom in the last two decades that has boosted fossil fuel energy and resource investments in Australia.

The situation for Germany is somewhat different and reveals incrementally higher and positive scores (Figure 6-3) when compared to Australia. The preconditions (static-landscape) supporting this political-acceptability rating reflects the national need to improve energy-supply security by minimising reliance on imports through transition to locally generated RE sources. This has been achieved through techno-economic transitions underpinned by its industrial-readiness economic structure designed to support and sustain a long-term socio-technical transition. RE generation has by and large targeted the replacement of only nuclear and black-coal power (both are non-indigenous), rather than focusing on the transition away from the dirtier yet domestic lignite power. The overarching static-landscape conclusions are that energy security for Australia has been driven by the income and employment derived from coal and gas sector inexorably linked to its resource-based economy while Germany has been driven by a need for domestic energy-supply security required to support its industry-based economy.

6.5.2 Enactment of regimes and niches to dynamic-landscape changes

Transitions have been described as the social-transformation processes in which socio-technical systems change structurally over an extended period (Rotmans et al. 2001). From a multi-level perspective, socio-technical transitions involve interactions between incumbent regimes, radical niche innovations and the socio-technical landscape that only come about through the alignment of processes reinforcing each other within and between the three levels (Geels et al., 2017). Based on a flat ontology of dimensions rather than levels, our MLP–MCA model examined the transition processes and complex interactions between regimes and niches in the context of the landscape level within which both dimensions have little influence on the static landscape, but to some degree can swing the developments of dynamic landscape (e.g. policies, pathways and speed) through their enactments. Based on this premise, our analysis found that even though regimes are characterised as path-dependence dominant and entrenched forces against radical niche-innovations for system changes in Australia and Germany, both exhibited hugely varying enactments in corresponding to their contrasting static landscape.

6.5.2.1 Australian regimes and niches enactments

In Australia, the collective regime forces of the moderate incumbent utilities and dominant entrenched fossil-fuel industries are disproportionally strong. This is particularly notable in the first analysis period (1996–2007) that exhibited very weak to almost non-existent niche activity. Throughout the three analysis periods, there was consistent growth of capital investments in the coal and LNG mining and infrastructure developments and ongoing bias of subsidies and R&D

funding towards fossil-fuel energy. This has further entrenched lock-in mechanisms both economically and politically, irrespective of the political party and their ideological inclination. The high degree of control and influence of the coal industry on energy policy and funding has thwarted any substantive energy transition heralding the construction of new coal-power plants as opposed to RE projects (Belot, 2017). This is a symptom of the dominant regime with an entrenched economic and political relationship that can swing dynamic-landscape developments, such as the government policies. This influence is evidenced by political support for major and controversial coal-mining projects tied to and supported by public-funding [89] despite fierce public opposition, price parity of RE and a grim global outlook on coal demand (Chang, 2017).

Compared to the fossil-fuel industries, the energy-utilities regimes in Australia are relatively moderate, agile and adaptive. This is evidenced by the investment trends and patterns initially being biased towards gas-fired generation that have subsequently shifted towards wind and solar-PV (Australian Government, 2015e; Penny et al., 2008; UNEP-BNEF, 2014, 2016, 2017, 2018). The utility-regimes have demonstrated their adaptability through a cautious uptake of RE founded on the compelling and increasingly favourable economic feasibility. These factors have also supported the closure of five coal/lignite power plants (Australian Government, 2015e). Such enactments of the utility-regimes can be attributed to the NEM liberalisation processes, during which many state-owned generation, transmission and distribution assets were transferred through privatisation to the business sector without creating concentrated ownership and dominant players. Thus, NEM has become a truly competitive environment for both the incumbents and new entrants to thrive. However, the development of RE as an industrial sector (niches) remains limited to installation, construction, maintenance and RE-project services, not manufacturing, reflecting the lack of a strong research, development and manufacturing based economy.

6.5.2.2 German regimes and niches enactments

Germany’s regimes and niches configuration is more in balance when compared to Australia. The fossil-fuel industries are non-dominant regimes: the non-economical production of hard-coal was publicly subsidised for decades which will cease in 2018. While lignite is still competitive and maintaining its share in power generation, there is no significant mine expansion, nor is there a specific phase-out plan in Germany. The dirtier lignite has political support as it has been a political

[89] The Northern Australia Infrastructure Facility is currently considering whether to grant Adani a $1 billion taxpayer-funded loan to build a railway line for its mine.

heartland of the SPD. Further it is the only indigenous energy source with supply security that can support the phasing out of nuclear power by 2022.

In contrast to the fossil-fuel industry, energy utilities are formidable forces in Germany with a highly concentrated, post-liberalisation market share of 80% controlled by the big-four as of 2002 (van Siclen, 2004). This has created a path dependence and barrier for new entrants to the sector. However, an enactment of the StrEG 1991 provided shielding of the niches against incumbent utilities, and the follow-on EEG 2000 has set new goals and broken market barriers for niches to more successfully enter the market through the private sector's deployment of small-scale RE technologies and decentralised energy systems. This has also set Germany on a substitution pathway directed to replace nuclear with RE.

The German government's support at the niche level is based on the twin-pillar integrated techno-economic strategies of energy security and economic growth. The focus on local energy-supply security has led to the flourishing of both wind and solar power and is enabled by relevant supply-chain industries. This vertically integrated climate/energy policies have in turn fuelled the ongoing expansion of the RE research and development leading to commercialisation, employment domestically and export revenue.

6.5.3 The utility of the MLP–MCA model and analysis

Combining the three dimensions (landscape, regimes and niches) of the multi-level perspective and multi-criteria analysis, our MLP–MCA model was constructed to provide a big-picture view of the energy transitions in Australia and Germany. By focusing analysis at the landscape level, it was clear that the domestic climate/energy policies responded to static (energy endowment and economic structure) and dynamic (resources cycle, oil crisis, techno-economic trend) factors in both countries. It has also dissected the interwoven three-dimensional enactments of the regimes and niches to the dynamic landscape (polices). The total assessment scores were reflecting an overarching political acceptability for or against energy transition. The political-acceptability scores offer evidence-based explanations to the contrasting trajectories of Australia and Germany (Cheung and Davies, 2017; Cheung et al., 2018 in review). The strength of MLP–MCA analytical model is its ability to quantify the overall political acceptability of energy transitions that extend beyond the contribution of the static landscape, but also to reveal the complex, interwoven interactions between the regimes and niches within the dynamic landscape.

The Likert-scale assessment scores applied to the three-level, multi-criteria hierarchical structure have an advantage in that they can detail the tapestry-like narratives of the existing sociotechnical regimes and emerging innovative niches and their enactments within both static and dynamic landscapes. The numbers within and between the two countries and the political time-based analysis has demonstrated clearly the rise/fall of regimes and niches as a function of dynamic landscape factors, that is who is in government and what are their policies. However, the limitation lies in the challenges of obtaining quality, comprehensive and consistently tracked ex-post historical data of both countries, given the longitudinal nature of the case study. Going forward, the sub-criteria selected for levels 2 and 3 are by no means perfect or complete and the scoring system could be further expanded and enhanced before application to other countries.

6.6 Conclusion

Extending two previous studies on energy transitions in Australia (Cheung and Davies, 2017) and Germany (Cheung et al., 2018 in review), we aimed to gain insight into the underlying factors of the varying political acceptability for transition to renewable energy in both countries that have shaped their pathways and contrasting achievements. Combining the MLP and MCA analysis framework and comparative longitudinal case study on both countries, we identified five factors that contribute to national energy-transition performance:

1. The static landscape including the natural-energy endowment, the degree of energy-resources development (capital investment) and economic structures of both Australia and Germany have a decisive effect on the dynamic landscape including the national climate/energy policies (decision-making) and socio-political sentiments on those policies. The dynamic policy landscape can in turn shape the overall configuration and relationships of the regimes and niches of a country, and consequently their ensuing enactments to the dynamic structural changes that can influence the speed and pathways of the transitions. Thus, the varying static-landscape configuration offers the rationale on true drivers underlying the contrasting energy-transition achievements of Australia and Germany.

2. Rich fossil-energy resources (static landscape) can reinforce a carbon lock-in irrespective of the renewable-energy endowments. Both Australia and Germany remain beholden to their coal/lignite reserves and associated socio-political connections. Australia remains heavily reliant and locked in to carbon at the national-economic and political level that arguably has led to energy policy being based on ideology not orthodoxy. Germany is locked in to lignite as part

of an embedded socio-political system but has positioned its transition on energy-security that has transcended ideological protections to most but not all of its traditional energy sources. Thus, the characteristics of energy security are nation-specific and defined to a large extent by static-landscape factors.

3. Mitigation costs are a feasible rationale for explaining Australia's delayed adoption of RE and more broadly a decarbonisation of its economy when compared with Germany. Mitigation costs of climate/energy mitigation policies are highly dependent on the timing (immediate or delayed actions) and speed (Bauer et al., 2012; Garnaut, 2008; Gerlagh et al., 2009; Sorrell and Sijm, 2003). Industrialised countries will benefit from early adoption of RE, whereas well-endowed energy and resource-based countries are likely be disadvantaged by early adoption (Bauer et al., 2010, 2012).

4. In the absence of strong federal climate and energy policy, state/territory governments and or the private sector are likely to fill the gap and support or drive energy transformation at regime and particularly niche levels. Their motivations are likely to be broad but will be driven by other dynamic landscapes such as falling prices of renewable technologies, regional economic development and energy-supply security.

5. Consistent with the multi-level perspective (Geels et al., 2016), we confirm that energy transitions are non-linear with ebbs and flows of advances and setbacks that depend on the: changing landscape contexts (elaborated in finding #1), such as governments and coalition partners, energy crises and natural disasters; and regime and niche level actions that will shift transition pathways from actor struggles over the speed, direction and technology deployment.

In conclusion, investigating energy transitions will require a full understanding of multi-level/dimensional aspects of socio-cultural, techno-economic and political relationships to answer the question of why and how some countries are able to implement policies that lead to deeper and faster change outcomes than others. Such analysis is aided through comparative studies which offer greater insights to reveal both the dynamic nature of transition and impact and nusance of actions across multiple scales.

6.7 Appendix A - MLP-MCA Tier-3 sub-criteria assessment scores and conditions

Tier-3 sub-criteria	Assessment scores	Scoring conditions
A11	-1	Abundant fossil resources for long-term (more than 50 years) domestic use and great potential for production growth
	-0.5	Abundant fossil resources for up to 50 years of domestic use
	0	Sufficient fossil resources for near-term (25 years) domestic use only
	0.5	Insufficient fossil resources for domestic use
	1	Very limited fossil resources for domestic use
A12	-1	Economy consumes far less fossil energy than production and energy export (over 50% of production) contributes significantly to GDP
	-0.5	Economy consumes less fossil energy than production and energy export (less than 50% of production) contributes slightly to GDP
	0	Economy consumes same amount of fossil energy as production
	0.5	Economy consumes more fossil energy than production with shortfall (less than 50% of consumption) covered by low value of import
	1	Economy consumes far more fossil energy than production with shortfall (more than 50% of consumption) covered by high value of import
A21	-1	Increased Kyoto emission-reduction and dismal renewable energy (RE) target
	-0.5	Low Kyoto emission-reduction and RE target
	0	In line with Kyoto emission-reduction and RE target
	0.5	Slightly above an average Kyoto emission-reduction and RE target
	1	Strongly above an average Kyoto emission-reduction and RE target
A22	-1	No national climate mitigation and energy policy as a result of no emission-reduction and RE target
	-0.5	Weak national climate mitigation and energy policy as a result of weak emission-reduction and RE target
	0	Short-term and inconsistent climate mitigation and energy policy in promoting RE investment and development towards moderate RE target
	0.5	Long-term comprehensive climate mitigation and energy policy in promoting RE investment and development towards the set RE target.
	1	Long-term integrated effective and consistent climate mitigation and energy policy in promoting RE investment and technologies development towards ambitious RE target
A31	-1	Long standing and consistent community and media standing opposition to climate mitigation and RE transition

	-0.5	Wavering support for climate mitigation and RE transition effectively resulting in or contributing to political indecision and low investment confidence
	0	Neutral positions of citizen on climate mitigation and RE transition
	0.5	Citizen recognise climate change risk and see the need for mitigation and RE transition
	1	Citizen recognise climate change risk and strongly support mitigation and RE transition and take positive actions which could be measures through the strong uptake of household solar systems
A32	-1	National or international event/factor has significant impact on citizen's sentiment against RE transition
	-0.5	National or international event/factor has some impact on citizen's sentiment against RE transition
	0	No national or international event/factor
	0.5	National or international event/factor has impact on citizen's sentiment for RE transition and triggers long term government policy in favour of RE
	1	National or international event/factor has significant impact on citizen's sentiment for strong RE transition and triggers immediate policy response in favour of RE
B11	-1	Highly regulated and protected electricity sector that is dominated publicly owned utility companies entrenched in mostly fossil-power assets with guaranteed market share and profit.
	-0.5	Regulated electricity market that is monopolised by a few large public or private utilities entrenched in high fossil-power assets and without competition from entry of new player
	0	Liberalised electricity market with limited governance and market policies that the big incumbent utilities retain significant market share in supplying fossil power and carry on with market advantages over new player through unfair competition
	0.5	Liberalised electricity market with governance and market policies that level the competition for and encourage entrant of new players in RE investment and development
	1	Liberalised electricity market with strong governance and market policies that support all incumbents and new players in RE investment and development towards decentralised system
B12	-1	Incumbent utilities dominated both horizontally and vertically with fossil-power generation, transmission and distribution assets and have no investment in new RE generation technologies
	-0.5	Incumbent utilities dominated horizontally with fossil-power generation assets and have no investment in new RE generation technologies
	0	Incumbent utilities dominated with fossil-power generation assets and their investment pattern in new generation capacity still dominated by more fossil-power than RE generation projects that has little impact on their generation mix
	0.5	Incumbent utilities dominated with fossil-power generation assets and their investment pattern in new generation capacity has

		improved to almost equally in both fossil-power and RE-generation projects that could lower the share of fossil-power capacity in their generation mix
	1	Incumbent utilities dominated with fossil-power generation assets and their investment pattern in new generation capacity has improved to be dominated by more RE-generation projects than fossil-power that could significantly lower the share of fossil-power capacity in their generation mix
B21	-1	Massive ongoing capital investment (over \$100 billion in certain year) in the development of new coal mine/gas/oil field and infrastructure for significant long-term production growth for export
	-0.5	High ongoing capital investment (over \$50 billion in certain year) in the development of new coal mine/gas/oil field and infrastructure for long-term production growth for export
	0	No new investment in the development of new coal mine/gas/oil field and infrastructure. The production of existing coal mine/gas/oil field is maintained only for domestic consumption
	0.5	No new investment in the development of new coal mine/gas/oil field and infrastructure. The production of existing coal mine/gas/oil field is decreasing with support from government subsidies
	1	No new investment in the development of new coal mine/gas/oil field and infrastructure. The production of existing mine/gas/oil field is decreasing with no government subsidies and with plan to phaseout the remaining mine
B22	-1	Significant R&D expenditure on fossil energy from the coal industry (up to \$1 billion) and significant public R&D funding (over \$2 billion) on clean-coal and CCS without achieving anticipated result
	-0.5	Significant R&D expenditure on fossil energy from the coal industry (up to \$500 million) and up to \$1 billion of public R&D funding
	0	No R&D expenditure on fossil energy from the coal industry and no public R&D funding
	0.5	Significant R&D expenditure on renewable energy from the coal industry (up to \$50 million)
	1	Significant R&D expenditure on renewable energy from the coal industry (up to \$100 million) and significant public R&D funding (up to \$2 billion) on clean-coal and CCS with good technological breakthrough and deployment to lower an emission from existing coal-power plants.
C11	-1	No public R&D funding support for RE technologies
	-0.5	Minimum public R&D funding support for RE technologies
	0	Public R&D funding (up to \$50 million) on RE technologies without focus and objective in achieving a specific technical result
	0.5	Significant public R&D funding (up to \$300 million) on RE technologies with clear objective and institutional support in achieving technical result
	1	Significant public R&D funding (up to \$1 billion) on RE technologies with cross-strategic focus that is highly integrated

		through multi-institutional coordination effort in optimising technical and commercial results
C12	-1	No obvious indicator for this score
	-0.5	No obvious indicator for this score
	0	No institutional support in commercialisation of R&D technologies
	0.5	Institutional support in commercialisation of R&D technologies
	1	Institutional support in commercialisation of R&D technologies and with close strategic collaboration with industries
C21	-1	No obvious indicator for this score
	-0.5	No obvious indicator for this score
	0	No RE-generation investment and no RE industry
	0.5	Steady growth of a diverse RE-generation shares in the domestic power generation mix and with an average/inconsistent investment growing trend
	1	Rapid growth of a diverse RE-generation shares and with a strong and consistent investment growing trend
C22	-1	RE industrial activity has significant negative impact to an overall national economy and employment (massive loss in investment and employment in other sectors)
	-0.5	RE industrial activity has negative impact to an overall national economy and employment
	0	No flow-on effect from the RE industrial activity
	0.5	RE industrial activity has positive impact to an overall national economy and employment (up to 10,000 new jobs)
	1	RE industrial activity has significant positive impact to an overall national economy and employment (up to 200,000 new jobs

6.8 Appendix B - MLP-MCA model assessment of Australia

Table B 6-1 MLP-MCA assessment of political-acceptability of energy transition in Australia 1996-2007

Tier 1 criteria	**Tier 2 criteria**	**Tier 3 sub-criteria**	**1996-2007** Prime Minister John Howard leading coalition of Liberal/National parties **Scoring rationale**
A – Landscape	**A1 – National energy profile**	A11=-1	Australia is richly endowed with natural energy resources. Globally it holds an estimated 38 % of uranium resources, 9 % of coal resources, and 2 % of natural gas resources. The total energy production in 2007–08 was 17 360 PJ within which 54% was coal, 27% was uranium, 11% was gas and 2% was from renewable energy sources. In 2007–08, Australia exported more than three-quarters of its energy production valued AU$45.6 billion. In 2008– 09, the value of energy exports increased to AU$77.9 billion supported by higher world energy prices. Coal accounted for over 50% of exports on an energy content basis, followed by 35% of uranium (ABARE, 2010 p.2-3,11). The value of Australia's energy exports has grown in real terms at an annual rate of 5% over the past twenty years to around $38 billion in 2006-07 and at current production level, Australia's energy resources are expected to last for many decades (ABARE, 2008 p.2-3).
		A12=-1	Australia is not energy-dependency on foreign imports. In 2005-06, Australia exported 76% of its total primary energy production. Domestic manufacturing consumed 35% of the total primary energy generation. Coal and petroleum were the primary energy sources. The share of natural gas has increased over the past 30 years and this trend is projected to continue in the longer term (ABARE, 2008 p.64-65).
	A2 – climate/energy targets and policies	A21=-1	As part of the Kyoto Protocol, Australia firstly negotiated an increase in the greenhouse gas emissions target of 108% on 1990 level then did not ratify the target (Riedy and Diesendorf, 2003; Crowley, 2010; Beeson and McDonald, 2013; McDonald, 2015). The national emissions rose to 109%

			of 1990 level in 2007 (ABS, 2010 p.60). Australia set an unambitious target of 9,500 GWh or 2% of electricity to be sourced from new renewable sources by 2010 without any national emission plan or pathway to facilitate the development of renewables (Talberg, 2013).
		A22=0.5	There were a few RE policy measures enacted: the establishment of Australian Greenhouse Office; the liberalisation of the National Electricity Market (NEM); the provision of A$2.9 billion for a range of climate change and renewable energy programs including the 'Securing Australia's Energy Future' for the period 2004 – 2013 with A$700 million (Cheung and Davies, 2017). In 2000/01, a total of A$365 million (41% from government and 59% from business) was spent on energy R&D in Australia, of which only 12% was on renewables (IEA, 2005, p180).
	A3 – Citizen sentiment on climate change and renewable energy	A31=0.5	A global survey report revealed that 50% of Australian's perceived global warming as 'serious' and below 50% were willing to pay 10% more for renewable electricity (GlobeScan, 2000, 2001). A 2006 study revealed a change in community attitudes reporting more than 70% of Australian's agreed that global warming is a serious and pressing problem and that actions should be taken now even if this involves significant costs and a similar percent perceived climate change as a national threat in next 10 years (Leiserowitz, 2007 p.7, 21).
		A32=0	Australia was the world's 18th largest consumer of primary energy, ranking 9th on a per person basis in 2007 and has experienced a continual decadal increase in annual energy consumption. During the 1960s, energy use in Australia grew by 5%/year. During the 1970's energy consumption grew at 3.8%/year during the 1970s, a decline largely as a result of the two major oil price shocks. During the 1980s, energy consumption rose at 2.6% per year as a result of a global economic recession and sharply rising energy prices. During the 1990s, energy consumption fell at 2.3% per year, despite falling real energy prices and robust economic growth (ABARE, 2008 p.63).

			The external oil crises and economic recession has very little impact on Australian actions on pushing for an alternative renewable energy due to abundant indigenous energy resources.
B – Regimes	**B1 – Incumbent utilities**	B11=0.5	The National Electricity Market (NEM) reform commenced in December 1998 which encompassed the Australian Capital Territory, New South Wales, Victoria, South Australia and Queensland government and in 2005 the Tasmanian government. This reform allowed the transmission of electricity across state and territory borders to meet customer demand in other jurisdictions. It also disaggregated the vertically integrated state-owned utilities into generation, transmission, distribution and retail supply components through corporatization and privatisation. The principal aims of NEM were to promote competition and efficiency in production and provision of electricity and associated services allowing consumers choice of supplier/retailer and regulated network supplier. However, most generation, transmission and distribution networks were still owned and operated by state governments, hence, were still operating as regional monopolies regulated through various Commonwealth and state economic regulatory bodies. In April 2007, the Council of Australian Governments (COAG) agreed to establish an industry funded National Energy Market Operator (AEMO) for wholesale electricity and gas by mid-2009. The regulation of transmission and generation is the responsibility of the Australian Energy Regulator (AER) which operates under the Competition and Consumer Act 2010 (Penny et al., 2008 p2-3). At the early stage of electricity market reform, NEM was dominated by a few major entities as majority of the generation, transmission and distribution assets were still in the hands of the state governments and only two large private Australian utility companies – the AGL and Origin. Smaller energy operators faced many challenges to enter the market given the control and dominance of the larger and established state-owned entities (ABARE, 2004 p.37-39). In 2007, 83% of Australia's electricity was produced by coal.

		B12=-0.5	In this period, there were more coal-fired power plants capacity being built than the renewables. Below were three generation projects completed in 2008 and given long lead time for planning and getting approval process, these projects would have been initiated a few years earlier (Penny et al., 2008 p6): • Macquarie Generation's Liddell Stage 2 (100MW black coal). • Trust Power's Snowtown stage 1 (99MW wind). • Loy Yang Power's Loy Yang A upgrade - unit 4 (80MW brown coal). The Liddell and Loy Yang were an expansion/upgrade of existing ageing plants.
	B2 – Fossil-fuel industry	B21=-1	The period 2004 to 2006 has seen rapid expansion of investment in development of both new coal mines (black and brown coal) and infrastructures. In 2004, the total reported investment for major new coal mines and infrastructure was around A$3 billion (ABARE, 2004 p.13), in 2005, the total investment grew to A$6.5 billion (ABARE, 2005 p.13-14) and then further grew to A$13.6 billion in 2006 (ABARE, 2006 p.15-17).
		B22=-0.5	Based on data between 1996 and 2001 Riedy and Diesendorf (2003) estimated that A$6.54 billion/annum in financial subsidies and incentives to fossil-fuel production and consumption in Australia. These included tax concessions to the fossil-fuel industry which acted as an incentive for fossil-fuel exploration and production companies. For example, in 1994/95, A$360 million was in deductible company tax for petroleum exploration which had increased to AU$720 million in 1999/2000. Other tax concessions and direct funding into fossil-fuel energy R&D projects were also provided. For example, in 1994 an estimated $180 million provided for energy R&D, only $27 million (15% of the total) was provided to renewable energy and energy efficiency applications (NIEIR, 1996). In 2004-05, Australia devoted 6% of total R&D expenditure to the energy sector which was around A$988 million, of which, around 54% was directed at mining and extraction of energy resources, 19% was directed at renewable energy and energy transformation and 4% at energy efficiency and conservation. The business sector funded 79% of total energy R&D

			and the share of renewable energy R&D in total energy R&D expenditure increased from 3% in 1994-95 to 9% in 2004-05. This increase in renewable energy R&D is largely funded by the business sector (ABARE, 2008 p.77-78).
C – Niche	**C1 – RE technologies R&D and commercialisation**	C11=-0.5	In 1994 the estimated subsidies and R&D for renewables and energy efficiency in Australia was $43.1 million which was equivalent to 2% of the total energy subsidies of almost $2 billion to the fossil-fuel industries (NIEIR, 1996). Energy R&D funding was also significantly bias towards fossil-fuel technologies which received about A$153 million/annum, exceeding the A$27 million for renewable energy industry by $126 million (Riedy and Diesendorf, 2003 p.132).
		C12=0	There were no funding or institutional supports for renewable energy technologies commercialisation at the time in Australia.
	C2 – RE industries and flow-on effects	C21=0	There was no renewable energy industry at the time.
		C22=0	Due to the factor in C21, there was no data on flow-on effects.

Table B 6-2 MLP-MCA assessment of political-acceptability of energy transition in Australia 2007-2013

Tier 1 criteria	Tier 2 criteria	Tier 3 sub-criteria	**2007-2010** Prime Minster Kevin Rudd leading the Labor Party **2010-2013** Prime Minster Julia Gillard leading the Labor Party **Scoring rationale**
A – Landscape	**A1 – National energy profile**	A11=-1	Since 1999-2000, national energy production has been growing at 3.2% annually. In 2011, Australia's share of global energy reserves was: 47% uranium, 10% coal and 2% natural gas and exported 68% of its total energy production with coal the largest earner valued around A$44 billion followed by A$12 billion for crude oil and A$11 billion for liquefied natural gas (LNG) (BREE, 2011 p.14,16). Energy exports were significant contributors to the economy accounting for 33% of the total commodity exports in value in 2011 (BREE,2012 pp.1-5). In 2013, Australia was the world's 9th largest energy producer, contributing around 2.5% to the world's energy production. The main fuels produced in Australia are coal, uranium and gas. Uranium production is not used for domestic consumption. Coal accounted for around 59% of total energy production in energy content terms followed by 22% uranium, 12.7% gas, 4.6% crude oil, condensate and naturally occurring LPG and 1.7% renewable energy (BREE, 2014b p.15).
		A12=-1	Australia has abundant domestic cheap fossil energy and free from dependency on import. Apart from importing crude oil (valued at $33 billion in 2012), Australia was a net energy exporter and with domestic energy consumption representing only one-third of the total energy production (BREE, 2011 p.16). In 2009, the manufacturing sector accounted for 20% of the primary energy consumption which was the second largest energy end user in Australia, with minerals processing—iron and steel making, alumina

			refining and aluminium smelting—contributing to the relatively high energy-intensity sectors (BREE, 2011 p.35). The manufacturing sector has grown relatively slowly over the past decade which share in total final energy consumption has remained around 32% (BREE, 2011 p. 44).
	A2 – climate/energy targets and policies	A21=1	The federal government ratified the Kyoto Protocol with an unconditional emission reduction of 5% from 2000 levels by 2020 for the second commitment period and 15%-25% from 2000 levels by 2020 subject to international achievement. The long-term emission reduction target was set at 80% from 2000 levels by 2050 with a 20% target of renewable energy target for electricity by 2020 (Commonwealth of Australia, 2011b; Durrant, 2010).
		A22=1	In 2009 the *Renewable Energy (Electricity) Amendment Act 2009 (Cth)* was passed with the objective to increase mandatory renewable energy target (MRET) from 9,500 GWh (2%)[90] by 2010 to 45,000 GWh (20%) by 2020. The *Act* also introduced a 'solar credits' multiplier scheme to provide an additional incentive to install solar photovoltaic systems (St John, 2014). The MRET was extended until June 2009 and to be subsequently replaced by the Solar Credits Initiative under the Renewable Energy Target (RET) Scheme (Clean Energy Regulator, 2016). The introduction of the *Clean Energy Act 2011 (Cth)* encompassed the implementation and governing institutes of Climate Change Authority, ARENA and CEFC. Its aim was to provide and safeguard the long-term stability and certainty of the climate/energy policies and support capital investment (Commonwealth of Australia, 2011a, 2011b). The *Clean Energy Act 2011 (Cth)* brought together existing policies and strengthened with new enabling legislation which covered four main elements including carbon price, renewable energy, energy efficiency and action on the land (Commonwealth of Australia, 2011a; 2011b, 2011c). As part of the *Clean Energy Act 2011 (Cth),* the state-based feed-in tariff (FiT) schemes were mandated to be maintained and managed by the

[90] The 9,500 GWh was setup by the previous Howard Government as the MRET since 2001 with an aim to generate 2% of electricity from renewable sources.

			state/territory governments through the Council of Australian Governments (COAG) agreement rather than being managed by a uniform federal scheme. However, the state-based FiT policy design was mostly funded by states' budget at the time that was financially unsustainable and ultimately altered to be paid by consumers through levies on distributors (Zahedi, 2010; IEA, 2012b; Martin & Rice, 2013). The RE installation capacity during the five-year period of 2007-2012 grew by 22% whereas the investment also grew by 26% under the new stimulative climate/energy policies of the Labor government (BNEF, 2012 p.18-19).
	A3 – Citizen sentiment on climate change and renewable energy	A31=1	Reser et al. (2012) studied with a sample size of 3,096 Australian found that: • 91% of Australian respondents believed that human activities were playing a causal role in climate change. • 66% of Australian respondents reported that they were 'very concerned' or 'fairly concerned' about climate change. Survey findings also suggested that majority of Australian respondents feel that despite clear difficulties and challenges, their actions can make a difference, and that the issue of climate change is serious, urgent, and personally relevant. • 71% of Australian respondents reported that their level of concern about climate change had increased over the preceding two years. The major reasons given for the reported increased concern were: increased awareness about the nature, magnitude, and possible consequences of climate change; media coverage of climate change; lack of action by government on climate change; and the perceived increasing frequency and intensity of natural disasters and extreme weather events. • 78% of Australian respondents agreed that, "If nothing is done to reduce climate change in the future, it will be a 'very serious' or 'somewhat serious' problem for Australia". Political affiliation, as measured by voting intention 'if there was a Federal election tomorrow', was an important consideration across many key variables for Australian respondents. The responses listing 'very' or 'fairly' concerned about climate change were, in order, 87.9% Greens, 73.6% Labour (the incumbent government) 53.9% Liberal and 48.6% Nationals.

			When asked about the acceptance of some level of human causality with respect to climate change, this was 96.8% Greens, 92.5% Labor, 86.6% Liberal and 85.5% Nationals (Reser et al., 2012 p.12-15).
		A32=0.5	Responding to the Global Financial Crisis in 2008, the federal government implemented an economic stimulus package with elements that supported, among other things, new energy polices such as feed-in tariffs and household insulation scheme. This was largely a one-off response, while economically successful, did not result in a contributed trajectory of long-term renewable energy or energy efficiency actions (Australian Government, 2009).
B – Regimes	**B1 – Incumbent utilities**	B11=1	As part of the Clean Energy Future package, in 2011 the Energy Security Council was established to advise the Government on support measures to address energy-security risks with the least distortion to markets and consistent with responsible fiscal policy. The Council was required to collaborate with the established Australian Energy Market Operator (AEMO) to address the energy security matters including: negotiation and potential payment for closure of up to 2000MW of emissions-intensive generation capacity before 2020; free permit allocations and cash payments to emissions-intensive coal-fired electricity generators, in return for adopting clean-energy investment plans; and short-term loans to generators to help finance the purchase of carbon permits (BREE, 2011 p.19).
		B12=1	At the end of October 2008, 29 energy related projects were either committed or under construction. These projects represented 12% of Australia's total generating capacity as at June 2007 with a total capacity of 6,285MW. 18 of the 29 projects were based on non-renewable electricity generation, accounting for 86% or 5,386MW of the planned additional capacity with a value of A$6.41 billion. Gas-fired project dominated the non-renewable energy investment contributing 67%. The 11 renewable projects accounted for 899MW costing A$1.88 billion (Penny et al., 2008 p7). New power stations and expansions as at October 2011 included: two black-coal power stations – Eraring 240MW at A$245 million and Muja Power Station (A and B) 220MW at A$150 million; 7 gas power stations with total capacity of 975MW at AU$1.37 billion; 8 new wind and solar project adding 1,143MW at AU$3.025 billion (BREE, 2012 p.111-112).

			In 2013, Australia ranked the 9th highest global investor in renewable energy. Total investment was US$4.4 billion roughly divided between the funding of small-scale and utility scale PV systems. Among the main transactions were US$406 million for the 182MW AGL Nyngan & Broken Hill PV portfolio, and US$334 million for the 113MW Boco Rock wind farm phase one (UNEP-BNEF, 2014 p.24, 54).
	B2 – Fossil-fuel industry	B21=-1	In 2008, total capital investment for major new coal-mine and infrastructure projects was A$11.26 billion which included committed and proposed projects start-up from 2008 to 2011. Whereas for the same period, the total investment for major new gas projects was around A$20 billion including committed and proposed gas infrastructure projects (ABARE, 2008 p.10-12, 33-34). In 2011, the total reported investment in new black-coal mining and infrastructure projects was A$24.43 billion with projects start-up from 2011 to 2014 (BREE, 2012 p.113-115). Since 2000, there were 5 major LNG projects under construction or completed across Australia with private capital investment of A$63.4 billion with a project construction timetable ranging from 2004 to 2015 together with A$5.8 billion invested in new and expansion of existing pipeline capacity (ABARE, 2010 p.112). Additionally, there was a total reported investment of A$145.5 billion on new or expansion gas projects in 2011 with start-up from 2011 to 2016 (BREE, 2012 p. 115-117).
		B22=-0.5	The Australian Government is funding the R&D of technologies under a suite of Low Emission Technologies for Fossil Fuels (LETFF). This comprised several initiatives including the Carbon Capture and Storage (CCS) Flagships program; the National Low Emissions Coal Initiative (NLECI); the Low Emission Technology Demonstration Fund; and the Coal Mining Abatement Technology Support Package. The NLECI program was announced as a A$500 million election commitment in November 2007 and was established in the 2008 Federal Budget. The aim of the NLECI was to accelerate the development and deployment of low emission technologies and carbon dioxide (CO2) transport and storage infrastructure. The CCS

			Flagships program was announced as part of the Clean Energy Initiative in the 2009 Federal Budget with A$2 billion to support the construction and demonstration of large-scale integrated CCS projects in Australia (ANAO, 2017). In 2009, the Australian Government also established the Global Carbon Capture and Storage Institute with annual funding of up to A$100 million to address barriers and accelerate deployment of industrial scale CCS technologies globally (ABARE, 2010 p.159). As part of the Clean Energy Package, there was a Jobs and Competitiveness Program with A$9.2 billion budget to serve as industrial transitional assistance between 2011–12 and 2014–15. A$1.3 billion was directed to the Coal Sector Jobs Package over 6 years from 2011–12 to provide transitional assistance to the coal industry to implementation carbon-abatement technologies (BREE, 2011 p.19). In 2008–09, the total expenditure on R&D in energy by all sectors of the economy (governments and business) was A$2.9 billion. Most R&D in energy was undertaken by the private sector which increased at an average annual rate of 28% from 2000–01 to 2009–10. Expenditure on energy R&D by Australian businesses was 16% of total business R&D expenditure in 2009–10. Within the energy related industries, the oil and gas-extraction industry had the largest R&D expenditure of A$1.3 billion and the coal-mining industry with A$717 million. Around 57% of business energy R&D in 2009–10 was devoted to the mining and extraction of energy resources and only around 7% was spent on renewable energy and 2% on energy efficiency or energy conservation (BREE, 2012 p.104-106). There was an expectation of a significant increase in the use of gas in electricity generation as at the time this technology was more cost competitive relative to other low-emission options. In effect, this led to a growth in gas consumption largely at the expense of coal. Despite this trend, coal expected to continue to be an important component in the energy mix and the development of cost-effective lower-emissions coal technologies including CCS was viewed as critical to maintaining coal's position in

			electricity generation (BREE, 2012 p.109).
C – Niche	**C1 – RE technologies R&D and commercialisation**	C11=1	The Australian Renewable Energy Agency (ARENA) was legislated to manage A$3.2 billion to support the research, development, demonstration and commercialisation of innovative renewable energy technologies. It also oversaw existing government R&D renewable energy programs. The Clean Technology Innovation Programme with funding of $200m was one of the many programs managed by ARENA to provide grants to support business investment in R&D of the renewable energy, low pollution and energy efficiency technologies (BREE, 2011 p.19).
		C12=1	The Clean Energy Finance Corporation (CEFC) was established in August 2012 with $10 billion in funding available over 5 years. The CEFC was setup as commercially oriented institute to support commercialization of innovative clean energy technologies and investments in renewable energy, low-emissions and energy efficiency project. Funding was generally provided through loans, loan guarantees and equity investments. However, the CEFC was not restricted from using other structured financial instruments to remove impediments to investment in the clean energy sector (BREE, 2011 p.19). As a result of the global financial crisis, Australia government injected US$4.1 billion within a green stimulus programme for 2008-2009. The aim of this was to boost investment and growth in the clean energy/green economy (UNEP-BNEF, 2010 p.54).
	C2 – RE industries and flow-on effects	C21=1	In 2010, Australia's new investment in renewable energy saw a surge in small-scale project installation, predominantly rooftop solar with new investment of US$0.9 billion which was 74% increase from 2009. This increased investment in 2010 was driven by New South Wales' AU$0.60/kWh feed-in tariff payments which was subsequently cut to AU$0.20/kWh (UNEP-BNEF, 2011 p.20, 45). In 2011, small distributed-capacity investment in Australia grew 105% on 2010 to US$3.8 billion. For example, the US$410 million 168MW Musselroe wind farm in Tasmania (UNEP-BNEF, 2012 p.23,47). In 2012,

			solar attracted US$3.6 billion adding capacity more than 1 GW and wind US$1.1 billion adding 100MW new capacity. The RET helped fuel contracts for large-scale solar projects greater than 100MW and 500MW for new wind capacity at the end of 2012 (UNEP-BNEF, 2013 p.33). In 2013, Australia continued to be a significant location for small-scale PV, helped by its strong solar resources and an active installation industry (UNEP-BNEF, 2014 p.22).
		C22=1	There is no manufacturing industry in Australia for renewable energy technologies such as solar PV or wind turbine. However, the investment in RE had a flow-on effect to the installation, construction and project management services industries. The government official tracking showed employment creation of 11,690 jobs in 2009-2010 and a peak of 19,220 jobs in 2011-2012 then a fall to 14,500 jobs in 2013-2014. There was no tracking on the economic value of the flow-on effect from the RE investment (CEC, 2016 p.25)

Table B 6-3 MLP-MCA assessment of political-acceptability of energy transition in Australia 2013-2017

Tier 1 criteria	Tier 2 criteria	Tier 3 sub-criteria	**2013-2015** Prime Minister Tony Abbott leading coalition of Liberal/National parties **2015-2017** Prime Minster Malcolm Turnbull leading coalition of Liberal/National parties **Scoring rationale**
A – Landscape	**A1 – National energy profile**	A11=-1	In 2015–16, black coal contributed 70.2% and natural gas contributed 19.6% of the national total energy production (DEE, 2017 p.23). In 2016, the proportion of fossil-fuelled (black and brown coal, gas and oil) electricity was 83.7% and renewables was 16.3%. At the same time, Australia exported around two-thirds of its total energy production which was a 4% increase from 2015. The exports comprised 80.7% of black coal (10-years annual growth rate of 5.3%) and 14.9% of LNG (10-years annual growth rate of 11.2% (DEE, 2017 p.9, 28, 30). In 2016-2017, 98% of metallurgic-coal and 81% of thermal-coal productions were exported, total coal exports were valued at A$55.3 billion and LNG A$22.8 billion. The value for 2017-2018 coal exports valued at A$62.8 billion and at A$30.4 billion for LNG (Australian Government, 2018 p.14).
		A12=-1	Australia consumed only one-third of its total primary energy production in 2015-2016. Of the energy produced, the manufacturing sector consumed 18.4% (with 10-years annual decline rate of 1.3%) and the mining sector consumed 10.1% (with 10-years annual growth rate of 7.2%) which was in line with the growth in the production of energy and mineral for exports (DEE, 2017 p.16).
	A2 – climate/energy targets and policies	A21=-1	The carbon tax was repealed by the newly elected LNP government in 2014 and replaced by the Direct Action Plan (DAP). The DAP was supported by a A$2.55 billion Emissions Reduction Fund (ERF) through to 2020. The ERF was designed to support industrial, commercial companies and agricultural

			activities to reduce GHG emissions through a reverse-auction process (Dept. of Environment, 2014; Commonwealth of Australia, 2014). The ERF with a mooted safeguard mechanism was deemed by an independent analysis to be inadequate to meet the 5% from 2000 reduction goal (BNEF, 2014) rather was likely to lead to an increase in GHG emissions of 12% above 2000 levels by 2020 (Climate Action Tracker, 2013). In June 2015, the LNP Government's effort of reducing the Large-scale Renewable Energy Target (LRET) set by the previous Labor Government also succeeded in passing the *Renewable Energy (Electricity) Amendment Bill 2015*. The amendment bill reduced the LRET from 41,000 GWh to 33,000 GWh for 2020 and the interim and post-2020 targets were adjusted accordingly. http://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/History-of-the-scheme
		A22=-0.5	As a result of uncertainty created since the change of ruling party in government in 2013 and its actions in reversing climate/energy policies and scaling back the LRET, Australia dropped out of the top 10 RE investment countries list. The utility-scale financing plunged to merely US$330 million from US$2.1 billion during the RET review period due to an indecision over the future renewable energy target. Policy uncertainty also contributed to a 72% reduction in small-scale PV financing to US$1 billion. The sharpest decline in percentage terms took place in the asset finance[91] of 87% for large-scale projects to US$262 million (UNEP-BNEF, 2015 p.20, 23, 53). After the LRET reduction confirmed in 2015 which improved market uncertainty, Australia's RE investment rose 16% to US$2.4 billion but remained at less than half of the peak in 2011 (UNEP-BNEF, 2016 p.26). In 2015, there was also a change in prime minister within the ruling coalition government who has stopped the full-scale assault on the Clean Energy policies and lifted the ban on the CEFC funding support to big-wind project.

[91] Asset finance: all money invested in renewable energy generation projects (excluding large hydro), whether from internal company balance sheets, from loans, or from equity capital. This excludes refinancing.

			This resulted in Australia re-entering the top 10 renewable investment countries in 2017. The asset finance rose 212% on 2016 to US$6.6 billion, whereas the small-distributed capacity investment was only up 18% on 2016 to US$1.6 billion despite the country has achieved commercial PV 'grid parity' where commercial rooftop solar electricity is cheaper than electricity from the grid (UNEP-BNEF, 2018 p.49, 55).
	A3 – Citizen sentiment on climate change and renewable energy	A31=1	In 2015, Australia has recorded as one of the highest penetrations of residential rooftop PV globally with around 1.4 million systems. This equates to one in six households is now a stakeholder in the industry. The Australian Federal Government had proposed scrapping the small-scale solar scheme and reducing the threshold at which commercial projects qualify for the subsidy programme but backed down in the face of opposition in March 2015 (UNEP-BNEF, 2016 p.58). The increased adoption of the solar PV by Australian businesses and households was driven by falling price of the technology and rising electricity price.
		A32=0	No significant landscape events impact on public sentiment or action.
B – Regimes	**B1 – Incumbent utilities**	B11=1	Nine coal-fired power stations (in private ownership) closed over the six years ending in 2017. Broadly, incumbent utilities tended to follow one of the three paths in reaction to the growth of renewables: fight; flight; or adapt. Bloomberg New Energy Finance found Australian utilities adopted the "adapt" strategy in actively building their own RE capacity in their home state, or doing the same outside their territory, or investing in solar at arm's length via tax equity or a partnership (UNEP-BNEF, 2015 p.39). A good example was the 10.6MW solar plant with 6MW of battery storage under construction at DeGrussa Copper Mine in Western Australia which was backed by funding from the ARENA and the CEFC (UNEP-BNEF, 2016 p.39).
		B12=1	In October 2015, the renewable-generation projects have exceeded the non-renewable in term of capacity and investment value for the first time. Many renewable and non-renewable generation projects at various stages ranging from committed, announced or in the feasibility study phase were adding a total new capacity of 28,968MW with estimated total capital investment of A$41.76 billion. Of which, 6,268MW was non-renewable (mostly gas

			power), with capital investment of AU$5.02 billion. Renewables (mostly wind and solar) were estimated to contribute 22,700MW with capital investment of A$36.75 billion (Australian Government, 2015e p.8).
	B2 – Fossil-fuel industry	B21=-1	Investments in export coal-mining capacity are normally associated with lead times of several years. Based on expansion projects currently under construction or in the planning stages, IEA estimated Australian coal-mining capacity expansions accounted for roughly half of global probable coal-mining capacity additions during the outlook period of 2013-2018. Projects that were committed, approved or under construction will add a total new production capacity to around 59 Mtpa (million ton per annum) when completed in 2018 with total investment costs estimated at US$13 billion (IEA, 2013a p.109-112). Australia coal export rose from 301Mt (million ton) in 2012 to 375Mt in 2014 (IEA, 2015a p.8). Refer to (IEA, 2013a p.129-132) for list of expansion projects. Existing[92] and new LNG projects boosted the additional LNG capital investment up to A$74.6 + US$62.9 billion (some projects reported in US dollar term) with the latest anticipated completion in 2017 (ABARE-BREE, 2014 p111; ABARE, 2010 p.112).
		B22=-1	Coal has been and remains an important contribution to the Australian export economy. The coal sector received disproportional favourable R&D funding provision both at the Commonwealth and state governments level that together, about A$2.5 billion was provided to the sector since 2008. For example, the NSW state government allocated A$100 million under the Coal Innovation NSW Fund (CINSW)[93] and Victorian state government allocated

[92] Pluto and Gorgon original capital cost A$12 and A$43 billion and overrun into A$14.9 and A$54 billion that the total overrun cost amounted to A$13.9 billion.
[93] The Coal Innovation NSW Fund (CINSW) was established to support research, development and the demonstration of low emissions coal technologies for future commercial application. It also aims to increase public awareness of the importance of low emissions coal technologies in reducing greenhouse gas emissions. Refer to:

			A$90 million for the Advanced Lignite Demonstration Program (ALDP)[94] for low emission coal demonstration projects in the Latrobe Valley which was shut down in 2018 and declared to be unsuccessful (Wahlquist, 2018). The NLECI and CCS programs were operating for almost a decade under the Department of Resources, Energy and Tourism (DRET)[95]. Key performance measures for the programs managed by this Commonwealth department provide limited insight into the extent to which the programs were achieving the LETFF[96] strategic objective of accelerating the deployment of technologies to reduce greenhouse gas emissions. An Auditor-General's Performance Audit report in 2017 on the LETFF concluded (ANAO, 2017): • As at 30 June 2017, approximately $233 million funding had expended on all NLECI programs and $217 million on CCS Flagships projects. • None of the CCS Flagships projects met the original timeframe or reached the stage of deployable technology as originally envisaged in the program design. It is therefore unclear whether the program can deliver on its strategic policy objective as the program is due to close in 2020 and all program funding is currently committed. Consequently, reporting and evaluation does not provide insights into the programs' contribution to advancing/accelerating the demonstration of low emission technologies, nor does it inform decisions on the future of the programs. • Over the life of both programs, funding was significantly reduced to around half the original NLECI program funding and around 75% of the CCS Flagships program funding. The program was not supported by a framework for monitoring the impact of the changing funding

https://www.resourcesandenergy.nsw.gov.au/investors/coal-innovation-nsw/about-coal-innovation-nsw.

[94] The Advanced Lignite Demonstration Program was one of the National Low Emission Coal Initiative (NLECI) program co-funded by the Commonwealth (A$75 million) and the Victoria state government to make up the rest. Refer to: https://industry.gov.au/resource/LowEmissionsFossilFuelTech/Pages/National-Low-Emission-Coal-Initiative.aspx.

[95] The Department of Industry, Innovation and Science (DIIS) is now responsible for the legislation, policy and program delivery for the NLECI and CCS Flagships programs. These programs were established under the former Department of Resources, Energy and Tourism (DRET). On 18 September 2013, DRET was abolished and the resources and energy functions were transferred to the Department of Industry. In September 2015, the department was renamed the Department of Industry, Innovation and Science.

[96] Low Emission Technologies for Fossil Fuels (LETFF) programs.

			environment. Hence, there was no clear strategy for determining how the reduced funding would be applied across the programs. • Both programs were designed on the premise of contributory funding from state governments and industry parties, however, the NLECI program did not achieve this intended outcome. Given the CCS Flagships projects have not reached the expected level of completion, it is unclear whether they would have achieved the level of contributory funding expected. Ongoing industrial R&D funding mechanisms were supported to the coal industry through Australian Coal Association Research Program (ACARP)[97]. At the same time, there was a report on misappropriation of the research funding being diverted to the election-campaign advertisement in the tune of A$2.5 million pushing the case for lower-emissions, coal-fired power plants in the run-up to 2016 election which is a cause the current Federal Government has since taken up with gusto with plan in public funding through CEFC for the CCS and Northern Australia Infrastructure Fund (NAIF) to help build new high-efficiency coal-fired power plants in the state of Queensland (Fabri, 2017; Long, 2017; Reuters, 2017).
C – Niche	**C1 – RE technologies R&D and commercialisation**	C11=-1	In 2014, the newly elected government sought to dismantle oversight institute and R&D funding for RE through structural changes. The mooted reforms were only partially successful and resulted in an immediate reduction of A$435 million and deferred cut of A$370 million to nearly a decade from the originally legislated A$3.2bn as R&D funding for ARENA (Sansom, 2014; Parkinson, 2013). These collective efforts of the federal government: in successfully repealed the carbon tax; the failed attempt to repeal the CCA, ARENA and CEFC; the A$805M funding cut to the ARENA operation; a ban on CEFC to provide funding support to wind project; and a talk of substantial reduction of the 20% RET have created uncertainty in the market with drastic negative impact on the RE investment which was grinding to a halt in the sector (Hannam, 2015).

[97] Australian Coal Association Research Program (ACARP) is a collaborative program between the coal-mining industry and research institutions and is funded, managed and governed by the coal industry. At any time, it manages around A$50-60 million across 200 research projects addressing production, technical market support, health and safety and environmental rehab. Its funding sources from 5 cents per tonne of coal contribution rate over the past 20 years and the Program expects to spend between A$75 million and A$85 million to deliver its R&D program for the period 2015 to 2020.

		C12=-1	As noted in the C11, the original climate/energy policy designs of the ARENA and CEFC were severely paralysed during the period of 2013-2015 and only the ban on the wind-project funding was lifted by the new prime minister in 2016.
	C2 – RE industries and flow-on effects	C21=1	As elaborated in A21, A22 and C11, the RE sector investment suffered significant setback under the new government policy direction and funding cut for the first half of this period 2013-2015. However, for the second half of this period 2015-2017, with the resumption of policy stability and certainty, the RE investment in 2016 has grown 51% on 2015 to US$3.3 billion. Given the unique geographic location and RE energy resources profile, Australia has become one of the leading nations on combined wind/solar installation projects which are reaping benefit of cost-saving in construction, operation & maintenance and onsite staff through co-located projects. These saving incentivised many combined wind/solar projects such as: 50MW Kennedy Energy Park complex (30MW of wind and 20MW of solar); 100MW Emu Downs project (80MW of wind and 20MW of solar); 176MW Gullen Range configuration (166MW and 10MW); and the 375MW Port Augusta project (206MW and 169MW) announced. As a result, the 2016 RE asset finance in Australia increased 127% on 2015 to US$2 billion (UNEP-BNEF, 2017 p.26, 45-46,52). Two of the largest wind projects financed in this period were the 270MW CWP Sapphire[98] installation at US$438 million and the 175MW White Rock plant at US$326 million, both in New South Wales. Commercially, New Energy Solar, an Australian PV project company raised US$154 million capital to fund developments in the U.S. and Australian. Similarly, another private company, Windlab raised $40 million to be used to develop the first phase of a 58MW hybrid wind and solar project in Queensland (UNEP-BNEF, 2018 p.61).

[98]The A$588 million Sapphire Wind Farm – the fifth and final winner of the ACT government's large-scale wind reverse auction – is minority-owned by CWP, and co-financed by Commonwealth Bank, Sumitomo Mitsui Banking Corporation and EKF, Denmark's export credit agency, while Partners Group has provided most of the equity funding. In December last year, the project also secured $120 million in debt finance from the Clean Energy Finance Corporation, allowing construction to begin (Vorrath, 2017).

			In 2017, high electricity prices and a rush to secure capacity under the Large-Scale Renewable Energy Target (LRET)[99], provided the driver for renewable energy investment. This increased 147% on 2016 to US$8.5 billion[100]. The largest transactions included the Goldwind Stockyard Hill wind project[101] in Western Victoria at 530MW with an estimated capital of US$822 million, and the EGP DIF Bungala PV portfolio[102] in South Australia at 270MW and US$495 million (UNEP-BNEF, 2018p.11, 26, 51).
		C22=1	Given the geographic focus of new RE projects in regional centres, many state governments identified and supported the emerging economic opportunities. With the support from the ARENA and the CEFC, many state and territory governments introduced a variety of complementary policies to repair the damage to investment confidence lingering since the 2014-15 review and changes to the RET. In 2015 the efforts by ARENA and CEFE supported more than A$6.9 billion of investment which has created 3725 direct jobs and 3150MW new renewable-generation capacity. This represents about half of what is needed to be delivered under the LRET to meet the 2020 target. In 2016, apart from the more stable policy front, the cost of large-scale solar has reduced more than 40% in the last couple of years. Rooftop and commercial solar continued to perform strongly at more sustainable level than the boom years of 2011 and 2012. The total solar-power production from all sectors[103] increased by 29% during 2016 (CEC, 2016). Bloomberg New Energy Finance confirmed that solar is now the cheapest type of power generation to be built in Australia that could undercut the skyrocketing price of gas and well below new coal-power plant (UNEP-BNEF, 2018).

[99] The LRET provides certificates for up to 33TWh of renewable generation by 2020 in Australia.
[100] Solar advanced 189% on 2016 to US$4.9 billion, and wind 109% on 2016 to US$3.6 billion.
[101] The Stockyard Hill Wind Farm secured A$700 million project finance from nine-member domestic and international bank syndicate led by National Australia Bank (NAB). The wind farm has also obtained the long-term Power Purchase Agreement (PPA) with Origin Energy.
[102] The Bungala Solar PV Project will have a total installed capacity of 275 MW that will produce 570 GWh per year. The total investment in the project is around US$315 million with the Enel Group investing around US$157 million. The overall Bungala Solar PV project is expected to become fully operational in early 2019.
[103] Solar power from household, commercial and large-scale commercial solar power.

References[104]

ABS 2010. Australia's Environment: Issues and Trends 2010. Special issue: Climate Change. Australian Bureau of Statistics. ABS Catalogue No. 4613.0. ISSN 1443–7155.

Australian Government. 2009. Government Response - Report on the Inquiry into Impact of the Global Financial Crisis on Regional Australia. November 2009. House of Representatives Standing Committee on Infrastructure, Transport, Regional Development and Local Government. Available at: https://www.aph.gov.au/Parliamentary_Business/Committees/House_of_Representatives_Committees?url=itrdlg/financialcrisis/govt%20response/global%20financial%20crisis%20response.pdf accessed on 4/09/2018.

BNEF, 2012. Who's winning the clean energy race – 2012 edition. The PEW Charitable Trusts in collaboration with the Bloomberg New Energy Finance.

BNEF, 2014. Modelling options for Australia's RET review - White Paper. Bloomberg New Energy Finance.

Clean Energy Regulator. 2016. About the Renewable Energy Target – History of the scheme. http://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/History-of-the-scheme accessed on 05/06/2016.

Vorrath, S. 2017. Sapphire Wind Farm seeks community investors in possible Australian first. Reneweconomy 28 August 2017. Available at: https://reneweconomy.com.au/sapphire-wind-farm-seeks-community-investors-in-possible-australian-first-20090/ accessed on 28/04/2018.

[104] To avoid duplication of the references used both here and in the main chapter, all the references supplied here are only used in this Appendix B. All other references in the tables which are not listed here can be found in the reference list of the main chapter.

6.9 Appendix C - MLP-MCA model assessment of Germany

Table C 6-1 MLP-MCA assessment of political-acceptability of energy transition in Germany 1990-1998

Tier 1 criteria	Tier 2 criteria	Tier 3 sub-criteria	**1990-1998** Chancellor Helmut Kohl leading coalition of CDU/CSU/FDP **Scoring rationale**
A – Landscape	**A1 – National energy profile**	A11=1	Coal (hard coal and lignite), is Germany's only significant indigenous energy source. It has limited oil and natural gas resources and relied heavily on energy imports (IEA, 2012a; Hatch, 1995). For example, for the period 1990 to 1995 energy imports for oil were 96.2% to 97.4%; and natural gas were at 72.9% to 74.7% (IEA, 2012a p.2).
		A12=1	Energy security was an important issue for Germany due to limited indigenous energy resources. In 2002, the country imported coal and natural gas at 27% and 78% respectively of its demand for these fuels and oil at 40% of its total primary energy supply. To address these energy security issues, Germany focused on the development of domestic fuels and renewable energy and end-use efficiency (IEA, 2002b p.7). Refer to A11 above for imports dependency.
	A2 – climate/energy targets and policies	A21=1	In 1995 Germany established a national target to reduce 25% of its CO2 emission from 1990 level by 2005 and as its interim target of 12% reduction on total CO2 emission was achieved between 1990 and 1995 (IEA, 2002b p.7, 35). Being a signatory to the Kyoto Protocol in 1997, it had subsequently adjusted its commitment to reduce its GHG emissions by 21% below 1990 levels by 2012 (Eloy et al., 2016).
		A22=1	In 1990 Germany adopted its first Climate Change Action Plan that incorporated initiatives to support RE development. During this period, the government instigated transformative energy policies and programs with €10.7 billion to support: Electricity Feed-In Act 1991 (Stromeinspeisungsgesetz - StrEG); 250 MW Wind Program; ERP-Environment and Energy Saving Program; tariff for photovoltaic installations (Kostendeckende Vergütung), initiatives to support rooftop solar installations;

			and legislation to support the sale of green power to the grid outside the established national electricity feed-in scheme. Share of renewable energy (including hydropower) increased from 3.4% of total primary energy supply in 1990 to 4.5% in 1998 (BMWi, 2014a p.7).
	A3 – Citizen sentiment on climate change and renewable energy	A31=1	The history of public engagement with energy and climate change in Germany has been strongly shaped by major grassroots protests against nuclear power. These started in the 1970s and continued well into the 2000s. In part this reflected a high level of environmental awareness among German citizens. In 1983, the Green Party entered the German Parliament as a result of the anti-nuclear grassroots movement (Steentjes et al., 2017). Germany ranked top within the Gallup study of 24 nations in 1993[105] on 'Cross National Public Perceptions on the Seriousness of Global Warming Health of the Planet Survey' that reported 73% of Germans perceived that the Global Warming and Health of the planet as a 'very serious' issue (Brechin, 2003 p.110). GlobeScan (1999, 2000, 2001) studies reported that around 75% of German were in favour for 'Act Now or More Research', above 60% of German 'Perceived Seriousness of Global Warming' and above 50% 'Willingness to Pay 10% More for Renewable Electricity' (Leiserowitz, 2007 p.5, 20, 32).
		A32=1	Prior to and during this period, three critical landscape events had impacted and shaped the attitude of citizen on climate and energy issues which contributed to strong political-acceptability in phasing-out the nuclear power and embracing the renewable alternatives. First, the Chernobyl nuclear accident in 1986 had shocked and highlighted the risk of the nuclear power and hardened negative public attitudes toward nuclear power. This led to an institutionalization of views that had been advanced by an active anti-nuclear movement in preceding years and cemented public supports to explore alternative-energy sources. Second, the German reunification in 1990 had enabled the nurturing Feed-in Law (StrEG) to pass in 1991. This set in train

[105] Dunlap, R., G.H. Gallup and A.M. Gallup, 1993. Health of the Planet Survey: A George H. Memorial Survey. Gallup International Institute, Princeton, NJ USA

			the development of the RE sector somewhat independent of the established energy utilities who were preoccupied with taking over the East-German energy sector. Third, the 1992 Earth Summit in Rio de Janeiro was a catalyst for broader political support and consensus to address the emerging concerns on climate change (Geels et al., 2017; Morris & Jungjohann, 2016; Morris & Pehnt, 2016).
B – Regimes	**B1 – Incumbent utilities**	B11=-1	Until 1998, the structures within the gas and electricity sectors were: fragmented as they generally assigned to specific territories (often based on municipally boundaries); mostly municipally owned that discouraged intrusive government regulation; and electricity generators were largely tied to the use of domestic coal reserves. These characteristics were complemented by various associations agreements amongst industries and electricity generators to implement political objectives, such as protecting domestic jobs in the coal mining sector. Consumers were divided into two groups, households and small businesses in the first group and electric distributors and large energy consumers as 'special customers' in the second group. Länder governments regulated prices to small customers which was never uniform and the sales to the latter group was virtually unregulated. The federal and Länder (states) governments oversaw investment and communities regulated access to rights-of-way. Entry by new generators was discouraged (van Siclen, 2004). The Associations Agreements in electricity and gas often were signed under pressure from the federal government with the threat of legislation if a voluntary agreement was not reached. The Jahrhundertvertrag (century agreements) reached in 1977 were an example that the agreements governed the sale of hard coal to German electricity generators and contained extensive rules on state aid, imports and procurement obligations. In effect this ensured continued hard-coal mining in Germany funded by German electricity consumers (van Siclen, 2004 p.8-10) In the mid-1990s, the regulatory environment in Europe and in Germany changed when the European Union adopted two directives on electricity in 1996 and on natural gas in 1998. These established minimum standards for the

			regulation and structure of the respective sectors in the EU Member States. In 1998, Germany amended the federal Energy Industry Law and the competition law to provide a fundamental new legal framework for electricity and gas and to implement the directives. This marked electricity and gas market liberalisation in support of the European single market objective and has changed the German energy market condition by increasing the economic choices of consumers and new market participants (van Siclen, 2004 p.11-16).
		B12=-1	Since the market was fragmented and unregulated and the electricity and gas sectors were not open for competition, most investment of utility-scale installations were initiated by the incumbents and focused on fossil-fuelled or nuclear power plants (van Siclen, 2004).
	B2 – Fossil-fuel industry	B21=1	The post-war economic boom in Germany (Wirtschaftswunder) was fuelled by the coal mining in the states of North Rhine-Westphalia and Saarland, which previously powered the industries of West Germany. It also helped spawn the country's oldest party, the centre-left Social Democratic Party. This party rejected a complete shutting down of the industry. From 1960 to 1980, many mines become uncompetitive with the number of mines reducing from 146 to 39. By 2000, only 12 were still operating, with output down to 20.7Mt in 2006 from 150Mt in 1957. Post reunification, annual production and consumption dropped considerably over the first half of the 1990s, largely due to restructuring that occurred following the integration of former East Germany into a unified Germany (CLEW, 2017; DW, 2007).
		B22=0	There was no R&D in the clean coal or carbon capture and storage at the time.
C – Niche	**C1 – RE technologies R&D and commercialisation**	C11=0.5	German R&D programs in wind and solar photovoltaics (PV) were stimulated by the 1970s' oil crises, but deployment initially remained limited because of the perceived poor performance and high costs. During the 1980s, small wind turbines were adopted by environmentally motivated citizen groups, farmers, and smaller utilities. This helped to stimulate a positive discourse around green energy (Geels et al., 2017 p.467). The basic plan for energy R&D in Germany was set out in the 1996 'Fourth Programme on Energy Research and Energy Technologies' which ran until 2005. The primary objective of energy R&D was to support energy policy and

			the secondary objective was to support industrial development and economic growth (IEA, 2002b p.11). The Programme did not contain any funding details.
		C12=0	This period occurred at the very early stage of energy transformation and there were no policies or institutes advocating or directly supporting RE R&D commercialisation.
	C2 – RE industries and flow-on effects	C21=0.5	Renewable-electricity generation (mostly wind) as a proportion of gross electricity consumption grew from 3.1% in 1990 to 4.7% in 1998 (AGEE-Stat, 2011 p.21).
		C22=0	During the 1990s, wind power was greatly developed with almost 9GW of installed capacity that Germany has become the world leader in wind-power technology (IEA, 2002b p.9). However, there was no tracking or reporting on the flow-on effect of RE was undertaken.

Table C 6-2 MLP-MCA assessment of political-acceptability of energy transition in Germany 1998-2009

Tier 1 criteria	**Tier 2 criteria**	**Tier 3 sub-criteria**	**1998-2005** Chancellor Gerhard Schröder leading coalition of SPD/Greens **2005-2009** Chancellor Angela Merkel leading coalition of CDU/CSU/SPD **Scoring rationale**
A – Landscape	**A1 – National energy profile**	A11=1	Germany continued to import 60% of total primary energy supply (TPES) which amounted to about €25 billion in 1999, €43.4 billion in 2004 and €67.6 billion in 2007. The only sufficient domestic energy source was lignite. Most of the imported energy came from Russia, Netherlands and Norway. There was an increasing reliance on the hard-coal imports which rose from 11.7 Mt in 1990 to 47.5 Mt in 2007. This represented two thirds of its demand. 90 %

			of its uranium consumption were imported from France, Canada, the United Kingdom and the US (BGR, 2009 p.206, 211, 221, 224). In 2007, power generation by source was 25% lignite, 23% hard coal, 22% nuclear power and 14% renewable sources (BGR, 2009 p.213; AGEB, 2009). Only 8 hard-coal mines were in operation in 2007 and reduced to 4 by 2012. Coal production maintained its subsidy under the Hard-coal Mining Financing Law (Steinkohlefi nanzierungsgesetz) until the end of 2018. 2/3 of the hard coal was imported due to decreasing domestic production since 1990 (BGR, 2009 p.205).
		A12=1	Germany has very little domestic oil and natural gas production and relied heavily on energy imports (IEA, 2012a; Hatch, 1995). The import dependency of oil ranged at 96.9% to 96.3% from 2000 to 2009, whereas for the natural gas, it ranged at 74.9% to 84% in the same period (IEA, 2012a p.2). Refer to A11 above for more details on energy dependency on imports.
	A2 – climate/energy targets and policies	A21=1	Germany's GHG emission reduction target within the EU Burden-Sharing Agreement adopted in 1998 under the Kyoto Protocol was to reduce GHG by 21% from 1990 levels for the first commitment period of 2008-2012. The parliament approved a bill on the ratification of the Kyoto Protocol on 26 April 2002. By 2000, the total GHG emissions were 19.1% lower than the 1990 level (IEA, 2002b p.35). The Renewable Energies Act (EEG 2000) set target of 4.2% minimum share of renewables in its total primary energy supply (TPES) by 2010. The national policy on renewable energy was embedded in the European RE framework. This meant Germany's actual (effective) target was 12.5% by 2010 (IEA, 2002b p.9). This target was reached in 2007 (IEA, 2007a). The EEG 2000 was subsequently amended in 2004 and set higher targets of at least 12.5% renewable electricity generation by 2010 and at least 20% by 2020 (Morris & Jungjohann, 2016).
		A22=1	The energy policies were integrated with various governmental economic and environmental platform (Eloy et al., 2016; Hager & Stefes, 2016; Morris & Jungjohann, 2016; Morris & Pehnt, 2016). A portfolio of RE-policy reforms

			backed by €6.8 billion funding for policies and programs included: the landmark Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz – EEG 2000); an eco-tax designed to reduce GHG emissions through energy efficiency; the 100,000 Roofs Programme to provide financial support for PV systems over 1kW; and the Energy Industry Act 2005 designed to enhance competition, security of supply and sustainable energy production (Eloy et al., 2016; BMU, 2007, 2010; Büsgen & Dürrschmidt, 2009; Butler & Neuhoff, 2008). The earlier achievement of both emission and renewable energy targets bear witness to the effectiveness of these policies.
	A3 – Citizen sentiment on climate change and renewable energy	A31=1	The 'Cross National Public Perceptions on the Seriousness of Global Warming Health of the Planet Survey' conducted by GlobeScan (2000; 2006) found that around 73% of German respondents perceived Climate Change as a 'Very Serious Problem' (Leiserowitz, 2007 p.6).
		A32=0.5	Increasing community and political concerns on energy security arose out of a series of interlinked exogenous events including the global financial crisis (GFC) in 2008, the follow-on turmoil in the oil market combined with gas supply problems in Eastern Europe. In 2009 to 2010, across the EU-27 countries there was a collective financial stimulus program of €400 billion to support the green economy and clean energy sector (UNEP, 2009 p.57-58). Refer to C21 below for Germany's stimulus package and its impact.
B – Regimes	**B1 – Incumbent utilities**	B11=0.5	The objectives of the 1998 national energy reforms that sought to liberalise the German and EU electricity and gas markets were to: enhance energy-supply security; achieve economic efficiency; and protect the environment. However, over half-decade since the liberalisation, the sectors has consolidated into four big and highly concentrated utilities with horizontally and vertically-integrated market share as a post-liberalisation strategy to defend their pre-liberalisation positions. Consequently, the big-four incumbent utilities[106] formed de facto regional vertically-integrated monopolies that discouraged entry of new players by hampering fair competition (van Siclen, 2004 p.15-17).

[106] The big-four utilities dominated in the regional structure with the RWE in the northwest, EnBW in the southwest, EON in a north-south strip in the middle of the country and Vattenfall in the new Länder – Hamburg and Berlin.

			The major issue was that the primary means of network access was initially through negotiated third-party access (TPA) without sectoral regulator for electricity. The rules for network access were established by the electricity industry (utilities) and network users (new power-suppliers) in Associations Agreements within the legal framework of the Energy Industry Act and the Competition Law. There were concerns of the high variation of TPA tariffs in both transmission and distribution networks. The amendment to the Associations Agreement in December 2001 established the monitoring mechanism which simplified the market-access conditions for small consumers (IEA 2002, p.10). The full-market access and competition did not improve until two significant changes in the legal framework by adoption of the Energy Industry Law and Act against Restraints of Competition in 2002-2003 and further amendments in 2004 (Van Siclen, 2004 p.20).
		B12=-0.5	There were a small number of new wind, combustible renewables and waste, and solar-energy generators entering the market. Wind, by far the largest of these, accounted for 2.8% of electricity generated in 2002. Each of these technologies generated electricity independent of market conditions without strategic consideration. Thus, entry or expansion of these generators has essentially no immediate effect on competition in electricity markets (Van Siclen, 2004 p.23). In 2004, around 40% coal-fired plants in Germany were more than 30 years old. Technically the power stations have an operable life of up to 60 years and could be extended through refurbishment. However, the performance gap between the old and modern units is significant. Even though there were a significant new investment proposal from the utilities in Germany, according to the German Electricity Association (VDEW), the new-generation addition of 31.4 GW to be commissioned by 2012, were dominated by fossil-fuel that made up of 50% coal-fired, 25% gas-fired and only 25% renewables, mainly wind (IEA, 2007a p.46,48).

			The most featured RE investment was one of the German utility companies, E.ON, acquired the Iberian wind assets of Danish energy company Dong for $990 million in August 2007. E.ON later acquired an Irish wind farm developer, Airtricity's North American operations, for $1.4 billion (UNEP, 2008 p.40). However, neither of these investments had a strong and positive impact on domestic renewable energy investment.
	B2 – Fossil-fuel industry	B21=1	The post-war economic boom in Germany (Wirtschaftswunder) was fuelled by subsidised hard coal mined in the states of North Rhine-Westphalia and the Saarland. On 7 February 2007, the Federal Government, the Länder (states) of North Rhine-Westphalia and Saarland, the mining company (RAG Corporation) and the trade union (IG BCE) reached an agreement on the socially acceptable phasing out of subsidies for hard coal in Germany by the end of 2018 (BMWi, 2018a; CLEW, 2017; BGR, 2016 p.15). This agreement is significant, as similar to the negotiated nuclear power to be phaseout in 2022, it has set a firmed date for the hard-coal subsidies to be phased out which in effect implies an end to the hard-coal mining in Germany.
		B22=-0.5	The EU directives on environmental impact assessment, integrated pollution prevention and control, and other directives on environmental protection were incorporated into German law in 2001. These included the support for Clean coal technologies designed to enhance the efficiency and the environmental acceptability of coal extraction, preparation and use. Clean coal technologies were advocated by the German government, including integrated gasification combined cycle (IGCC) which is used in many power stations. The annual R&D expenditure by the federal government on clean coal and related technologies was €17 million in 2000 which was exceeded only by Japan and the United States (IEA, 2002b p.41-42). Carbon capture and storage (CCS) was also supported by a €1.05 billion across five EU countries (Germany, the Netherlands, Poland, Spain and UK) (UNEP, 2009 p.58).
C – Niche	**C1 – RE technologies R&D and commercialisation**	C11=1	The Future Programme was established with total budget of €123 million (approx. €41 million per year) over the period 2001-2003. This was used to support specific energy research including: fuel cells, alternative vehicle propulsion (high performance batteries), regenerative fuel production, geothermal and offshore wind energy.

			https://www.iea.org/policiesandmeasures/pams/germany/name-21001-en.php The overall R&D funding for renewable energy technologies increased annually from €399 million in 2006 to €604 million 2009 (BMWi, 2017b p.46).
		C12=1	The objectives of the EEG 2000 were to establish Germany's long-term plan for a sustainable and affordable power supply and concurrently create an economic policy to ensure an ongoing development of the RE industry (Morris & Jungjohann, 2016; Morris & Pehnt, 2016). Under the EEG 2000 wind power grew rapidly and placed Germany as the world leader in wind-power generation and at the time generated a third of all global wind power (Morris & Jungjohann, 2016). The German Energy Agency (DENA) was established in 2000 to promote sustainable energy, through RE and energy efficiency projects. The DENA worked in close co-operation with the energy agencies of the Laender (States) as well as the industrial and financial sectors to provide technical and financial support (IEA, 2002b p.7-8). In 2003, the German parliament authorised the Renewables Technology Export Initiative with €30 million to support of RE technology export initiatives.(Refer to the following links for more details: https://www.iea.org/policiesandmeasures/pams/germany/name-21389-en.php https://www.iea.org/policiesandmeasures/pams/germany/name-21537-en.php) These policy incentives created an entrepreneurial environment for solar technology in Germany that housed 16 successful incubators in 2008 which represented a significant success in commercialization of the RE technologies from its R&D investment and effort (UNEP, 2009 p.26).
	C2 – RE industries and flow-on effects	C21=1	Under the EEG 2000 wind-power capacity grew rapidly from 1GW in 2000 to 3.2GW in 2002 that placed Germany as the world leader in wind-power generation and at the time generated a third of all global wind power (Morris & Jungjohann, 2016). Some 18 GW of wind power was commissioned between 1995 and 2005 (IEA, 2007a p132). Collectively, a significant share

			and diverse portfolio of RE sources (including: hydropower, onshore and offshore wind, biomass, photovoltaics and geothermal) in gross electricity consumption grew from 4.5% in 1998 to 16.3% in 2009 that surpassed the national RE targets and at the time led an upward revision to at least 20% by 2020, reinforcing future growth potential for the RE industries (BMWi, 2014a p.7, 2016a p.11). Investment in the building of renewable energy installations steadily increased from €4.7 billion in 2000 to €23.6 billion in 2009 (BMWi, 2016a p.26). As a consequence of the global financial crisis, the green-stimulus programme was initiated as an industry support mechanism for 2009-2010. US$15.3 billion was provided to for RE industries (UNEP-BNEF, 2010 p.54).
		C22=1	Economic impulses (flow-on effect just within the power sector) from the operation of renewable energy installations grew from €2 billion in 2000 to €9.3 billion in 2009 (BMWi, 2016a p.27). According to an ongoing BMU research project, the number of people working in the renewable energy sector in Germany increased to around 300,500 in 2009. Compared with around 160,500 in 2004, approximately 140,000 new jobs were created in five years (UNEP-BNEF, 2010 p.54).

Table C 6-3 MLP-MCA assessment of political-acceptability of energy transition in Germany 2009-2017

Tier 1 criteria	Tier 2 criteria	Tier 3 sub-criteria	**2009-2017** Chancellor Angela Merkel leading coalition of CDU/CSU/FDP (2009-2013) Leading coalition of CDU/CSU/SPD (2013-2017) **Scoring rationale**
A – Landscape	**A1 – National energy profile**	A11=1	Coal is the most important energy source in the production of electricity in Germany. Around 40.2% of electricity generation is provided by coal (lignite 23%, hard coal 17.2%) in 2016 (AGEB, 2018). Hard-coal mining in Germany has been undergoing a process of restructuring for a few decades and there has been steady decrease in the number of mines and people employed in this sector. In 2016 almost 90% (54.1Mt) of hard coal and hard-coal products were imported (BMWi, 2018a; BGR, 2016 p.13).
		A12=1	Germany relies on imports to meet the majority of its energy demand (EIA, 2018). Around 45% of electricity flows into industrial and commercial enterprises in the industrial regions (BMWi, 2015c p.9). In 2015, apart from producing sufficient lignite for domestic use, Germany produced only 2% crude oil, 10% natural gas, 11% hard coal of the total primary energy supply. The shortfalls were covered by import (costed €65.7 billion) from three major supplying countries - Russia, Norway and the Netherlands (BGR, 2016 p.15).
	A2 – climate/energy targets and policies	A21=1	Germany committed to long-term and progressive GHG emission reduction targets below the 1990 level. These included at least 40% by 2020, 55% by 2030, 70% by 2040 and 80%-95% by 2050. Renewable energy targets as a share of gross electricity consumption are to achieve at least 35% by 2020, 50% by 2030, 65% by 2040 and 80% by 2050 (BMWi, 2015a).
		A22=1	The delivery of the RE targets are based on three key principle energy-transition policies: security of supply, economic efficiency and environmental sustainability (Jurca, 2014; Jacobs, 2012; IEA, 2002b, 2007b, 2013b). In 2016, Germany achieved 32.3% of its gross electricity consumption from RE sources and reduced its GHG emissions by 28% below 1990 levels (Wigand & Amazo, 2017). This validated the effectiveness of its policies. In 2017,

			30GW of new capacity were added by residential and commercial PV installations (which was ranked second after Japan with 36GW) (UNEP-BNEF, 2018 p.55). From 2015 onward, Germany shifted away from the feed-in tariffs structures to auctions for all RE technologies aiming to achieve cost-effectiveness through a faster response to market developments. This change in market conditions is anticipated to favour big projects, typically by large companies. Notable the change in market policy and lower costs per MW for offshore wind created investment uncertainty in 2017 that resulted in a 35% decline to $10.4 billion compared to the previous year (UNEP-BNEF, 2015 p.16). Responding to this change the last auction in 2017 for onshore wind featured specific rules that resulted in almost all capacity being awarded to projects set up by local citizens (UNEP-BNEF, 2018 p.11, 25).
	A3 – Citizen sentiment on climate change and renewable energy	A31=1	Public support for the energy transition was further evidenced by an opinion polls of between 56% and 92% approval ratings based on different survey methodology. Research also focuses on public acceptance and involvement and on long-term options for the evolution of the energy supply system (BMWi, 2014a p21). The European Perceptions of Climate Change Project (EPCC) surveyed four countries in 2016 including the United Kingdom, Germany, France and Norway. For Germany it reported: over 50% of participants think more negative than positive that the effects of climate change will be on Germany; over 80% felt positive about renewable energy sources, such as solar power, hydropower and offshore wind; nearly 70% were in support of using public money to subsidise renewable energy (such as hydropower, wind and solar power); and there were high levels of opposition to the inclusion of nuclear power into the energy mix (Steentjes et al., 2017).
		A32=1	During the CDU/CSU/FDP coalition government (2009-2013) the large energy utilities and pro-nuclear politicians briefly succeeded in extending the operation of nuclear-power plants in 2010 under the Energy Concept (BMWi, 2012; Jacobs, 2012). The 2011 Fukushima nuclear accident changed the view of the government as to the risk of nuclear power and reinforced the

			community's opposition to nuclear power. That led to a backflip of the government extension to the nuclear-power plants and the immediate shutdown of 8 of the 17 nuclear plants and resumed the phase-out of the remaining plants (Thalman & Wettengel, 2017; Morris & Jungjohann, 2016; Morris & Pehnt, 2016). This dramatic reversal was unanimously supported in Parliament by the CDU/CSU, SPD and the Greens parties and had the support of 80% of the German population (Morris & Jungjohann, 2016; Morris & Pehnt, 2016).
B – Regimes	**B1 – Incumbent utilities**	B11=1	In 2013, the German electricity market remained dominated by big-four utilities (RWE, EnBW, E.ON and Vattenfall) which suppled 67% of electricity. Despite many smaller power providers in the market offering cheaper prices, households are reluctant to switch providers and the big-four utilities retain a dominant market position. As Germany shifts towards a low-carbon economy, the big-four utilities have been impacted by: the nuclear phase-out; the growing share of renewable generation from 6.6% in 2000 to 25.8% in 2014; an increasing market competition and lowering wholesale electricity price eroded their market share and revenue; and declining demand from German companies and households generating their own power which grew from 8% of total power demand in 2008 to 11% in 2012. When 8 nuclear-power plants closed simultaneously in 2011, the big-four utilities recorded a fall in their company profits. For example, EON reported a loss of €1.9 billion after presenting €6.3 billion of profits in the year before (CLEW, 2015). Besides the big-four, many of the public owned municipal utilities (stadtwerke) that held regional monopolies over power supply were privatised during the 1990s. Some are now owned, or part-owned by the big four. However, with the introduction of subsidies for green power, many municipal utilities have been renationalised. Between 2005 and 2013, 72 new stadtwerke were founded with bias in RE generation (CLEW, 2015). Thus, the stadtwerke help decentralization of the RE generation and improve market competition of the European single energy market.

		B12=0.5	In 2013, utilities re-examining their business priorities in light of the eroding market share and revenue that had been falling since 2011. Many have cut back on capital spending, including investment in renewables, to protect balance sheets and credit ratings. In Europe, an aggregate capital expenditure on renewables by the seven leading utilities[107] fell from US$12.3 billion in 2010 to US$8.1 billion in 2013. In 2013, RWE, one of the largest German utilities, announced a cut on renewables investment by half to about US$500 million (UNEP-BNEF, 2014 p.53). RWE has subsequently raised US$5.2 billion[108] of new capital by floating its renewable-energy assets through an initial public offer (IPO) of Innogy (UNEP-BNEF, 2017 p.24, 85). A similar split, separating the conventional and RE generation, was undertaken by E.ON contrary to its earlier decision of keeping its renewable power assets and divesting or floating off its fossil-fuel generation portfolio instead (UNEP-BNEF, 2017p.85; UNEP-BNEF, 2015 p.39). In 2013, Germany's energy markets investment was US$13.2 billion. This included US$8.4 billion in asset finance a 34% reduction from 2012 and primarily used to fund offshore and onshore wind projects. On-shore wind generation projects have seen a progressive decline in investment due to a tightening in planning rules and uncertainty ahead of a move in 2017 from guaranteed tariffs to auctions (UNEP-BNEF, 2016 p.25). There were also many offshore wind-farm including: Butendiek (288MW valued US$1.9 billion); Baltic II (288MW valued US$1.6 billion) owned by EnBW and financed through European Investment Bank loan of €500 million (US$684 million) (UNEP-BNEF, 2014 p.24, 49); Veja Mate (402MW US$2.1 billion); and Nordsee 1 (332MW at US$1.3 billion) (UNEP-BNEF, 2016 p.49).

[107] SSE, Iberdrola, Enel, EON, RWE, Energias de Portugal and Electricite de France.

[108] Innogy's IPO raised US$5.2 billion, comprising US$2.9 billion for its previous owners and US$2.2 billion in new equity for a company that has around 3.6GW of renewable capacity, overwhelmingly wind and hydro, along with grid and gas assets.

			In 2016, there were a few offshore-wind mega projects investment by incumbent utilities: 385MW Arkona Becken Sudost[109] reaching final investment decision in 2016 (UNEP-BNEF, 2017 p.25, 40); Hohe See[110] project at US$1.9 billion for 497MW; the 252MW Deutsche Bucht[111] array in German waters; and a long list of medium-sized onshore wind projects worth between $10 million and $100 million (UNEP-BNEF, 2018 p.50). According to British climate NGO Sandbag, RWE operates three of Europe's five most polluting lignite power plants, and the associated lignite mines. In 2016, RWE's fossil-power plants generated 130 terawatt hours of electricity in Germany, compared to Innogy's less than four terawatt hours from renewables (CLEW, 2017).
	B2 – Fossil-fuel industry	B21=0.5	Hard-coal mining in Germany (3.8 million tonnes in 2016) is unable to compete with international imports and was heavily subsidised by the states since the 1960s and subsidies will be phased out in 2018. According to the Green Budget Germany (FÖS), the sector has received €337 billion between 1970 and 2016 (CLEW, 2017). According to the Federal Institute for Geosciences and Natural Resources (BGR), there were 9,640 people employed in hard-coal mining (2015). While the production of lignite is self-sufficient, in 2016, it still accounted for 23% of electricity generation that has made Germany the biggest producer of lignite in the world even though its remaining hard-coal mines will be closed by the end of 2018 (BMWi, 2018a; CLEW, 2017; BGR, 2016 p.15)
		B22=-0.5	After Germany closed 8 nuclear plant and resumed the phaseout of nuclear power in 2011, a total of 6.7GW new coal-fired plants came into service while about 3.8GW were retired. Since the planning and construction of a coal-fired

[109] Germany's E.ON and Norwegian energy company Statoil have teamed up on a €1.2 billion project to build the 385MW Arkona offshore wind farm in the German waters of the Baltic Sea. Ownership E.ON (50%), Statoil (50%) Installed Capacity 385MW Turbine Supplier Siemens Construction Started August 2016.

[110] Hohe See is a 497MW offshore wind farm being constructed in the German North Sea waters. The project was proposed by German utility, EnBW Energie Baden-Württemberg (EnBW), which took the final investment decision on the project at the end of 2016.

[111] Northland Power owns 100% of the approximately EUR1.3 billion DeBu offshore wind project, and will play an active role throughout construction and operations. DeBu has a capacity of 252 MW and is located 95 km west of Borkum in the German Exclusive Economic Zone, 77 km from Northland's other German offshore wind project, Nordsee One.

			power station takes at least three years, the new capacity would have been planned before the 2011 Fukushima accident. In 2018, it is anticipated that a new 1055MW hard-coal power plant (Uniper's Datteln 4) will be commissioned after years of legal struggle with local environmental organisations (CLEW, 2017). As of 2017, no new lignite-powered stations are planned, according to the Federal Network Agency (Bundesnetzagentur). However, that there is a continued push for new fossil-fuel generation evidenced by the plan for a combined hard coal-biomass-hydrogen plant with a capacity of 1,000 MW by Dow Chemical in Stade, and RWE is seeking permission for a new lignite unit at Niederaussem to start running in 2022. The status quo in 2018, there will be 10 hard-coal units with total capacity of 3,420MW retired and 2,378 MW of lignite capacity will be transferred into the so-called security reserve by 2019. According to an analysis of EU-ETS data by climate NGO Sandbag, German lignite plants make up seven out of Europe's 10 biggest polluters and 55.3% of ETS emissions in Germany came from coal-power plants in 2016 (CLEW, 2017).
C – Niche	**C1 – RE technologies R&D and commercialisation**	C11=1	Between 2011 and 2014, the 6th Energy Research Programme provided €3.5 billion for energy research and development. The aims were to improve German industry competitiveness through an ongoing dialog with industry to prioritise industry-focused energy research strategic funding and to make leading-edge technologies more cost-effective for faster penetration of markets (BMWi, 2014a p.19-20). The Programme had a strategic focus on: RE; energy efficiency; energy storage and grid technologies; the integration of renewable energy into the energy-supply network; and the interaction of these technologies in the overall system. These selected fields were identified by the government as being of strategic importance to future energy supply. In 2010, the Federal Ministry of Economics and Technology, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the Federal Ministry of Education and Research established a joint 'Energy Storage' funding initiative, and other programs in the areas of 'Electricity

			Grids' and 'Solar Buildings – Energy Efficient Cities' will follow (BMWi, 2011 p.7). R&D funding for renewable energy technologies increased annually from €604 million in 2009 to €876 million 2016 (BMWi, 2017b p.46), and increased to more than a billion euros on R&D and demonstration of modern technologies for the energy transition in 2017 (BMWi, 2018b).
		C12=1	The Federal Ministry for Economic Affairs and Energy (BMWi) is responsible in ensuring that innovations emerge through R&D are successfully transferred from research laboratories and workshops to the market (BMWi, 2016c p.6). As a result, this integrated approach of R&D in Germany has made a significant contribution to the global mitigation of climate change through commercialising two key RE technologies – wind and solar. These technologies are now economically competitive with fossil-fuel technologies and serving as a catalyst and enabler for energy transition across developed and developing countries (Morris & Jungjohann, 2016; Greenpeace, 2014). Domestically, Germany has been one of the exporters of RE technologies since the 1990s which has recently contributed around €10 billion to its economy (BMWi, 2014a p.19-20).
	C2 – RE industries and flow-on effects	C21=1	In 2010, fuelled by feed-in tariff subsidies, the small-scale rooftop solar investment increased to US$34 billion, a rise of 132% on previous year. The new installed small-scale capacity of 7.4GW was well above its target of 3.5GW per year and is directed at meeting the intended goal of 52GW small-scale capacity by 2020 (UNEP-BNEF, 2011 p.11,16,45). The feed-in tariffs for new PV projects were subsequently reduced to reflect falls in technology costs as the declining cost of PV resulted in greater-than-expected returns for investors and boosted the small-scale installation to more than 7GW in 2011 (UNEP-BNEF, 2012 p.15). Small-scale investment was curbed in 2013 as a result of policy uncertainty ahead of the September 2013 general election, reduced tariffs and a shortage of good quality, unexploited onshore wind sites. In the period of 2009-2016, a significant share and diverse portfolio of renewable-based electricity in gross consumption has grown from 16.3% in 2009 to 31.7% in 2016 and investment in the building of renewable-energy

			installations also grew from €14 billion to €27.9 billion respectively (BMWi, 2016a p.11, 26).
		C22=1	Economic impulses (flow-on effect just within the power sector) from the operation of renewable energy installations grew from €9.3 billion in 2009 to €15.6 Billion in 2016 (BMWi, 2016a p.27). The energy transition is strengthening the growth of the German economy and the employment for around 370,000 people. About 261,000 jobs can be traced back to the Renewable Energy Sources Act 2000 (BMWi, 2014a p20). Renewable energy technologies such as solar PV and wind turbine have become important established industry operating in Germany and around the world (UNEP-BNEF, 2011 p28).

References[112]

GlobeScan. 1999. Environics International Environmental Monitor Survey Dataset.

GlobeScan. 2006. 30-country poll finds worldwide consensus that climate change is a serious problem. Toronto, Canada: GlobeScan, Inc.

IEA, 2017. Key World Energy Statistics 2017. International Energy Agency. OECD/IEA, 2017.

Thalman, E., Wettengel, J. 2017. Factsheet – The story of "Climate Chancellor" Angela Merkel. Clean Energy Wire CLEW. Available at: https://www.cleanenergywire.org/factsheets/making-climate-chancellor-angela-merkel accessed on 6/12/2017.

[112] To avoid duplication of the references used both here and in the main chapter, all the references supplied here are only used in this Appendix C. All other references in the tables which are not listed here can be found in the reference list of the main chapter.

Chapter 7: Synthesis and discussions

This thesis has set out to investigate the energy-transition aspirations in Australia and Germany to gain insights on how and why Germany is performing much better than Australia in terms of greenhouse-gas emissions reduction and decarbonisation of their energy systems. To gain knowledge of the causal factors such as drivers, barriers and challenges underlying the contrasting energy-transition achievements between Australia and Germany, the investigation was guided by three central research questions:

1. *With abundant fossil and renewable energy resources and consistent trend of GDP growth, what is holding Australia back from transformation of its energy systems?*
2. *What are the underlying factors for an outstanding achievement of Germany in transforming its energy systems and what lesson can be learnt?*
3. *From the multi-level perspective, what are the true causal factors (drivers, barriers and challenges) underlying the contrasting energy-transition achievements in Australia and Germany?*

This chapter presents an overarching perspective on the three central research questions and what insights are gained in this dissertation. The rest of this chapter will: (i) synthesise and discuss the findings of this investigation with respect to the energy-transitions perspective; (ii) discuss the methodologies, strengths and limitations of the MCA and MLP–MCA models; and (iii) elaborate the significance of contributions of this dissertation to the ongoing energy-transitions research field and literature.

7.1 Synthesis of findings

Chapters 4–6 are dedicated to examining the underlying causal factors that have contributed to the energy transitions in Australia (Chapter 4), Germany (Chapter 5) and through a comparative analysis employing the MLP (Chapter 6). This section synthesises all the findings, which are fully discussed in the next section (7.2).

7.1.1 Chapter 4: In the transformation of energy systems: what is holding Australia back?

Question 1: With abundant fossil and renewable energy resources and consistent trend of GDP growth, what is holding Australia back from transformation of its energy systems?

Australia is endowed with abundant and diverse renewable-energy resources and has had strong and consistent economic growth over many decades. However, it has been unable to unshackle its dependency on fossil-fuelled energy. The analysis of Chapter 4 focused on identifying causes underlying Australia's underachievement in decarbonisation of its energy systems through transitioning to renewable-energy sources. Applying a combined mixed-methods case-study and multi-criteria analysis (MCA) strategy, an MCA energy-transition evaluation model/framework was developed. The model was structured with an understanding of energy-policy developments that are not simply technocratic processes devoid of politics, rather an outcome of politically contested debates and accepted through contestation and sometimes harmonisation on issues perception, agenda setting and ways to implement, govern and monitor. Therefore, the model was framed at the energy-system transition perspective with a multi-criteria evaluation ability to assess the political acceptability, energy policies and governance institutes at a national level. The energy-transition policies were based on a set of generic energy policies/instruments recommended for policy-makers by IPCC and IEA as effective tools in steering structural changes and governance of an ongoing transition. The MCA model was applied to ex-post historical official data, reports, IEA/IRENA (2016, 2018) member-countries' policy database and published academic studies to evaluate the political commitment, renewable energy policy and enabling programs, and governance framework in monitoring and reporting of four prime ministers (John Howard, Kevin Rudd, Julia Gillard and Tony Abbott) and their cabinets in their term of government between 1996 and 2015.

The investigation of Chapter 4 identifies four high-impact factors that contribute to Australia's GHG emission trajectory and poor decarbonisation outcomes, as follows:

1. The political stance of the prime minister and that of their political party towards climate change is a critical and fundamental political and policy driver in setting the direction of the climate/energy agenda.
2. An absence of target-driven policy frameworks results in less-effective policy outcomes. This was particularly notable during the long period in office (1996–2007) of Prime Minister Howard.
3. An orderly and cost-effective energy-system transformation requires strategic long-term planning and substantial capital investment underpinned by bipartisan support at the federal and state government levels to provide policy certainty and stability that can induce new investment in renewable technologies and industries.

4. Underlying economic conditions are not a determinant of whether climate change action and RE transformation can effectively be achieved, but climate/energy policy is primarily a political and ideological issue.

From an energy-transition research perspective, my findings are consistent with or adding value to the findings of other researchers on: (1) the critical role of power and politics on energy transition (Grin et al., 2010; Meadowcroft, 2009; 2011); (2) sustainability transitions need to be goal-oriented in driving the purposive agenda (Smith et al., 2005); (3) consistency, stability and certainty of government policy is crucial for long-term socio-technical changes (Geels, 2006; van Rooijen and van Wees, 2006; Verbong and Geels, 2007). My final finding that underlying economic conditions of a nation are not a prime determinant of national climate change actions and achievements in RE transformation offers new perspective in the field of socio-technical transition.

From a research-strategy perspective, the methods used in the examination highlighted the contribution of policy analysis techniques through a socio-political lens with my constructed MCA model focusing on examining transition-specific politics, policies and governance. The adoption of a semi-crisp MCA evaluation criterion was simple and comprehensive and was able to successfully differentiate the energy-policy political actions and policies of successive governments that have impacts on national pathways and transition performance. This new approach provided both a point in time and temporal analysis technique underpinned by robust data analysis and evaluation.

This chapter was published as a co-authored paper with my academic supervisor in the *Journal of Energy Policy* (Cheung and Davies, 2017). I was the lead author of the article and was responsible for the overall conceptualisation, design, research and empirical analysis of the paper.

7.1.2 Chapter 5: In the transition of energy systems: what lesson can be learnt from the German achievement?

Question 2: What is underlying the outstanding achievements of Germany in transforming its energy systems and what lesson can be learnt?

In 2000, Germany decided to phase out its nuclear power and set an ambitious CO_2 emissions reduction target of 40% below 1990 levels by 2020 and generate 35% of its electricity from renewable energy sources. By 2016, CO_2 emissions were reduced by 28% and 32% of electricity was derived from renewable sources.

The primary objective of Chapter 5 was to gain insight into factors underlying Germany's outstanding energy-transition achievement. The secondary objectives were to test the robustness and utility of the multi-criteria analysis (MCA) energy-transition evaluation model developed in Chapter 4 through its application to another nation state. Concurrently, within Chapter 5, I also sought to advance the utility of the MCA model with greater emphasis to enable a comparison between nation states.

Chapter 5 extended the methods and approach developed in Chapter 4 (Cheung and Davies, 2017) which identified the causality of underachievement of Australia's energy transition and GHG emission reduction. The same MCA model was applied, as per Chapter 4, to evaluate the climate/energy actions of the three German chancellors, Helmut Kohl, Gerhard Schröder and Angela Merkel, and their respective coalition governments between 1990 and 2017. This study was informed by ex-post historical official data drawn from government reports, IEA/IRENA (2016, 2018) member countries' policy database and published academic studies to evaluate political commitment, policy and enabling frameworks. Additionally, a time-weighted coefficient was incorporated into the model. This addition was due to the analysis results from Germany's case study reflected the limitation of the semi-crisp scoring rule set that were unable to reflect the short time-span phenomenon of Australia's leadership. This indicated the need for the time factors to show the long-process nature of policy-making to be able to see its effectiveness. At the same time, this MCA-model enhancement with a time-in-office weighting coefficient for one of the top-tier criteria, Policy measures/instruments, also acted as a way of 'normalising' the data to enable a comparison of the scores between Australia and Germany.

The study revealed four interdependent high-impact factors that contributed to Germany's energy transition:

1. Bottom-up anti-nuclear grassroots movements have established the foundation for and enabled the socio-political energy policy as the genesis of *Energiewende* (energy transition) in seeking alternative energy sources that can improve energy security and sustain economic growth, as well as address climate change issues.
2. The *Energiewende* harbours a compelling socio-technical experiment based on government-led, policy-driven structural changes to the energy system and a strong community-supported

phasing-out of the nuclear power concurrently through strategically decentralised power generation with diversified ownership.

3. The vision and social experiment of the *Energiewende* remains a cross-partisan policy enduring many changes in coalition governments across the political divide and shares wide community support despite the burden of higher energy costs.
4. The political stability of leadership and the ability of politicians to champion long-term RE-enabling policies to be strategically integrated with the economic policy platform over successive coalition governments have provided the certainty and confidence needed by the private investment sector to deliver on the short to medium term RE-generation targets.

From an energy-transition research perspective, the first two findings (1 and 2) are consistent with and add value to the well-researched field of the German *Energiewende* on the impact of the anti-nuclear grassroots movements on the domestic energy policies and achievements (Hager and Stefes, 2016; Morris and Jungjohann, 2016), and the transition model and pathway of the socio-technical structural changes (Geels et al., 2016; 2017). The last two findings (3 and 4) are new insights on the long-term policy stability through cross-partisan harmonisation of political differences on national climate/energy strategy in Germany. This is most valuable when seen through a lens of a comparative study with the Australian case to uncover the contrasting policy instability as a result of political divides, which is a primary underlying factor contributing to their energy transition performance. In essence, this study has revealed the important role of a robust, consistent and complementary energy governance system spanning successive political parties.

From a research-strategy perspective, the method that was adopted in Chapter 4 and now being applied and tested in this chapter has proven its ability to quantify the importance of those impacts and events that have contributed to the energy policy success in Germany. The enhancement of a time-weighted coefficient to the MCA model has improved the utility of the method in reflecting the policy effectiveness and time-factor relationship that can capture the political stability/instability relating to climate/energy policy-making. Consequent to the enhancement, the MCA model can easily be adopted and applied to any other nation states.

This chapter was submitted on 18th April 2018 as a co-authored paper with my two academic supervisors, Dr Peter Davies and Dr Alexander Bassen, to the *Journal of Energy Policy* and is currently under review with the manuscript number of JEPO-D-18-01280. I am the lead author of the article and was responsible for the overall conceptualisation, design, research and the empirical analysis of the paper.

7.1.3 Chapter 6: From a multi-level perspective, what is underlying the contrasting performance of energy transition in Australia and Germany?

Question 3: From the multi-level perspective, what are the true causal factors (drivers, barriers and challenges) underlying the contrasting energy-transition achievements in Australia and Germany?

Building on and extended from the tested concept of the MCA model for Chapters 4 and 5, which studied energy transitions in Australia and Germany, this Chapter 6 aimed to gain further insight into the underlying factors that have shaped the differing political positions and socio-technical pathways in decarbonisation that in turn reflect the current trajectories in both countries. An integrated MLP–MCA analytical model was constructed by adopting the MLP theories and conceptual elements of landscape, regimes and niches as its top-tier criteria (Geels, 2002; Geels and Schot, 2007; Smith et al., 2010). A three-tiered MLP–MCA model with a set of well-defined assessing scores was designed to offer a system-wide view of the enactments of regimes and niches within the national energy-transitions landscape. The study applied a combined mixed-methods and comparative longitudinal case-study approach to ex-post historical official data from government reports and academic studies of the field to assess the political commitment, policy and enabling frameworks and actions enacted by the regimes and niches in response to the policies and exogenous conditions. The focus of the analysis covers the tenure of five Australian prime ministers and their respective governments between 1996 and 2017, and three German chancellors in their terms of government between 1990 and 2017. This research study revealed five impactful factors underlying the contrasting energy-transition performance of Australia and Germany.

1. The static landscape including the natural-energy endowment, the degree of energy-resources development and economic structures of both Australia and Germany have a decisive effect on the dynamic landscape such as the national (decision-making on) climate and energy policies and social sentiments on those policies. The dynamic policy landscape can in turn shape an overall configuration and relationships of the regimes and niches of the country and subsequently their ensuing enactments to the dynamic structural changes can interactively influence the speed and pathways of the energy transitions.

2. Rich fossil-energy resources (as part of a static landscape) can reinforce a carbon lock-in, irrespective of the renewable energy endowments. Both Australia and Germany remain beholden to their coal reserves and associated industries to a different degree and for a

different rationale. Australia is heavily locked in to carbon at the national economic level as a result of massive investment in the development of coal and liquefied natural gas (LNG) in the past two decades. In contrast, for Germany the ongoing lock-in to lignite as part of embedded socio-political systems to date is for energy security reasons, as lignite is the only self-sufficient indigenous energy resource.

3. Mitigation costs as a feasible rationale for Australia's delayed adoption versus Germany's early adoption have contributed partly to the contrasting transition performance. Studies show that mitigation costs are highly dependent on the timing (immediate or delayed actions) of implementation of climate/energy mitigation policies and targeted speed (Bauer et al., 2012; Garnaut, 2008; Gerlagh et al., 2009; Sorrell and Sijm, 2003). Industrialised countries will benefit from early adoption of RE, whereas well-endowed energy and resource-based countries would likely lose (Bauer et al., 2010; 2012).

4. The state/territory governments in Australia are filling the gap of weak national climate/energy policy drive in the socio-political nexus and serving as a catalyst for energy transformation across multiple scales. The states and territories have set more ambitious targets above the federal government and beyond 2020 that are compelled and motivated by other dynamic landscapes such as falling prices of renewable technologies, regional economic development and energy-supply security.

5. Consistent with the multi-level perspective (Geels et al., 2016), this research confirms that energy transitions are non-linear with ebbs and flows of advances and setbacks that depend on the changing landscape contexts (elaborated in finding #1), such as governments and coalition partners, energy crises and natural disasters; and regime- and niche-level actions that will shift transition pathways due to actor struggles over speed, direction and technology deployment.

This chapter was submitted on 21/09/2018 as a co-authored paper with my academic supervisor (Dr Peter Davies) to the *Journal of Energy Policy*. I am the lead author of the article and was responsible for the overall conceptualisation, design, research and the empirical analysis of the paper.

7.2 Discussion

The findings summarised in Section 7.1 reflect the differing scales and perspectives as a focus of my investigation and analysis and offer an understanding of varying conditions of climate/energy governance in terms of decision- and policy-making to steer socio-technical structural changes. Steering and governing structural changes often constitutes complex decadal discursive socio-technical reconfigurations and reorientations of new directions to get there. These reconfigurations and reorientations are the consequence of the political enactments between many groups of actors (such as the political leaders, incumbent regimes and innovative niches) to the social sentiments, external events, policies and market conditions. This section offers insights and observations of the national decision- and policy-making that has shaped the reconfigurations and reorientations of the transformative processes of energy systems, thus, the speed and performance of the decarbonisation in Australia and Germany as discovered in my investigation results in Chapters 4–6.

7.2.1 Insights from the multi-level perspective and multi-criteria analysis

The culminative analyses of Chapters 4 and 5, complemented with comparative analysis of MCA model results of Australia and Germany, reveal that the most fundamental contrast between Australia and Germany is the political acceptability of climate/energy mitigation agenda and approaches at the federal government level. The clear differences in political ideology and stance of climate/energy policy and an inability to harmonise those differences across the party lines have resulted in energy-policy backflips in successive Australian governments and created an impasse on the momentum of transition to renewable energy. In contrast, there is a clear political acceptance and stability of successive German coalition governments in pursuit of the ultimate goal of energy transition. As elaborated in Chapter 2, energy transition is found to be a protracted and gradual process of policy development and implementation that steers the modes and means of a step-wise socio-technical change (Allen, 2012; Elzen et al., 2004; Fouquet, 2010; 2015; Fouquet and Pearson, 2012; Kern and Markard, 2016). Hence, the flip-flop of energy policies in Australia has led to suboptimal performance of policies, investment confidence and momentum.

This causal factor was well captured by the MCA model showing poor political-acceptability rankings of the right-leaning Liberal/National Party coalition government led by Prime Ministers Howard and Abbott, and much higher rankings of Prime Minsters Rudd and Gillard of the left-leaning Labor governments. In contrast, for the German leaders, that ranking was consistently across the board above medium to strong throughout the assessment period. However, the MCA model did not offer the causality underlying the differing political acceptability of the two countries.

To uncover the true causality of the differing political acceptability in Australia and Germany, a constructed MLP–MCA analytical model has extended the previous investigation scale, focusing only on energy actions and policies of leaders and governments to the big-picture view at the national level. The MLP–MCA model encompasses multiple actors based on the MLP theory and concepts of the landscape, regime and niche to be incorporated in the MCA hierarchical structure. The model was designed to capture the characteristics of static and dynamic landscape developments and changes[113] over time, which have impacts on actors' enactments relating to their decision making as responses to those changes. The static landscape, such as economic and constitutional structures, policy styles, ideologies and natural-energy endowments, provides affordances and action possibilities where the enactments and decision patterns of a nation are playing out (Geels et al., 2016). The dynamic landscape, however, reflects changes at the national level in terms of elections, accidents, macro-economic trends and commodity prices. These dynamic changes would affect complex interwoven dynamics in political struggles, social acceptance and governance that serve as both constraints and catalysts for shifting pathways and accelerated/stalled transitions (Cherp et al., 2018).

Drawing on transitions theory and concepts, my MLP–MCA analysis found that the static landscape, especially the natural-energy endowment and economic structures, has a decisive effect on the motivations and impacts on national decision-making on climate and energy policies. Rich and well-developed fossil-energy resources can reinforce a carbon lock-in irrespective of the renewable energy endowments. As a deductive observation of grounded theory, Australia's energy transition has been driven by international pressures and obligations on climate change actions. Its Kyoto recalcitrance, with a decade of inaction and ongoing instability and backflips of domestic climate/energy policies, is just a symptom of the dilemma of its own energy-rich and resources-based economy. The massive capital investments in coal and LNG over the last two decades has increased the carbon lock-in of Australia's economy at the national level. Hence, to navigate a cautious and balanced path that is acceptable both politically and economically is a mammoth challenge.

[113] Landscape developments/changes comprise both slow-changing trends (e.g., demographics, ideology, spatial structures, geopolitics) and exogenous shocks (e.g., wars, economic crises, major accidents, political upheavals).

In contrast, the constraint of insufficient natural-energy resources for Germany was primarily driven by its need for energy-supply security to sustain its energy-intensive industrialised economy. Relatively free from economy-wide carbon lock-in, with its readily developed industries and strong citizen demand for alternatives to nuclear power, the national decision in the socio-technical transformation of the energy system encountered less resistance, given that the electricity sector (mainly the big-four utilities) was heavily locked in to carbon, which has rendered certain resistance in shifting both speed and direction (Geels et al., 2016). Energy-supply security is the most important decision-making factor for Germany, evidenced in the absence of phasing-out mandates or agendas on the highly polluting lignite in the nation's power-generation mix. This is despite the fact that support and subsidies for the diminishing black coal will stop by the end of 2018, as lignite is the only abundant indigenous energy source that is also still economically viable on its own (BGR, 2016; BMWi, 2018a; CLEW, 2017).

7.2.2 Ongoing drivers for energy transitions in Australia

While I was researching Australia (Chapter 4), the new Prime Minister Malcolm Turnbull ascended to the leadership of the Liberal-National Coalition Government, replacing Prime Minister Tony Abbott. Due to the lack of track record in governing, Turnbull was not included as part of the case study for Australia. Prior to becoming prime minister, he expressed strong support for climate action with carbon pricing as a key lever for change. As limited by the scope of the investigation for this thesis, I can only gauge his ascension to power based on his actions to retain Prime Minister Abbott's Direct Action Plan legacy, despite ongoing critiques of this policy as beholden to the conservative faction of the Liberal Party. As it stands, the conservative political stance is still leaving Australia's climate/energy policies out of step with the global push for more actions after the Paris Agreement. However, as the impasse at the federal government level continues, the study (in Chapter 6) found that the state/territory governments have stepped in to fill the gap in assuming their leadership roles. Most states and territories are pursuing renewable-energy targets over their federal counterpart and beyond 2020. Good examples are the Australian Capital Territory (ACT) (100% by 2020), Tasmania (100% by 2022), Victoria (40% by 2025), Queensland and Northern Territory (each 50% by 2030), South Australia (50% by 2025 with 47% already achieved) and New South Wales (NSW), Queensland, Victoria and Tasmania all with net-zero state-wide emissions target by 2050 (Stock et al., 2017).

Going forward, I have identified here three compelling drivers that will propel the speed of transformation from this stage, despite the incumbent conservative government trying hard to put a brake on the established momentum without increasing renewable energy targets that are fast being exceeded and at the same time through talks of phasing out of solar subsidies. Following are the drivers for increasing renewable energy deployment in addition to the state/territory-led incentives:

1. *Economic-push driver*: as the prices of wind and solar technologies continue to drop significantly, they have become economically more competitive with fossil-fuelled power (including coal and gas) (IRENA, 2018). This is evidenced by the new phenomenon of more RE investment projects and no new investment in coal-fired power generators in Australia.

2. *Demand-pull driver*: economic factors have also affected the aged and inefficient coal-fired plants that led to the closure of many in Victoria and South Australia. This has left a shortfall in the generation to meet the current demand. Based on the first driver, any new investment is most likely to be in RE technologies.

3. *Paradigm-shift driver*: as the global investment momentum gathered after the Paris Agreement, there have been increasing numbers of big, centralised renewable-energy generation projects financed through loans from large global investment funds. Most global investment funds have set corporate and social responsibility mandates that exclude funding carbon-intensive industries in their investment portfolios under the Paris Agreement pledge (Hannam, 2014; Kiyar and Wittneben, 2015; Zindler and Locklin, 2016).

7.2.3 Rationale for Australia's delayed adoption versus Germany's early adoption

As discussed above (section 7.1.3), one of the causal factors underlying the contrasting energy-transition achievements between Australia and Germany was the delayed adoption of renewable energy in Australia versus early adoption in Germany. The study in Chapters 4 and 6 found that the cost of energy transition was often a primary concern both politically and socially in Australia and manifested as eleven years of inaction as identified in Chapter 4 (Cheung and Davies, 2017). The arguments for delayed mitigation actions were often directed at the concerns for economic growth and job loss in the fossil-fuel industry. This could be explained by the studies on mitigation costs that are highly dependent on the timing (early or delayed actions) in the implementation of climate/energy mitigation policies and targeted speed (Bauer et al., 2012; Garnaut, 2008; Gerlagh et al., 2009; Sorrell and Sijm, 2003). Bauer et al. (2010; 2012) found that industrialised countries would likely benefit from early adoption of RE, whereas well-endowed energy- and resource-based countries would likely be disadvantaged. This offers a profound rationale on the early adoption of RE in Germany as an industrialised economy heavily dependent on imported energy, and the delayed action in Australia with a well-endowed energy- and resource-based economy.

Nonetheless, the pioneering role of German *Energiewende* represents one of the most important social, economic, and political undertakings of our time; it has enhanced renewable energy technologies and contributed to the progressively falling costs in a positive feedback loop that has driven global transitions in energy generation systems (Grübler, 2012). This has also contributed to the *economic-push* and *paradigm-shift* drivers in Australia as identified in section 7.2.2 above. Without effective globally linked carbon pricing, Australia seems to have been benefiting from its delayed action in its transition to renewable energy, whose costs are falling markedly in the few years and its deployment has gained momentum since 2016.

7.3 Methodologies and constructed models

To investigate the three central research questions of this thesis, new and novel approaches were developed and applied across different scales (at energy-transition policy level and national landscape level) to examine the complex multi-dimensional dynamics of energy-transition performance in Australia and Germany. These approaches, encompassing mixed methods, a longitudinal nested case study, Grounded Theory, multi-level perspective (MLP), multi-criteria analysis (MCA) and comparative analysis, have underpinned and formed my overarching methodological design throughout the research project. Chapter 3 and Figure 3-1 provide detailed methodological strategies and design. This section discusses the theoretical underpinnings and approaches adopted in the study, and the utilities, strengths and limitations of the evaluation tools (MCA and MLP–MCA models) developed.

7.3.1 Theoretical underpinnings and approaches

The mixed-methods strategy, integrating both qualitative and quantitative data collection and analysis design, is best used to enhance the scope and breadth of the nested case studies and draw insights based on the data analysis and observations of the grounded theory. Grounded theory is considered one of the most elucidating ways to knowledge (Flick, 2006), as it encourages a constant interaction of pre-existing theoretical and experiential insights with the generation of empirical evidence through data collection and analysis (Strauss and Corbin, 1990; 1998). The observations of emergence theme of this thesis were grounded to the evidence-based data analysis framed by the MCA and MLP-MCA model and conducted throughout Chapter 4 to 6. This process is synonymous with the constant comparative technique where the new data are constantly compared with existing data, categories, concepts and theories throughout the research process (Bryman, 2004; 2012). In other words, the discovery or emergence of theory from the research study is really a result of the constant interplay between data and the researcher's developing conceptualisations from a flip-flop between ideas and research experiences (Pidgeon and Henwood, 1997).

The longitudinal nested case-oriented research strategy combined with the multi-criteria analysis (MCA) method (Konidari and Mavrakis, 2007; Ragin, 1987; Rihoux and Grimm, 2006) were to help frame the focus of study at the varying time-scale with specific multiple criteria to uncover the causal barriers to and performance of energy transition at individual leader and government levels, nested within national cases. The MCA method allows for the synthesis of multiple objective analyses with subjective considerations on the multiple dimensions of a problem, whereas MLP offers a big-picture view of enactments of actors at different levels. It is through the lens of MLP and MCA that I examined and evaluated the socio-technical energy transition of Australia and Germany. Applying comparative analysis to the leaders' and countries' cases, qualitative data were used to provide an insightful narrative of new perspectives related to the development of influential events or conditions. The relevant variables in the MCA and MLP–MCA models employing quantitative data as relevant indicators in the evaluation processes enhanced knowledge from the qualitative interpretation (Guest, 2013).

The next section discusses the utility, strength and limitations of the constructed MCA and MLP–MCA models that were used in the studies of Chapters 4–6.

7.3.2 The analytical tools: MCA and MLP–MCA evaluation models

(i) The utility, strength and limitations of the MCA evaluation model

The MCA model was developed as a key element of this research to evaluate and rank the climate-change and energy policies and actions of multiple national governments and two nations (Australia and Germany). The MCA model served to provide a temporal analysis focus within each council and offered insights by way of comparison between leaders and the countries. The three-tier multi-criteria hierarchical structure[114] supported by a semi-crisp three-point ranking-score system (0=no, 0.5=partial, 1=yes) provided an effective method to score and compare the

[114] The top-tier criteria include political acceptability, policy measures/instruments, and implementation, tracking and reporting.

leadership actions of both countries and gain insight on causal factors of the differing transition performances. The semi-crisp rule-set method was designed to provide simplicity and repeatability to an otherwise large and complex review during the evaluation and analysis processes. The MCA model also served to provide a time-series longitudinal case study of both countries. The time-series value of this tool was able to quantify the impact of climate/energy policy stability/instability and certainty/uncertainty. For Australia, instability and uncertainty was evidenced by the ratings comparing various governments. For Germany, the value of stability and certainty could be tracked over time through an analysis of the political leaders and their coalition governments.

Applying the MCA model as a comparative tool between nation states enabled the dissection and identification of socio-political and economic nuances operating within otherwise complex systems. As part of the development of the MCA model, it was tested for its robustness of the weighting coefficients assigned to the tier-1 criteria (A=political acceptability, B=policy measures and instruments, and C=implementation, tracking and reporting). The sensitivity test was performed by varying coefficients from (Ax0.5+Bx0.4+Cx0.1) to (Ax0.4+Bx0.4+Cx0.2) and (Ax0.33+Bx0.33+Cx0.33). The test results showed that the ranking scores of each prime minister are not sensitive to changes in weighting coefficients. This implies that the criteria and weightings reflect the equally important nature of each criterion included in the model.

Due to the macro system-view nature and the semi-crisp ranking rule set of the model, certain limitations were observed in the study of Chapter 4 and 5 that are discussed below. Suggestions are also made on future enhancements to improve the robustness of the model.

Limitations include: (i) the model does not rank the effectiveness of the climate/energy policies, especially when subject to short time horizons due to policy backflips; (ii) the model does not rank the significant impact of ground-breaking policies such as StrEG 1991[115] and EEG 2000[116] to the successive German governments which just need to maintain momentum created by the policies from previous governments; (iii) the model does not assess equally the achievements of long-serving leaders who altered transition speed/courses in light of varying coalition-governmental agreements; (iv) the scores for Criterion-C are similarly very low for the earlier leaders such as Prime Minister Howard and Chancellor Kohl and high for successive leaders such as Prime Ministers Rudd and Gillard, and Chancellors Schröder and Merkel, which reflects that in the early phase of the RE transition, the monitoring and reporting framework has yet to be established.

[115] Electricity Feed-In Law of 1991 (Stromeinspeisungsgesetz – StrEG 1991).
[116] Renewable Energy Sources Act 2000 (Erneuerbare-Energien-Gesetz EEG 2000).

These limitations reflect the nature of the high-level view of both Criterion-B and Criterion-C that can be enhanced with these recommendations. Firstly, a time-weighted coefficient can be incorporated with Criterion-B to reflect the lengthy time-cycle required for policy-making process and implementation. Secondly, Criterion-C could be replaced with a criterion including a group of sub-criteria to assess in more detail the impact, effectiveness and significance of policies. Lastly, the new Criterion-C could include a time-based evaluation for a leader with long tenure who should be assessed for all individual milestone periods to be averaged to reflect the impact of specific policy changes.

(ii) The strength and limitations of the MLP-MCA analytical model

Combining the three dimensions (landscape, regimes and niches) of the multi-level perspective and multi-criteria analysis, the MLP–MCA model was constructed to provide a big-picture view of the energy transitions in Australia and Germany. The model gauged the three-dimensional political-acceptability scores for/against energy transition, thus the assessment scores offer further evidence-based explanation for their contrasting achievements, which were identified in the two previous studies in Chapter 4 and 5 (Cheung and Davies, 2017; Cheung et al., 2018, peer-reviewed pending publication). The strength of the MLP–MCA analytical framework is its ability to shed light on the significant decisive role of the static landscape, such as the energy endowment and economic structures in the overall political-acceptability of both countries, and consequently in the complex interwoven interactions between the regimes and niches. The five Likert-scale assessment scores applied to the three-level multi-criteria hierarchical structure offer detailed tapestry narratives of the existing socio-technical regimes and emerging innovative niches and their enactments within both static and dynamic landscapes. However, the MLP–MCA analysis is based on longitudinal ex-post historical data that is often limited by the availability of comprehensive, complete and well-tracked reporting of both countries. Going forward, the sub-criteria selected for levels 2 and 3 are by no means perfect or complete, so as the scoring system could all be further expanded and enhanced before application to other countries.

Chapter 8: Conclusion

It is time to reflect on what this thesis has achieved. It started with three central research questions (listed in the beginning of Chapter 7 above), and explored ways to facilitate strategic investigation methodologies to answer the complex socio-technical transition issues confronting many countries seeking to mitigate acute global climate-change risks. The choice of Australia and Germany for this analysis is especially interesting due to their many similarities and differences, particularly, their contrasting achievements in the transformation of national energy systems and greenhouse gas emissions reduction. This final chapter is dedicated to presenting the contributions of this research project to the extensive research field of socio-technical transitions, concluding remarks and offering thoughts on the outlook and future research potential.

8.1 Contributions

This thesis contributes to the well-established, crucial research field of socio-technical transition in terms of both novel, viable analytical frameworks, new perspectives and results which add strength to transition theory. Following is a list of contributions.

In terms of analytical frameworks:

This is the first time that:

1. A constructed MCA analytical model has been developed and applied with a view to understanding multi-scale energy policy/action and governance frameworks. This new MCA analytical framework, combined with a longitudinal nested case-study approach, was effective in dissecting (through time-series value) the complexity of impact of leaders' and governments' actions and policies on the national performance in decarbonisation of energy systems.

2. An innovative analytical tool synthesising both multi-level perspective (MLP) theory/concept and multi-criteria analysis (MCA) has been developed and applied to analyse socio-technical transitions. The MLP–MCA evaluation model applied to the longitudinal nested case study of Australia and Germany has uncovered true motivations and causalities underlying the decision-making on setting energy-transition agendas, policies and pathways which have impacted their respective achievement in emission reduction and RE deployment.

   In addition:

3. Collectively this research built on and expanded the socio-political and socio-technical influences of energy transitions that operate at a national level. At the same time, the study also demonstrated that an integrated multi-disciplinary, multi-dimensional and multi-scale analysis and system thinking is necessary to gain new perspectives (refer to new perspectives listed below) on socio-technical transition.

In terms of new perspectives gained:

1. The static landscape such as national fossil-energy endowment, degree of development (massive investment reinforces carbon lock-in) and economic structure (readiness of niche-enabling industries) of a country is more a determinant of energy-transition urgency (national decision-making) than an international socio-political intervention pushes such as the Kyoto Protocol and the Paris Agreement.

2. Mitigation costs are a concern as one of the underlying causal factors for the delayed adoption of renewable energy in Australia versus early adoption in Germany due to different configurations of static landscape such as energy- and resources-based versus industrialised economic structure (refer to section 7.2.3 above).

3. Underlying economic conditions such as consistent growth are not a precondition as a driver to climate/energy transition, nor a prime determinant on national achievements in RE transformation within developed nations.

4. Innovative and integrated technologies development given to the eventualities of cost competitiveness on a par with fossil-fueled energy and an international investment paradigm shift will ultimately drive and expedite socio-technical changes.

In terms of investigation results:

1. Socio-technical transition is a multi-decadal process whose progress is non-linear marking with advances and setbacks in tandem with changing landscape contexts such as coalition, crises and natural disaster, and is shifting between transition pathways due to actor struggles over speed, direction and technology deployment (Geels et al., 2016).

2. Steering socio-technical structural changes is politically difficult (Grin et al., 2010; Meadowcroft, 2009; 2011). Climate/energy policy formulation and implementation are found

to be essentially a political process in both Australia and Germany, not purely a management or governance issue (Kern and Smith, 2008). Therefore, analysis for motivations, barriers and causalities needs to be complemented by analysis of transition policies and their politics (Hill 1997).

3. Policy stability and consistency are important in providing long-term certainty and confidence to the capital-investment market (Geels, 2006; van Rooijen and van Wees, 2006, Verbong and Geels, 2007).

4. Central to dealing with transitions investigation is an understanding of the interactions between different levels of scale, particularly regime and niche interactions as well as their enactments to the changing landscape. None of these can be analysed in isolation (Loorbach et al., 2008).

5. My analysis confirms that incumbent regimes (coal miners of Australia and utility companies of Germany) are dominant forces in the energy transition trajectory (Berkhout et al., 2004; Geels, 2014b; Turnheim and Geels, 2013).

8.2 Concluding remarks

In conclusion, through this journey of research exploration, I have learnt that energy transitions are very complex and will require a full understanding of multi-level and multi-dimensional aspects of socio-cultural, economic, and political relationships to answer the question of why and how some countries are able to implement policies that lead to deeper and faster change outcomes than others. The main objective of this thesis is to uncover the true causal factors that have differentiated the performance of energy transition between Australia and Germany. A comparative analysis of MCA model results of Australia and Germany in Chapter 5 revealed the most fundamental contrast between Australia and Germany is the political acceptability of climate/energy mitigation approaches and agenda at the federal government level. The political divide of climate/energy policy and an inability to harmonise those differences across party lines in Australia have resulted in the energy-policy backflips in successive governments that created an impasse on the momentum of transition to renewable energy. However, in Germany, there was a consistent political acceptance across multiple party lines and policy stability of successive coalition governments in pursuit of the ultimate goal of energy transition. Hence, the flip-flop of energy policies in Australia led to suboptimal performance of policies, investment confidence and momentum.

Going forward, growth of the share of renewable-energy generation will be driven by technologies as they have become economically viable, thus challenging fossil-fueled energy as a political domain. The drivers presented in section 7.2.2 have worked their magic as evidenced by these headlines: 'Investor appetite for renewable energy projects, such as large-scale solar and wind projects, is set to help Australia exceed its 2020 Renewable Energy Target two years ahead of schedule' (Ludlow, 2018); 'Australia's renewable energy capacity is set to exceed a target the Federal Government said was impossible to reach by 2020' (Letts, 2018); 'Renewable energy set to supply one-third of market needs by 2020' (Letts and Barbour, 2018). This in itself seems to be the breaking point that can challenge the federal government policy directions and influence (discussed in finding #4 of section 7.1.3). In Australia, states have jurisdiction power over their energy systems. In this light, if Australia's domestic climate/energy political landscape can build upon a bipartisan platform at all levels (federal and state) with a vision to meeting international obligations as well as supporting and enabling state and territory governments' ambition to reform, there is nothing to stop Australia from being fully powered by clean and renewable energy within the next decade.

Germany is an industrial and economic driver of the European Union. Being heavily dependent on imported energy for its economic development and growth in the 20th century, the combined concerns of energy security and environmental sustainability have provided a profound rationale for crafting integrated strategic renewable-energy policy and acts as the main driver for Germany and EU-wide policy coordination towards an internal energy market. Despite all these achievements, the path-dependency and supply-security concerns have given way to the socio-political hold of lignite-based power generation, which remains and will prevent the achievement of longer-term energy-transition targets. This is a socio-political hurdle in the last mile of the herald of *Energiewende* that Germany has yet to address and overcome. On a positive note, German energy transition represents one of the most important social, economic and political undertakings of our time. Apart from its role in enabling crucial renewable-energy technologies (wind and solar PV) to be economically competitive with fossil fuels, it also offers valuable lessons for other countries looking to learn and adapt for their compelling paths to sustainable energy future.

8.3 Outlook and future research

This final section discusses the outlook of energy transition and outlines the potential future research domains that could build on this research to make a positive contribution to and be of interest to the broader energy-transition research field.

The first potential domain is to extend the analytical frameworks to incorporate actions and policies taken at state government level and how these would affect each state and overall national performance as an integrated system-thinking approach. This inter-jurisdictional analysis can enrich a vertical-and-horizontal government and temporal analysis of energy policy, and is particularly relevant to federated nation states such as Australia and Germany.

The second interesting domain is a comparative analysis on energy transition in emerging countries such as China and India. Given the nature of the political structures of these two countries, China being a centralised nation state and India a federal parliamentary democratic nation, a study comparing their climate and energy policies, actions and governance structures in priorities and their impacts through a socio-political versus techno-political perspective would make a significant contribution to the global greenhouse gas emissions reduction need, since China is now the top emitter of the world and India is fast catching up in tandem with its economic growth.

The last interesting domain is a comparative study focusing on energy transition in a centralised nation state such as China versus a federal democratic developed nation such as the United States. Analysis could focus on comparing their policies, actions and governance structures that have impacts on their differences in priorities through a socio-political versus techno-political perspective. This would make a significant contribution to the world that is pushing for speedy reductions in greenhouse gas emissions, as these countries are the top two global emitters and investors in renewable energy technologies.

References

ABARE, 2004. *Energy in Australia 2004*, Australian Bureau of Agricultural and Resource Economics (ABARE). Department of Resources, Energy and Tourism.

ABARE, 2006. *Energy in Australia 2006*, Australian Bureau of Agricultural and Resource Economics (ABARE). Department of Resources, Energy and Tourism.

ABARE, 2008. *Energy in Australia 2008*, Australian Bureau of Agricultural and Resource Economics (ABARE). Department of Resources, Energy and Tourism.

ABARE, 2010. *Australian Energy Resource Assessment 2010*, Australian Bureau of Agricultural and Resource Economics (ABARE). Department of Resources, Energy and Tourism.

ABARE-BREE, 2014. *Australian Energy Resource Assessment 2014*, Australian Bureau of Agricultural and Resource Economics (ABARE) and Bureau of Resources and Energy Economics (BREE).

ABC News. Hazelwood power station closure: Tony Abbott urges Malcom Turnbull to intervene to save electricity plant. 23 Mar 2017. Available at: http://www.abc.net.au/news/2017-03-24/abbott-to-turnbull-step-in-and-save-hazelwood-power-plant/8382612 accessed on 08 May 2017.

ABC News. Fact check: Tony Abbott overstating household savings from axing the carbon tax. June 27, 2014. Available at: http://www.abc.net.au/news/2014-06-27/tony-abbott-carbon-tax-savingsoverstated-fact-check/5554748 accessed 16 March 2017.

AEMO 2013. 100 Percent Renewables Study: Modelling Outcomes. Australian Energy Market Operator, https://www.environment.gov.au/system/files/resources/d67797b7-d563-427f-84eb-c3bb69e34073/files/100-percent-renewables-study-modelling-outcomes-report.pdf

AEMO 2017. Black System South Australia 28 September 2016: Final Report. Published: March 2017. Australian Energy Market Operator (AEMO).

ABS 2010. Australia's Environment: Issues and Trends 2010: Special issue: Climate Change. Australian Bureau of Statistics (ABS). ABS Catalogue No. 4613.0 ISSN 1443–7155.

AGEB 2009. Preliminary 2008 energy balance for Germany. Arbeitsgemeinschaft Energiebilanzen (AGEB), Berlin, Germany.

AGEB 2016. Evaluation Tables of the Energy Balance for Germany 1990 to 2016. Prepared by DIW Berlin and EEFA on behalf of Arbeitsgemeinschaft Energiebilanzen (AGEB).

AGEB 2018. Gross electricity generation in Germany from 1990 by energy source. Arbeitsgemeinschaft Energiebilanzen (AGEB). February 2018. Available at: https://ag-energiebilanzen.de/index.php?article_id=29&fileName=20171221_brd_stromerzeugung1990-2017.pdf accessed on 8/9/2018.

AGEE-Stat, 2011. *Renewable Energy Statistics in Germany*, Working Group on Renewable Energy Statistics (AGEE – Stat).

Agora Energiewende. 2015. Understanding the Energiewende. FAQ on the ongoing transition of the German power system. Available at: www.agora-energiewende.de

Aguirre, M., Ibikunle, G., 2014. Determinants of renewable energy growth: A global sample analysis. Energy Policy 69, 374–384. http://dx.doi.org/10.1016/j.enpol.2014.02.036.

Alberici E. Carbon tax ‘economically efficient’: Garnaut. ABC Lateline. July 2, 2012. Available at: http://www.abc.net.au/lateline/content/2012/s3537442.htm accessed 16 March 2017.

Alexander, S., Nicholson, K. & Wiseman, J. 2014. Fossil free: The development and significance of the fossil fuel divestment movement. MSSI Issues Paper No. 3, 1-16. Melbourne Sustainable Society Institute, The University of Melbourne. Available at: http://sustainable.unimelb.edu.au/sites/default/files/docs/MSSI-IssuesPaper-4_Divestment_2014.pdf accessed on 17 March 2017.

Allen, R.C. 2012, ‘Backward into the future: The shift to coal and implications for the next energy transition’, *Energy Policy*, 50, pp. 17–23.

ANAO, 2017. *The Auditor-General Performance Audit Report No. 20 2017–18: Low Emission Technologies for Fossil Fuels*. Department of Industry, Innovation and Science. Australian National Audit Office (ANAO).

Australian Government 2015a. Australia’s Intended Nationally Determined Contribution to a new Climate Change Agreement: August 2015. Available at: http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx

Australian Government 2015a. Australia’s Intended Nationally Determined Contribution to a new Climate Change Agreement - August 2015. Available at: http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx

Australian Government 2015b. Final report on Australia's future emissions reduction targets. Climate Change Authority.

Australian Government 2015c. Quarterly Update of Australia’s National Greenhouse Gas Inventory: June 2015. Department of the Environment.

Australian Government 2015d. Australian Energy Update. Department of Industry and Science, Office of Chief Economist.

Australian Government, 2015e. *Electricity generation major projects*, Department of Industry, Innovation and Science, Canberra, November 2015.

Australian Government, 2018. Resources and Energy Quarterly March 2018. Department of Industry, Innovation and Science. Office of the Chief Economist.

Avelino, F. 2011. *Power in Transition: Empowering Discourses on Sustainability Transitions.* Rotterdam: Erasmus Universiteit Rotterdam

Bailey, I., Macgill, I., Passey, R. & Compston, H. 2012. The fall (and rise) of carbon pricing in Australia: a political strategy analysis of the carbon pollution reduction scheme. *Environmental Politics*, 21, 691-711.

Bauer, N., Edenhofer, O., Haller, M., Klein, D., Lorenz, A., Luderer, G., Ludig, S., Lüken, M. and Pietzcker, R. 2010. Technologies, Policies and Economics of Global Reductions of Energy Related CO2 Emissions. Potsdam Institute for Climate Impact Research (PIK), Germany.

Bauer, N., Baumstark, L. and Leimbach, M. 2012. The REMIND-R model: the role of renewables in the low-carbon transformation—first-best vs. second-best worlds. *Climatic Change*, 114, pp. 145–168.

Baumstark, L. 2011. *Investment Strategies for Climate Change Mitigation*. Doctoral Thesis. Fakultät VI - Planen Bauen Umwelt, Technische Universität Berlin. http://dx.doi.org/10.14279/depositonce-2977.

Bechberger, M. & Reiche, D. 2004. Renewable energy policy in Germany: pioneering and exemplary regulations. *Energy for Sustainable Development*, 8(1), 47-57.

Beeson, M. & McDonald, M. 2013. 'The Politics of Climate Change in Australia'. *Australian Journal of Politics & History*, 59, 331-348.

Belot, H., 2017. 'Clean energy subsidies could be used to build new coal power plants, Scott Morrison says'. 2 Feb. ABC News. Available at: http://www.abc.net.au/news/2017-02-02/clean-energy-money-could-fund-coal-power-stations-morrison-says/8234118 accessed on 30/08/2018.

Bergek, A., Jacobsson, S. Carlsson, B. and Lindmark, S. 2006. *Analysing the Dynamics and Functionality of Sectoral Innovation Systems*. RIDE/IMIT Working Paper No 84426-007, Chalmers University of Technology, Gothenburg, Sweden, 2006.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., Rickne, A., 2008. 'Analyzing the functional dynamics of technological innovation systems: a scheme of analysis', *Research Policy*, 37, pp. 407–429.

Beria, P., Maltese, I. & Mariotti, I. 2011. Comparing cost benefit and multi-criteria analysis: the evaluation of neighbourhoods' sustainable mobility. *XIII Riunione Scientifica della Società Italiana degli Economisti dei Trasporti e della Logistica (SIET)*, 1-26.

Berkhout, F., Smith, A. and Stirling, A. 2004. Socio-technological regimes and transition contexts. *System innovation and the transition to sustainability: theory, evidence and policy. Edward Elgar, Cheltenham*, 44, 48–75.

Berkhout, F., Angel, D. and Wieczorek, A. J. 2009. 'Asian development pathways and sustainable socio-technical regimes', *Technological Forecasting and Social Change*, 76, pp. 218–228.

Berkhout, F., Marcotullio, P. and Hanaoka, T. 2012. 'Understanding energy transitions', *Sustainability Science*, 7, pp. 109–111.

Beuermann, C., & Jäger, J. 1996. Climate change policy in Germany: How long will any double dividend last? In T. O'Riordan & J. Jäger (Eds.), *Politics of climate change: A European perspective* (pp.186-227). London: Routledge.

BGR, 2009. *Energy Study 2009. Reserves, resources and availability of energy resources,* The Federal Institute for Geoscience and Natural Resources (BGR).

BGR, 2016. *Energy Study 2016. Reserves, resources and availability of energy resources*. The Federal Institute for Geoscience and Natural Resources (BGR).

Blazejczak, J., Braun, F., Edler, D. & Schill, W. 2011. Economic effects of renewable energy expansion: A model-based analysis for Germany (No. 1156). Discussion Papers, German Institute for Economic Research, DIW Berlin.

Bloomberg New Energy Finance [BNEF]. 2014. Modelling options for Australia's RET review - White Paper. Bloomberg New Energy Finance.

Bloomberg New Energy Finance [BNEF]. 2015. New Energy Outlook 2015 - Long-term projections of the global energy sector. Bloomberg New Energy Finance.

BMU, 2007. *The integrated energy and climate program of the German government*. The Federal Ministry of the Environment, Nature Conservation, and Nuclear Safety of Germany (BMU). Berlin: 2007.

BMU, 2010. *Erneuerbare Energien in Zahlen: Nationale und internationale Entwicklung*. Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Berlin, June 2010.

BMUB 2016. Climate Action Report 2016. Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)

BMWi 2000. Agreement between the federal government and the energy supply companies (Vereinbarung zwischen der Bundesregierung und den Energieversorgungsunternehmen, Berlin: 14 June 2000).

BMWi, 2011. *Research for an environmentally sound, reliable and affordable energy supply. 6th Energy Research Programme of the Federal Government*, Federal Ministry for Economic Affairs and Energy (BMWi).

BMWi 2012. *Germany's new energy policy. Heading towards 2050 with secure, affordable and environmentally sound energy*. The Federal Ministry for Economic Affairs and Energy (BMWi).

BMWi, 2014a. *The Energy of the Future: First 'Energy Transition' Progress Report. Summary*, The Federal Ministry for Economic Affairs and Energy (BMWi).

BMWi, 2014b. *An electricity market for Germany's energy transition*. Discussion Paper of the Federal Ministry for Economic Affairs and Energy (Green Paper). The Federal Ministry for Economic Affairs and Energy (BMWi).

BMWi 2015a. *The Energy of the Future: Fifth 'Energy Transition' Monitoring Report*. 2015 reporting year. The Federal Ministry for Economic Affairs and Energy (BMWi).

BMWi 2015b. *An electricity market for Germany's energy transition*. White Paper by the Federal Ministry for Economic Affairs and Energy (BMWi)

BMWi 2015c. *Annual Economic Report Investing in Germany's and Europe's future 2015*, Federal Ministry for Economic Affairs and Energy (BMWi).

BMWi 2015d. *Renewable Energy Sources in Figures 2015*. Federal Ministry for Economic Affairs and Energy (BMWi).

BMWi 2016a. *Renewable Energy Sources in Figures: National and International Development, 2016*. Federal Ministry for Economic Affairs and Energy (BMWi).

BMWi 2016b. *Electricity 2030. Long-term trends – Tasks for the coming years.* Discussion Paper. The Federal Ministry for Economic Affairs and Energy (BMWi).

BMWi 2016c. *Innovation Through Research: Renewable Energies and Energy Efficiency: Projects and Results of Research Funding in 2015*, Federal Ministry for Economic Affairs and Energy (BMWi).

BMWi, 2016d. Green Paper on Energy Efficiency: Discussion Paper of the Federal Ministry for Economic Affairs and Energy (BMWi).

BMWi 2017a. *Overview of legislation governing Germany's energy supply system. Key strategies, acts, directives, and regulations/ordinances*. Federal Ministry for Economic Affair and Energy (BMWi). Jan 2017.

BMWi, 2017b. *Report of the Federal Government on Energy Research 2017: Research Funding for the Energy Transition*, Federal Ministry for Economic Affairs and Energy (BMWi).

BMWi, 2018a. Conventional Energy Sources: Coal. Federal Ministry for Economic Affairs and Energy (BMWi). Available at: https://www.bmwi.de/Redaktion/EN/Artikel/Energy/coal.html accessed on 18 April 2018.

BMWi, 2018b. Minister Altmaier: "Energy research makes key contribution to the energy transition". 11/07/2018. Press release. Energy Research. Federal Cabinet adopts 2018 Federal Report on Energy Research. Available at: https://www.bmwi.de/Redaktion/EN/Pressemitteilungen/2018/20180711-altmaier-energy-research-makes-key-contribution-to-the-energy-transition.html

BNEF 2015. New Energy Outlook (NEO) 2015: Executive Summary. Bloomberg New Energy Finance. Bloomberg Finance L.P. 2015. Bolton, R., Foxon, T.J. and Hall, S. 2016. 'Energy transitions and uncertainty: Creating low carbon investment opportunities in the UK electricity sector', I, 34, pp. 1387–1403.

Bonney, M., 2000. 'Climate change policies in the Netherlands: analysis and selection'. In: Workshop on Good Practices in Policies and measures, 11–13 April 2000, Copenhagen http://unfccc.int/files/meetings/workshops/other_meetings/application/pdf/nld.pdf

Bonney, M., 2001. 'How effective are greenhouse gas reduction policies in the Netherlands?' In: Workshop on Good Practices in Policies and measures, 8–10 October 2001, Copenhagen http://unfccc.int/files/meetings/workshops/other_meetings/application/pdf/bonney.pdf

Bosman, R. 2012. *Energy transition in the Netherlands: storylines from regime actors*. Masterarbeit, Albert-Ludwigs-Universität Freiburg, 2012.

Boyle, G., ed. 2007. *Renewable energy and the grid: the challenge of variability*. London: Earthscan.

Brechin, S.R. 2003. 'Comparative public opinion and knowledge on global climatic change and the Kyoto Protocol: The US versus the World?', *International Journal of Sociology and Social Policy*, 23, pp. 106–134.

BREE, 2011. *Australian Energy Projections to 2034-35*, Bureau of Resources and Energy Economics.

BREE, 2012. *Energy in Australia 2012*, Canberra: Bureau of Resources and Energy Economics.

BREE, 2014a. Energy in Australia 2014. Canberra: Bureau of Resources and Energy Economics. Available at: http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/energy-in-aust/bree-energyinaustralia-2014.pdf

BREE, 2014b. *Australian Energy Projections to 2049-50*. Bureau of Resources and Energy Economics.

BREE, 2014c. Australian Energy Statistics. Bureau of Resources and Energy Economics. Canberra.

Bryman, A. 2004. *Social research methods,* Oxford: Oxford University Press.

Bryman, A. 2012. *Social research methods,* Oxford: Oxford University Press.

Budischak, C., Sewell, D., Thomson, H., Mach, L., Veron, D. E. and Kempton, W. 2013. 'Cost-minimized combinations of wind power, solar power and electrochemical storage, powering the grid up to 99.9% of the time', *Journal of Power Sources*, 225, pp. 60–74.

Bullard, N. 2014. Fossil fuel divestment: a $5 trillion challenge. White Paper, Bloomberg New Energy Finance, August 25.

Bundesgesetzblatt, 2004. Gesetz zur Neuregelung des Rechts der Erneuerbaren Energien im Strombereich. Bundesgesetzblatt, Jahrgang 2004, Teil I, Nr. 40, 1918-1930, 31.07.2004.

Bundesgesetzblatt, 2008. Gesetz zur Neuregelung des Rechts der Erneuerbaren Energien im Strombereich und zur Änderung damit zusammenhängender Vorschriften. Bundesgesetzblatt, Jahrgang 2008, Teil I, Nr. 49, 2074-2100, 31.10.2008. See also English Translation: http://www.bmu.de/files/english/pdf/application/pdf/eeg_2009_en_bf.pdf

Burke, P.J., 2010. 'Income, resources, and electricity mix', *Energy Econ*. 32 (3), pp. 616–626, http://dx.doi.org/10.1016/j.eneco.2010.01.012.

Burke, P.J., 2016. Undermined by Adverse Selection: Australia's Direct Action Abatement Subsidies. Economic Papers: *A journal of applied economics and policy*, 35(3), pp.216-229.

Büsgen, U. & Dürrschmidt, W. 2009. The expansion of electricity generation from renewable energies in Germany: A review based on the Renewable Energy Sources Act Progress Report 2007 and the new German feed-in legislation. *Energy Policy* 37 (7), 2536-2545.

Butler, L. & Neuhoff, K. 2008. Comparison of feed-in tariff, quota and auction mechanisms to support wind power development. *Renewable Energy* 33 (8), 1854-1867.

Butzengeiger, S. & Michaelowa, A. 2004. The EU Emissions Trading Scheme–Issues and Challenges. *Intereconomics*, 39, 116-118.

Caldecott, B., Tilbury, J. and Ma, Y. 2013. *Stranded Down Under. Environment-related factors changing China's demand for coal and what this means for Australian coal assets*. Smith School of Enterprise and the Environment, University of Oxford.

Cárdenas-Rodríguez, M., Haščič, I., Johnstone, N., Silva, J. & Ferey, A. 2013. Inducing private finance for renewable energy projects: Evidence from micro-data. OECD Environment Working Papers.

Cavender, J., & Jäger, J. 1993. The history of Germany's response to climate change. *International Environmental Affairs*, 3(1), 3-18.

CEC, 2016. *Clean Energy Australia Report 2016*, Clean Energy Council (CEC).

Chalvatzis, K. J. and Hooper, E. 2009. Energy security vs. climate change: theoretical framework development and experience in selected EU electricity markets. *Renewable and Sustainable Energy Reviews*, 13, pp. 2703–2709.

Chang, Charis. Is this the worst mistake Australia could make? News.com.au. April 3, 2017. Available at: http://www.news.com.au/technology/environment/is-this-the-worst-mistake-australia-could-make/news-story/f461955f66050fb32f0c1717571399fa accessed on 08 May 2017.

Chang, C., 2017. 'The tough choice Australia has to make about coal', Reuters. November 2. News.com.au. Available at:
https://www.news.com.au/finance/business/mining/the-tough-choice-australia-has-to-make-about-coal/news-story/da40ba40d656a563cf602304a551b9b3 accessed on 30/08/2018.

Charmaz, K. 2000. Grounded Theory: Objectivist and Constructivist Methods. *In:* Denzin, N. K. and Lincoln, Y. S. (eds.) *Handbook of Qualitative Research.* Thousand Oaks, CA: Sage.

Charmaz, K. 2006. *Constructing Grounded Theory: A Practical Guide through Qualitative Analysis*. London: Sage Publications.

Charmaz, K. 2011. Grounded theory methods in social justice research. *The Sage handbook of qualitative research*, 4, pp. 359–380.

Chase, J. 2018. Germany's SPD members approve coalition with Angela Merkel's conservatives. DW News 05.03.2018. available at: http://www.dw.com/en/germanys-spd-members-approve-coalition-with-angela-merkels-conservatives/a-42803601 accessed on 7/03/2018.

Cheung, G. and Davies, P. J. 2017. In the transformation of energy systems: what is holding Australia back? *Energy Policy*, 109, pp. 96–108.

Cheung, G., Davies, P.J. and Bassen, A. 2018. 'In the transition of energy systems: what lesson can be learnt from the German achievement?', *Energy Policy*. (In review)

Cherp, A., Vinichenko, V., Jewell, J., Brutschin, E. and Sovacool, B. 2018. 'Integrating techno-economic, socio-technical and political perspectives on national energy transitions: A meta-theoretical framework', *Energy Research and Social Science*, 37, pp. 175–190.

Child, M. and Breyer, C., 2017. 'Transition and transformation: a review of the concept of change in the progress towards future sustainable energy systems', *Energy Policy*, 107, pp. 11–26.

Childs, D. 2017. Helmut Kohl, obituary: The man who reunified Germany and encouraged European integration. Independent. Available at: http://www.independent.co.uk/news/obituaries/helmut-kohl-dead-life-career-german-chancellor-unite-europe-87-a7793916.html accessed on 1/12/2017.

Choo, E.U., Schoner, B. and Wedley, W.C. 1999. 'Interpretation of criteria weights in multicriteria decision making', *Computers & Industrial Engineering*, 37, pp. 527–541.

Christoff, P., 2013. Climate discourse complexes: national climate regimes and Australian climate policy. *Australian Journal of Politics and History*. 59, 349–367.

Chubb, P. A. 2015. *Power failure: a study of climate politics and policy under Rudd and Gillard*. Monash University. Faculty of Arts. School of Social Sciences.

Clarke, M. 2009. 'Power generation systems; matching capacity, load and system requirements for cleaner, adequate, secure, reliable and affordable energy supply', *Asian Journal on Energy and Environment*, 10(04), pp. 194–200.

CLEW, 2015. 'German utilities and the Energiewende factsheet', By Kerstine Appunn and Ruby Russell, 12 January 2015. Clean Energy Wire (CLEW). Available at: https://www.cleanenergywire.org/factsheets/german-utilities-and-energiewende accessed on 12/05/2018.

CLEW, 2017. ‘Coal in Germany: factsheet’. By Kerstine Appunn, 05 Dec 2017. Clean Energy Wire (CLEW). Available at: https://www.cleanenergywire.org/factsheets/coal-germany accessed on 12/05/2018.

Climate Action Tracker. 2013. *Australia backtracking on promising progress - Policy Brief*. Climate Action Tracker.

Climate Action Tracker. 2015a. *INDCs lower projected warming to 2.7˚C: significant progress but still above 2ºC*. Climate Action Tracker. Available at: http://climateanalytics.org/files/cat_global_temperature_update_october_2015.pdf accessed 31/12/2015.

Climate Action Tracker. 2015b. *Australia set to overshoot its 2030 target by large margin*. Climate Action Tracker. Available at: http://climateactiontracker.org/assets/publications/briefing_papers/082015_Australia.pdf

Climateworks 2014. Pathways to Deep Decarbonisation in 2050: How Australia can prosper in a low carbon world

CMI 2016. Australian Climate Policy Survey 2016. Carbon Market Institute, Melbourne. http://carbonmarketinstitute.org/wp-content/uploads/2016/10/CMI-Australian-Climate-Policy-Survey-2016.pdf accessed on 17 April 2017.

Cohen, M.J., Brown, H.S. and Vergragt, P.J. 2010. ‘Individual consumption and systemic societal transformation: introduction to the special issue’, *Sustainability: Science, Practice and Policy*, 6, pp. 6–12.

Commonwealth of Australia, 2008. *Australia's Low Pollution Future: The Economics of Climate Change Mitigation*, Treasury Department, Commonwealth of Australia.

Commonwealth of Australia, 2011a. *Clean Energy Bill 2011*. Bills Digest No. 68, 2011–12. Department of Parliamentary Services. Available at: http://parlinfo.aph.gov.au/parlInfo/download/legislation/billsdgs/1185490/upload_binary/1185490.pdf;fileType=application%2Fpdf#search=%22r4653%22

Commonwealth of Australia, 2011b. *Securing a Clean Energy Future: The Australian Government's Climate Change Plan*, Department of Climate Change and Energy Efficiency. Commonwealth of Australia 2011. http://www.acci.asn.au/Files/Government-Carbon-Tax-Plan

Commonwealth of Australia, 2013. *How Australia’s carbon price is working: one year on*. Department of Industry, Innovation, Science, Research and Tertiary Education, Canberra; 2013. Available at:

https://www.thepmr.org/system/files/documents/0045+Carbon+Price+One+Year+On+18_06+d_1_0.pdf accessed 16 March 2017.

Commonwealth of Australia, 2014. *Targets and Progress Review Final Report*, Climate Change Authority.

Connolly, D., Lund, H., Mathiesen, B., Pican, E., Leahy, M., 2012. 'The technical and economic implications of integrating fluctuating renewable energy using energy storage', *Renewable Energy*, 43, pp. 47–60.

Costantini, V., Gracceva, F., Markandya, A. & Vicini, G. 2007. Security of energy supply: Comparing scenarios from a European perspective. *Energy Policy*, 35, 210-226.

Creswell, J. 1998. *Qualitative inquiry and research design: Choosing among five traditions.* Thousand Oaks, CA: Sage.

Creswell, J.W. 2003. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (2nd edition). Thousand Oaks, CA: Sage.

Creswell, J., and Plano Clark, V. 2011. *Designing and Conducting Mixed Methods Research*. Thousand Oaks, CA: Sage.

Creswell, J. W., Klassen, A. C., Plano Clark, V. L. and Smith, K. C. 2011. Best practices for mixed methods research in the health sciences. *Bethesda (Maryland): National Institutes of Health*.

Crowley, K. 2010. 'Climate Clever: Kyoto and Australia's Decade of Recalcitrance' in Harrison & Sundstrom *Global Commons, Domestic Decisions: The Comparative Politics of Climate Change* (eds) Kathryn Harrison and Lisa McIntosh Sundstrom MIT Press: Cambridge, Massachusetts, pp. 201–228.

Crowley, K, 2011. Climate policy failure: Was Australia's CPRS more politics than policy? *Environmental Policy Failure*: The Australian Story. Tilde University Press, K Crowley and KJ Walker (ed), Prahan, pp. 29-43. ISBN 9780734611406 (2011).

Crowley, K. 2013a. Pricing carbon: the politics of climate policy in Australia. Wiley Interdisciplinary Reviews: Climate Change, 4, 603-613.

Crowley, K. 2013b. Irresistible force? Achieving carbon pricing in Australia. *Australian Journal of Politics & History*, 59, 368-381.

Crowley, K. 2017. 'Up and down with climate politics 2013–2016: the repeal of carbon pricing in Australia'. *Wiley Interdisciplinary Reviews: Climate Change*. doi: 10.1002/wcc.458.

Cullinane, B. The Australian oil and gas paradox: Will the world's largest LNG exporter become an importer? 13 February 2017. Business News Western Australia. Available at: https://www.businessnews.com.au/article/The-Australian-oil-and-gas-paradox-Will-the-world-s-largest-LNG-exporter-become-an-importer accessed on 17 March 2017.

Curran, G., 2009. Ecological modernisation and climate change in Australia. *Environ. Politics* 18, 210–217.

Curran, G. 2011. Modernising climate policy in Australia: climate narratives and the undoing of a Prime Minister. Environment and Planning C: *Government & Policy*, 29, 1004-1017.

DEE, 2017. *Australian Energy Update 2017*, Department of the Environment and Energy (DEE) Canberra, August 2017.

DEE, 2018. 'Australian Energy Statistics: Table of Electricity generation by fuel type 2016–17 and 2017', Department of the Environment and Energy (DEE) Canberra, April 2018. Available at: https://www.energy.gov.au/sites/g/files/net3411/f/aes-table-o-2016-17_2017.pdf accessed on 23/08/2018.

Denniss, R. & Grudnoff, M. 2011. The Real Cost of Direct Action: An analysis of the Coalition's Direct Action Plan, Australia Institute.

Dey, I. 1999. *Grounding Grounded Theory Guidelines for Qualitative Inquiry*, San Diego: Academic Press.

DOE, 2014. 'Repealing the Carbon Tax', Canberra: Department of the Environment July; 2014. Available at: http://www.environment.gov.au/climate-change/repealing-carbon-tax accessed on 16 March 2017.

Ezzy, D. 2002. *Qualitative Analysis: Practice and Innovation*, London: Routledge.

Diesendorf, M., 2012. Lost energy policies, opportunities and practice. In: Crowley, K., Walker, K. (Eds.), *Environmental Policy Failure: The Australian Story*. 1st ed. Tilde University Press, Prahran, Vic, pp. 44–59.

Diesendorf, M., 2016. 'Dispelling the nuclear "baseload" myth: nothing renewables can't do better!' *The Ecologist*, 10 March 2016. Available at: http://www.theecologist.org/News/news_analysis/2987376/dispelling_the_nuclear_baseload_myth_nothing_renewables_cant_do_better.html accessed on 18 April 2017.

Directive 2003/87/EC of the European Parliament and of the Council, of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, OJ L 275/32 of 25.10.2003.

Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms, OJ L 338/18 of 13.11.2004.

DRET 2012. Australian Gas Resource Assessment. Department of Resources Energy and Tourism. Available at: http://www.ga.gov.au/webtemp/image_cache/GA21116.pdf accessed on 18 April 2017.

Durrant, N. A. 2010. The Australian response to climate change: business as usual or legal innovation? *Environmental Law and Management*, 22, 105-114.

DW, 2007. 'The Rise and Fall of Germany's Coal Mining Industry', Deutsche Welle, 31.01.2007. Available at: http://www.dw.com/en/the-rise-and-fall-of-germanys-coal-mining-industry/a-2331545 accessed on 14/05/2018.

EIA, 2018. 'Germany's Key Energy Statistics', The U.S. Energy Information Administration (EIA). Available at: https://www.eia.gov/beta/international/country.cfm?iso=DEU accessed on 18/04/2018.

Elliston B, Diesendorf M, MacGill I 2012. Simulations of scenarios with 100% renewable electricity in the Australian National Electricity Market. *Energy Policy* 45:606-613.

Elliston B, MacGill I, Diesendorf, M. 2013. Least cost 100% renewable electricity scenarios in the Australian National Electricity Market. *Energy Policy* 59:270-282.

Elliston B, MacGill I, Diesendorf M. 2014. Comparing least cost scenarios for 100% renewable electricity with low emission fossil fuel scenarios in the Australian National Electricity Market. *Renewable Energy* 66:196-204.

Elliston B, Riesz J, MacGill I 2016. What cost for more renewables? The incremental cost of renewable generation - An Australian National Electricity Market case study. *Renewable Energy* 95:127-139.

Eloy, Á. P., Iñigo, O. M. & Jaime, M. S. 2016. The German energy transition (Energiewende) - Policy, Energy Transformation and Industrial Development. Cuadernos Orkestra 2016/15_ENG. ISSN 2340-7638. Available at: http://www.orkestra.deusto.es/images/investigacion/publicaciones/cuadernos/Energiewende_English.pdf

Elzen, B., Geels, F.W. and Green, K. 2004. *System innovation and the transition to sustainability: theory, evidence and policy*. Cheltenham, UK: Edward Elgar Publishing.

Elzen, B., Geels, F.W., Leeuwis, C. and van Mierlo, B. 2011. 'Normative contestation in transitions "in the making": Animal welfare concerns and system innovation in pig husbandry', *Research Policy*, 40, pp. 263–275.

ESB National Grid, 2004. Impact of wind power generation in Ireland on the operation of conventional plant and the economic implications. Dublin: ESB National Grid.

Eurostat, 2016. *Energy, transport and environment indicators – 2016 edition*. Publications Office of the European Union, 2016. Luxembourg.

European Commission, 2000. *Green Paper Towards a European strategy for the security of energy supply*. COM, 2000, 769 final, Brussels.

Eyre, N. & Lockwood, M. 2016. The governance of retail energy market services in the UK: a framework for the future. London, UK: UK Energy Research Centre (UKERC).

Fabri, E., 2017. 'Funding clean coal', *Australian Energy Review*, 02 Jun 2017. Available at: http://australianenergyreview.com.au/New/funding-clean-coal/ accessed on 08/05/2018.

Falk, J. and Settle, D., 2010. Australia: approaching an energy crossroads. *Energy Policy*, doi: 10.1016/j.enpol.2009.12.028.

Fischer, W., Hake, J.-F., Kuckshinrichs, W., Schröder, T. and Venghaus, S. 2016. 'German energy policy and the way to sustainability: Five controversial issues in the debate on the "Energiewende"', *Energy*, 115, pp. 1580–1591.

Flick, U. 2006. Constant Comparative Method. In: Jupp, V. (ed.) *The Sage Dictionary of Social Research Methods*. London: Sage, pp. 37-38.

Fouquet, R. 2010. 'The slow search for solutions: lessons from historical energy transitions by sector and service',' *Energy Policy*, 38(11), pp. 6586–6596.

Fouquet, R. 2015. *Lessons from energy history for climate policy*. Grantham Research Institute on Climate Change and the Environment.

Fouquet, R. and Pearson, P.J.G. 2012, 'Past and prospective energy transitions: Insights from history', *Energy Policy*, 50, pp. 1–7.

Foxon, T. J. 2011. 'A coevolutionary framework for analysing a transition to a sustainable low carbon economy', *Ecological Economics*, 70, pp. 2258–2267.

Freeman, C., and Louca, F., 2001. *As Time Goes By: From the Industrial Revolutions to the Information Revolution.* New York: Oxford University Press.

Garnaut, R. *The Garnaut Climate Change Review*. Cambridge: Cambridge University Press; 2008.

Garnaut, R. 2014. Ross Garnaut Q&A: "There is no doubt Australia is out of step". The Conversation. 14 July 2014. Available at https://theconversation.com/ross-garnaut-qanda-there-is-no-doubt-australia-is-out-of-step-29099 accessed on 30 May 2016.

Geels, F.W. 2002. 'Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study', *Research Policy* 31, pp. 1257–1274.

Geels, F.W. 2004a. 'From sectoral systems of innovation to socio-technical systems: insights about dynamics and change from sociology and institutional theory', *Research Policy* 33, pp. 897–920.

Geels, F.W. 2004b. 'Understanding system innovations: a critical literature review and a conceptual synthesis', *System innovation and the transition to sustainability: Theory, evidence and policy*, Cheltenham, UK: Edward Elgar Publishing, pp. 19–47.

Geels, F.W. 2005. 'Co-evolution of technology and society: the transition in water supply and personal hygiene in the Netherlands (1850–1930): a case study in multi-level perspective', *Technology in Society*, 27, pp. 363–397.

Geels, F.W. 2006. 'Co-evolutionary and multi-level dynamics in transitions: The transformation of aviation systems and the shift from propeller to turbojet (1930–1970)', *Technovation* 26(9), pp. 999–1016.

Geels, F.W. 2010. 'Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective', *Research Policy*, 39, pp. 495–510.

Geels, F.W. 2011. 'The multi-level perspective on sustainability transitions: Responses to seven criticisms', *Environmental innovation and societal transitions*, 1, pp. 24–40.

Geels, F.W. 2014a. 'Reconceptualising the co-evolution of firms-in-industries and their environments: Developing an inter-disciplinary Triple Embeddedness Framework', *Research Policy*, 43, pp. 261–277.

Geels, F.W. 2014b. 'Regime resistance against low-carbon transitions: Introducing politics and power into the multi-level perspective', *Theory, Culture & Society*, 31, pp. 21–40.

Geels, F. W. 2018. Disruption and low-carbon system transformation: Progress and new challenges in socio-technical transitions research and the Multi-Level Perspective. *Energy Research & Social Science*, 37, 224-231.

Geels, F.W. and Schot, J. 2007. 'Typology of sociotechnical transition pathways', *Research Policy* 36, pp. 399–417.

Geels, F.W. and Schot, J. 2010. 'The dynamics of sociotechnical transitions – a sociotechnical perspective', In: Grin, J., Rotmans, J. and Schot, J. (Eds.), *Transitions to Sustainable Development*. New York & London: Routledge, pp. 9–101.

Geels, F.W., Kern, F., Fuchs, G., Hinderer, N., Kungl, G., Mylan, J., Neukirch, M. and Wassermann, S. 2016. 'The enactment of socio-technical transition pathways: A reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990–2014)', *Research Policy*, 45, pp. 896–913.

Geels, F.W., Sovacool, B.K., Schwanen, T. and Sorrell, S. 2017. 'The Socio-Technical Dynamics of Low-Carbon Transitions', *Joule*, 1, pp. 463–479.

Geoscience Australia and BREE, 2014, Australian Energy Resource Assessment. 2nd Ed. Geoscience Australia, Canberra. https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/GA21797.pdf accessed on 18 April 2017.

Gerlagh, R., Kverndokk S., Rosendahl K.E. 2009. 'Optimal timing of climate change policy: interaction between carbon taxes and innovation externalities', *Environ Resour Econ*, 43, pp. 369–390

Glaser, B.G., and Strauss, A.L. 1967. *The discovery of grounded theory: Strategies for qualitative research.* New York: Aldine de Gruyter.

GlobeScan, 2000. *Environics International Environmental Monitor Survey Dataset*.

GlobeScan, 2001. *Environics International Environmental Monitor Survey Dataset*.

Goldenberg, S., Vidal, J., Taylor, L. Adam Vaughan, A., & Harvey, F. 2015. Paris climate deal: nearly 200 nations sign in end of fossil fuel era. The Guardian - Sunday, 13 December 2015. Available at http://www.theguardian.com/environment/2015/dec/12/paris-climate-deal-200-nations-sign-finish-fossil-fuel-era accessed on 28 May 2016.

Graichen, P. 2014. Proposal for a Revision of the Industry Exemption rules under the German EEG. Towards a model that complies with European Laws and balances energy, industry and consumers' stakes. Summary of the results of a study conducted by the Oeko-Institut e.V. Agora Energiewende 2014. Available at: https://www.agora-energiewende.de/fileadmin/downloads/publikationen/Impulse/EEG-Umlage_Oeko-Institut_2014/Impulse_Summary_Revision_of_EEG_Exemptions_EN.pdf accessed on 5/3/2018.

Grattan, M., Wroe, D. Abbott's blood oath to repeal carbon tax. Sydney Morning Herald. October 13, 2011. Available at: http://www.smh.com.au/national/abbotts-blood-oath-to-repeal-carbon-tax-20111012-1ll80.html accessed 16 March 2017.

Grattan, M. 2015. Abbott has papal disconnect on fossil fuels, renewables. The Conversation. June 19, 2015. Available at https://theconversation.com/abbott-has-papal-disconnect-on-fossil-fuels-renewables-43555 accessed on 3 May 2016.

Greene, J.C., Caracelli, V.J. and Graham, W.F. 1989. 'Toward a Conceptual Framework for Mixed-method Evaluation Designs', *Educational Evaluation and Policy Analysis*, 11(3), pp. 255–274.

Greenpeace, 2014. *The Energy Transformation in Germany*. Background briefing for the IPCC WG3 report in Berlin, 7-11 April 2014.

Grin, J., Rotmans, J., and Schot, J. 2010. *Transitions to sustainable development: New directions in the study of long term structural change*. New York: Routledge.

Griffiths E. Carbon tax scrapped: PM Tony Abbott sees key election promise fulfilled after Senate votes for repeal. ABC News. July 18, 2014. Available at: http://www.abc.net.au/news/2014-07-17/carbon-taxrepealed-by-senate/5604246 accessed 16 March 2017.

Groba, F. and Breitschopf, B. 2013. *Impact of Renewable Energy Policy and Use on Innovation: A Literature Review* (No.1318). Discussion Papers, German Institute for Economic Research, DIW Berlin.

Gross, R., Blyth, W. and Heptonstall, P. 2007. *Investment in Electricity Generation: The Role of Costs, Incentives and Risks*. London: Imperial College.

Gross, R., Blyth, W. and Heptonstall, P. 2010. 'Risks, revenues and investment in electricity generation: Why policy needs to look beyond costs', *Energy Economics* 32, pp. 796–804.

Grubb, M., Laing, T., Sato, M. & Comberti, C. 2012. Analyses of the effectiveness of trading in EU ETS. Climate Strategies Working Paper.

Grübler, A. 2012. 'Energy transitions research: Insights and cautionary tales', *Energy Policy, 50*, pp. 8–16.

Grubler, A., Wilson, C. and Nemet, G. 2016. 'Apples, oranges, and consistent comparisons of the temporal dynamics of energy transitions', *Energy Research and Social Science*, 22, pp. 18–25.

Guest, G., 2013. 'Describing mixed methods research: an alternative to typologies', *J. Mixed Methods Res.*, 7, pp. 141–151.

Haas, R., Panzer, C., Resch, G., Ragwitz, M., Reece, G. & Held, A. 2011. A historical review of promotion strategies for electricity from renewable energy sources in EU countries. *Renewable and sustainable energy reviews*, 15, 1003-1034.

Hager, C. and Stefes, C.H. 2016. *Germany's Energy Transition: A Comparative Perspective*, New York: Springer.

Halkier, B., Katz-Gerro, T., Martens, L. and Hargreaves, T. 2011. Practicing behaviour change: Applying social practice theory to pro-environmental behaviour change', *Journal of consumer culture*, 11, pp. 79–99.

Hall, P.A., Soskice, D., 2001. *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*. Oxford University Press, Oxford.

Hall, S., Foxon, T.J. amd Bolton, R. 2016. 'Financing the civic energy sector: How financial institutions affect ownership models in Germany and the United Kingdom', *Energy Research & Social Science*, 12, pp. 5–15.

Hall, S., Foxon, T.J. and Bolton, R. 2017. 'Investing in low-carbon transitions: energy finance as an adaptive market', *Climate policy*, 17, pp. 280–298.

Hammons, T. J. 2008. 'Integrating renewable energy sources into European grids', *International Journal of Electrical Power & Energy Systems*, 30, pp. 462–475.

Hamilton, C., 2007. *Scorcher: The Dirty Politics of Climate Change*. Black Inc Agenda, Melbourne. ISBN 978 0977594 900

Hamilton, J. D. 2011. Historical oil shocks. National Bureau of Economic Research.

Hannam, P 2014. Australia's first fossil-free super fund launched, The Sydney Morning Herald, September 4, 2014. http://www.smh.com.au/environment/climate-change/australias-first-fossilfree-super-fund-launched-20140904-10bu4l.html accessed on 5/8/2018.

Hannam, P. 2015. 'Australia's renewable energy investment grinds to a halt', *The Sydney Morning Herald*. 15 April 2015. Available at http://www.smh.com.au/environment/climate-change/australias-renewable-energy-investment-grinds-to-a-halt-20150414-1mkn70.html accessed on 3 May 2016.

Hasham, N. 2015a. 'Climate Change Authority head Bernie Fraser issues blistering rebuke to Abbott government', *The Sydney Morning Herald*, 14 August 2015. Available at: https://www.smh.com.au/politics/federal/climate-change-authority-head-bernie-fraser-issues-blistering-rebuke-to-abbott-government-20150814-gizh1f.html accessed on 4/8/2018.

Hasham, N. 2015b. 'Climate Change Authority chair Bernie Fraser resigns', *The Sydney Morning Herald*, 8 September 2015. Available at: https://www.smh.com.au/politics/federal/climate-change-authority-chair-bernie-fraser-resigns-20150908-gji1rr.html accessed on 4/8/2015.

Hatch, M.T. 1995. 'The politics of global warming in Germany', *Environmental Politics*, 4, pp. 415–440.

Hekkert, M., Suurs, R.A.A., Negro, S., Kuhlmann, S., Smits, R. 2007. 'Functions of innovation systems: a new approach for analysing technological change', *Technological Forecasting and Social Change*, 74, pp. 413–432.

Helm, D. 2009a. Climate change policy: Why has so little been achieved? In D. Helm and C. Hepburn, eds. *The economics and politics of climate change*. Oxford: Oxford University Press.

Helm, D. 2009b. *EU climate-change policy—a critique*. Smith School of Enterprise and the Environment, University of Oxford.

Hess, D. J. 2014. 'Sustainability transitions: A political coalition perspective', *Research Policy*, 43, pp. 278–283.

Hess, D. J. 2016. 'The politics of niche-regime conflicts: Distributed solar energy in the United States', *Environmental Innovation and Societal Transitions*, 19, pp. 42–50.

Hetherington, D., Prior, D., 2012. After the Party: How Australia spent its mining boom windfall. Percapita research paper [Online]. Available at: http://percapita.org.au/wp-content/uploads/2012/05/small_After_the_Party_Final4.pdf accessed on 10 March 2016.

Hetherington, J., Soutphommasane, T., 2010. What's the story? Nation building narratives and climate politics. Policy Network Essay. Available at: http://percapita.org.au/wp-content/uploads/2014/11/Nation-building-narratives-in-climate-politics-2.pdf accessed on 10 March 2016.

Hildingsson, R. 2014. *Governing Decarbonisation: the state and the new politics of climate change*, Lund University.

Hill, M. J. 1997. *The policy process in the modern state*, New York: Prentice Hall PTR.

Höhne, N., Fekete, H., Hagemann, M., Hare, B., Rocha, M., Schaeffer, M., Sferra, F., Jeffery, L., Blok, K. & Deng, Y. 2015. Are governments doing their "Fair share?" - New method assesses climate action. Climate Action Tracker. Available at: http://climateanalytics.org/files/cat_fair_share.pdf accessed 31/12/2015.

Hollo T. New analysis shows Direct Action abatement short term or non-existent. Reneweconomy. November 3, 2016. Available at: http://reneweconomy.com.au/new-analysis-shows-direct-action-abatement-shortterm-non-existent-96450/ accessed 16 March 2017.

Hudson, M. 2016. How climate denial gained a foothold in the Liberal Party, and why it still won't go away. The Conversation. 10 March 2016. Available at https://theconversation.com/how-climate-denial-gained-a-foothold-in-the-liberal-party-and-why-it-still-wont-go-away-56013 accessed on 31 May 2016.

IEA, 2001. Toward a sustainable energy future. OECD/IEA, Paris.

IEA, 2002a. *Security of Supply in Electricity Markets: Evidence and Policy Issues*, International Energy Agency Paris.

IEA, 2002b. *Energy Policies of IEA Countries*: Germany 2002 Review, OECD/IEA Publishing.

IEA, 2003a.*World Energy Investment Outlook*. Paris: International Energy Agency.

IEA, 2003b. *Power generation investment in electricity markets*. Paris: OECD/IEA Publishing.

IEA, 2005. *Energy Policies of IEA Countries: Australia 2005 Review*, OECD/IEA Publishing.

IEA, 2007a. *Energy Policies of IEA Countries: Germany 2007 Review*. Paris: OECD/IEA Publishing.

IEA, 2007b. *Tackling investment challenges in power generation in IEA countries*. Paris: OECD/IEA Publishing.

IEA, 2008. *Deploying Renewables: Principles for effective policies*. Paris: OECD/IEA Publishing.

IEA, 2010. *The economics of transition on the power sector*. Paris: OECD/IEA Publishing.

IEA, 2011a. *Harnessing variable renewables: A guide to the balancing challenge*. Paris: OECD/IEA Publishing.

IEA, 2011b. *Deploying Renewables: Best and Future Policy Practice*. Paris: OECD/IEA Publishing.

IEA, 2012a. *Oil and gas security: Emergency response of IEA countries, Germany*. International Energy Agency.

IEA, 2012b. *Energy Policies of IEA Countries: Australia 2012 Review*, OECD/IEA Publishing.

IEA, 2013a. *Coal: Medium-term market report 2013. Market Trends and Projections to 2018*, International Energy Agency.

IEA, 2013b. *Energy Policies of IEA Countries: Germany 2013 Review*, OECD/IEA Publishing.

IEA, 2014a. *World Energy Investment Outlook 2014 Special Report*. OECD/IEA, Paris.

IEA, 2014b. *World Energy Outlook 2014*. OECD/IEA, Paris.

IEA, 2014c. *Seamless Power Markets: Regional Integration of Electricity Markets in IEA Member Countries*. Paris: OECD/IEA Publishing.

IEA, 2014d. Germany - National Action Plan on Energy Efficiency. IEA/IRENA member policy database. Available at: https://www.iea.org/policiesandmeasures/pams/germany/name-146641-en.php

IEA, 2015a. *Key coal trends: excerpt from Coal Information 2015*. International Energy Agency.

IEA, 2015b. *World Energy Outlook 2015 Special Report on Energy and Climate Change* International Energy Agency.

IEA, 2016. *World Energy Outlook 2016* OECD/IEA, Paris.

IEA, 2017. *CO_2 emissions from fuel combustion: highlights 2017*. Paris: OECD/IEA Publishing.

IEA/IRENA, 2016. *Global Renewable Energy Policies and Measures Database: key elements of climate change renewable energy policy framework for Australia*, International Energy Agency and International Renewable Energy Agency. Available at: http://www.iea.org/policiesandmeasures/renewableenergy/?country=Australia accessed on May 28, 2016.

IEA/IRENA, 2018. *Global Renewable Energy Policies and Measures Database: key elements of climate change renewable energy policy framework for Germany*, International Energy Agency and International Renewable Energy Agency. Available at: http://www.iea.org/policiesandmeasures/renewableenergy/?country=Germany accessed on 28/01/2018.

Inderberg, T. H. J., Tews, K. & Turner, B. 2018. Is there a Prosumer Pathway? Exploring household solar energy development in Germany, Norway, and the United Kingdom. *Energy Research & Social Science*, 42, 258-269.

IPCC 2001. *Mitigation. Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK: Cambridge University Press.

IPCC 2007. *Working Group III: Mitigation of Climate Change. Executive summary*. http://www. ipcc. ch/publications_and_data/ar4/wg3/en/ch11s11-es. html.

IPCC 2012. *Special Report on Renewable Energy Sources and Climate Change Mitigation. SRREN full Report*. Cambridge, UK: Cambridge University Press.

IPCC, 2014. *Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK and New York, NY.

IRENA 2018. *Renewable Power Generation Costs in 2017*. International Renewable Energy Agency (IRENA).

Jacobs, D. 2012. The German Energiewende–History, Targets, Policies and Challenges. *Renewable Energy Law and Policy Review*, 223-233.

Jacobsson, S., and Johnson, A. 2000. 'The diffusion of renewable energy technology: an analytical framework and key issues for research', *Energy Policy,* 28, pp. 625–640.

Jacobsson, S., and Bergek, A. 2004. 'Transforming the energy sector: the evolution of technological systems in renewable energy technology', *Industrial and Corporate Change*, 13(5), pp. 815–849.

Jacobsson, S., Bergek, A., Finon, D., Lauber, V., M itchell, C., Toke, D. & Verbruggen, A. 2009. EU renewable energy support policy: Faith or facts? *Energy policy*, 37, 2143-2146.

Jacottet, A. 2012. Cross-border electricity interconnections for a well-functioning EU Internal Electricity Market. The Oxford Institute for energy Studies, University of Oxford.

Jamasb, T. and Pollitt, M. 2005. 'Electricity market reform in the European Union: review of progress toward liberalization & integration', *The Energy Journal*, 26, pp. 11–41.

Jänicke, M., and Jacob, K., 2005. Ecological Modernisation and the Creation of Lead Markets. In *Towards Environmental Innovation Systems*. M. Weber and J. Hemmelskamp. Berlin Heidelberg New York, Springer, pp. 175–194.

Jones, S. 2009. The Future of Renewable Energy in Australia: A Test for Cooperative Federalism? *The Australian Journal of Public Administration*, 68(1),1-20

Jordan-Korte, K. 2011. *Government Promotion of Renewable Energy Technologies: Policy Approaches and Market Development in Germany, the United States, and Japan*. Germany: Springer.

Jotzo, F., Tim, J. & Fabian, N. 2012. Policy Uncertainty about Australia's Carbon Price: Expert Survey Results and Implications for Investment. The Australian Economic Review, 45, 395-409.

Jotzo, F. 2012, Australia's Carbon Price, Nature Climate Change, 2, 475-476.

Jotzo, F., Pears, A., Sullivan, C.A., Green, J., Quiggin, J., Coghill, K., Perry, N. 2014. Palmer deal gives green light to Direct Action – experts react. The Conversation. 29 October 2014. Available at https://theconversation.com/palmer-deal-gives-green-light-to-direct-action-experts-react-33601 accessed 10 August 2015.

Jungjohann, A. & Morris, C. 2014. The German Coal Conundrum: The status of coal power in Germany's energy transition. Retrieved August 15, 2014.

Jurca, A.M. 2014. 'The Energiewende: Germany's Transition to an Economy Fuelled by Renewables', *Georgetown International Environmental Law Review*, 27, p. 141.

Keane, P. 2015. Tony Abbott New Path of Climate Change Obstruction. Independent Australia. 22 July 2015. Available at: https://independentaustralia.net/environment/environment-display/tony-abbott-new-path-of-climate-change-obstruction,7969 accessed on 3 May 2016.

Keating, M. 1994. The Earth Summits agenda for change: a plain language version of Agenda 21 and the other Rio agreements. Centre for Our Common Future, Geneva, Switzerland.

Kemp, R. 1994. 'Technology and the transition to environmental sustainability', *Futures*, 26, pp. 1023–1046.

Kemp, R., Schot, J., and Hoogma, R. 1998. 'Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management', *Technology Analysis & Strategic Management*, 10, pp. 175–195.

Kenny, M., Cox, L. Ricky Muir and Palmer United Party strike deal to save Renewable Energy Agency. The Sydney Morning Herald. July 9, 2014. Available at: http://www.smh.com.au/federal-politics/political-news/rickymuir-and-palmer-united-party-strike-deal-to-saveaustralian-renewable-energy-agency-20140709-3bmqg.html accessed on 16 March 2017.

Kenny, M., Wen, P. Liberal right wing's climate warning to Malcolm Turnbull: don't touch Direct Action. The Sydney Morning Herald. September 25, 2015. Available at: http://www.smh.com.au/federal-politics/political-news/liberal-right-wings-climate-warning-tomalcolm-turnbull-dont-touch-direct-action-20150925-gjv73s.html Accessed 16 March 2017.

Kern, F. and Markard, J. 2016. Analysing energy transitions: combining insights from transition studies and international political economy. In: Van de Graaf, T., Sovacool, B., Ghosh, A., Kern, F., Klare, M., (Eds.), *The Palgrave Handbook of the International Political Economy of Energy*. Springer Nature, London, UK, pp. 291-318.

Kern, F., and Smith, A., 2008. 'Restructuring energy systems for sustainability? Energy transition policy in the Netherlands', *Energy Policy*, 36, pp. 4093–4103.

Kerr, S. & Newell, R. G. 2003, Policy-induced technology adoption: Evidence from the U.S. lead phasedown, Journal of Industrial Economics 51(3): 317-343.

Kiyar, D. & Wittneben, B. B. 2015. Carbon as Investment Risk—The Influence of Fossil Fuel Divestment on Decision Making at Germany's Main Power Providers. *Energies*, 8, 9620-9639.

Konidari, P. and Mavrakis, D. 2007. 'A multi-criteria evaluation method for climate change mitigation policy instruments', *Energy Policy*, 35, pp. 6235–6257.

Krey, V., Luderer, G., Clarke, L. & Kriegler, E. 2014. Getting from here to there–energy technology transformation pathways in the EMF27 scenarios. *Climatic Change*, 123, 369-382, http://dx.doi.org/10.1007/s10584-013-0947-5.

Kuhlmann, S., Shapira, P., and Smits, R. 2010. A systemic perspective: the innovation policy dance. In: Smits, R., Kuhlmann, S., Shapira, P. (Eds.), *The Theory and Practice of Innovation Policy. An International Research Handbook*. Edward Elgar, Cheltenham, UK, pp. 1–22.

Laing, T., Sato, M., Grubb, M. & Comberti, C. 2013. Assessing the effectiveness of the EU Emissions Trading System. Centre for Climate Change Economics and Policy.

Laing, T., Sato, M., Grubb, M. & Comberti, C. 2014. The effects and side-effects of the EU emissions trading scheme. *Wiley Interdisciplinary Reviews: Climate Change*, 5, 509-519.

Law, J., and Hassard, J. 1999. *Actor-network Theory and After*. Oxford, UK: Blackwell Publishing.

Leiserowitz, A. 2007. 'International public opinion, perception, and understanding of global climate change', *Human development report 2007/2008*, pp. 1–40.

Lenzen M, McBain B, Trainer T, Jütte S, Rey-Lescure O, Huang J 2016. Simulating low-carbon electricity supply for Australia. *Applied Energy* 179:553-564.

Letts, S. 2018. Renewable energy capacity set to exceed target Federal Government said was impossible. 18 April 2018. ABC News. Available at: http://www.abc.net.au/news/2018-04-18/renewable-energy-capacity-to-exceed-impossible-target/9667870 Accessed on 31 July 2018.

Letts, S. and Barbour, L. 2018. Renewable energy set to supply one-third of market needs by 2020. 27 June 2018. ABC News. Available at: http://www.abc.net.au/news/2018-06-27/renewables-can-supply-one-third-of-market-needs-by-2020/9912342 Accessed on 31/7/2018.

Liberal Party of Australia. 2013. The Coalition's Policy to Scrap the Carbon Tax and Reduce the Cost of Living. The Coalition Party. Available at:

http://parlinfo.aph.gov.au/parlInfo/download/library/partypol/2645370/upload_binary/2645370.pdf;fileType=application%2Fpdf#search=%22library/partypol/2645370%22 accessed on 28 May 2016.

Liinanki, C 2013, Swedish pension funds urged to dump fossil fuel holdings. Financial Times. 8 September 2013. Available at: http://www.ft.com/cms/s/0/bdfbf812-16e0-11e3-9ec2-00144feabdc0.html#axzz3BeM9bMWh accessed on 17 March 2017.

Lins, C., Williamson, L. E., Leitner, S. and Teske, S. 2014. 'The first decade: 2004—2014: 10 years of renewable energy progress', Renewable Energy Policy Network for the 21st Century, REN21 2014, 20 pp. 1 - 48 (48).

Lipp, J. 2007. Lessons for effective renewable electricity policy from Denmark, Germany and the United Kingdom, *Energy Policy* 35(11): 5481-5495.

Liscouski, B. and Elliot, W. 2004. Final report on the August 14, 2003 blackout in the United States and Canada: Causes and recommendations. *A report to US Department of Energy*, 40, 86, 17-140.

Lise, W., Sijm, J. & Hobbs, B. F. 2010. The impact of the EU ETS on prices, profits and emissions in the power sector: simulation results with the COMPETES EU20 model. *Environmental and Resource Economics*, 47, 23-44.

Long, S., 2017. 'Pre-election coal advertising funded by money meant for clean coal research', The ABC News, 20 February. Aavailable at: http://www.abc.net.au/news/2017-02-20/coal-advertising-funded-by-money-meant-for-clean-coal-research/8287326 accessed on 08/05/2018.

Loorbach, D. A. 2007. *Transition management: New mode of governance for sustainable development*. Rotterdam: Erasmus University.

Loorbach, D., 2010. 'Transition management for sustainable development: a prescriptive, complexity-based governance framework', *Governance*, 23, pp. 161–183.

Loorbach, D., van der Brugge, R., and Taanman, M. 2008. 'Governance in the energy transition: Practice of transition management in the Netherlands', *International Journal of Environmental Technology and Management*, 9(2), pp. 294–315.

Loorbach, D. and Verbong, G. 2012. Conclusion: is governance of the energy transition a reality, an illusion or a necessity? In: *Governing the energy transition: reality, illusion or necessity?* New York: Routledge, Taylor & Francis group.

Ludlow, M. 2018. Renewable energy investment surges as Australia on track to exceed RET. 16 May 2018. Financial Review. Available at: https://www.afr.com/news/politics/renewable-energy-investment-surges-as-australia-on-track-to-exceed-ret-20180514-h101vo Accessed on 31/7/2018.

Marchetti, C. and Nakicenovic, N. 1979. *The Dynamics of Energy Systems and the Logistic Substitution Model.* IIASA Research Report. IIASA, Laxenburg, Austria: RR-79-013

Markard, J. 2011. 'Transformation of infrastructures: sector characteristics and implications for fundamental change', *Journal of Infrastructure Systems (ASCE)*, 17, pp. 107–117.

Markard, J., Raven, R. and Truffer, B. 2012. 'Sustainability transitions: An emerging field of research and its prospects', *Research Policy*, 41, pp. 955–967.

Marques, A. C., Fuinhas, J. A. 2012. Are public policies towards renewables successful? Evidence from European countries. *Renew Energy* 44,109–118. http://dx.doi.org/10.1016/j.renene.2012.01.007.

Martin, N. & Rice, J. 2013. The solar photovoltaic feed-in tariff scheme in New South Wales, Australia. *Energy Policy*, 61, 697-706.

Martin, R., Muûls, M. & Wagner, U. 2012. An evidence review of the EU Emissions Trading System, focussing on effectiveness of the system in driving industrial abatement. Department of Energy and Climate Change.

Mattauch, L., Creutzig, F. and Edenhofer, O. 2015. 'Avoiding carbon lock-in: Policy options for advancing structural change', *Economic Modelling*, 50, pp. 49–63.

Matthes, F., Graichen, V., Repenning, J., Doble, C., Macadam, J., Taylor, S., Zanoni, D. & Chodor, M. 2005. The environmental effectiveness and economic efficiency of the European Union Emissions Trading Scheme: Structural aspects of allocation. A report to WWF. Berlin. Available at: http://assets.wwf.es/downloads/ets_estructura_oeko_completo.pdf

Matthes, F. C., Newbery, D., Colombier, M., Mathieu, M. & Rüdinger, A. 2015. The energy transition in Europe: initial lessons from Germany, the UK and France.

Matthes, F. C. 2017a. Energy transition in Germany: a case study on a policy-driven structural change of the energy system. Evolutionary and Institutional Economics Review, 14, 141-169.

Matthes, F. C. 2017b. The current electricity costs of energy-intensive industries in Germany. The Greens / European Free Alliance in the European Parliament. 2017. Available at: http://reinhardbuetikofer.eu/wp-content/uploads/2017/09/Matthes-2017-Memo-Electricity-costs-of-energy-intensive-industries-in-Germany-1.pdf accessed on 5/3/2018.

McDonald, M. 2012. The Failed Securitization of Climate Change in Australia. *Australian Journal of Political Science,* 47, 579-592.

McDonald, M. 2013. The Future of Australian Climate Politics. *Australian Journal of Politics & History*, 59, 449-456.

McDonald, M. 2015. Climate security and economic security: The limits to climate change action in Australia [quest]. *International Politics*, 52, 484-501.

McKenzie-Murray M. Abbott's campaign to kill renewable energy sector. The Saturday Paper. July 18, 2015. Available at: https://www.thesaturdaypaper.com.au/news/politics/2015/07/18/abbotts-campaignkill-renewable-energy-sector/14371416002142 accessed 16 March 2017.

McMahon, J. 2016. 2 Questions Every Investor Should Ask About Climate Risk. Forbes - Sunday, 3 January 2016. Available at http://www.forbes.com/sites/jeffmcmahon/2016/01/02/two-questions-every-investor-should-ask-about-climate-risk/#707c4b767451 accessed on 28 May 2016.

Meadowcroft, J. 2005. 'Environmental political economy, technological transitions and the state', *New Political Economy*, 10(4), pp. 479–498.

Meadowcroft, J. 2009. 'What about the politics? Sustainable development, transition management, and long-term energy transitions', *Policy sciences*, 42, p. 323.

Meadowcroft, J. 2011. 'Engaging with the politics of sustainability transitions', *Environmental Innovation and Societal Transitions*, 1, pp. 70–75.

Milman O. Climate change talks: no minister to represent Australia. The Guardian. November 7, 2013. Available at: http://www.theguardian.com/environment/2013/nov/07/climate-change-talks-nominister-represent-australia accessed 16 March 2017.

Mitchell, J. C. 1983. 'Case and situation analysis', *The Sociological Review*, 31(2), pp. 187–211.

Mitchell, C. 2010. *The Political Economy of Sustainable Energy (Energy, Climate and the Environment)*, Basingstoke: Palgrave Macmillan.

Morris, G. & Belton, V. 2011. MCA4climate: A practical framework for planning pro-development climate policies. Available at: http://www.mca4climate.info/_assets/files/south_africa_case_final.pdf

Morris, C. 2013. Citizens Own Half of German Renewable Energy. Energy Transition – The Global Energiewende October 29, 2013. Available at: http://energytransition.de/2013/10/citizens-own-half-of-german-renewables accessed on 11/3/2018.

Morris, C. and Jungjohann, A. 2016. *Energy democracy: Germany's Energiewende to renewables*, Switzerland Palgrave Macmillan.

Morris, C., Pehnt, M., 2016. *Energy Transition the German Energiewende*. An initiative of the Heinrich Böll Foundation Released on 28 November 2012. Revised July 2016. www.energytransition.de

Moser, C. 2011. *Carbon Mitigation Strategies in the Electricity Distribution Sector in Australia*. IIIEE, Lund University, Sweden.

Mourmouris, J. C. & Potolias, C. 2013. A multi-criteria methodology for energy planning and developing renewable energy sources at a regional level: A case study Thassos, Greece. *Energy Policy*, 52, 522-530.

Neij, L., and Astrand, K. 2006. 'Outcome indicators for the evaluation of energy policy instruments and technical change', *Energy Policy*, 34, pp. 2662–2676.

Nelson, R.R., and Winter, S.G. 1982. *An Evolutionary Theory of Economic Change*. Harvard University Press, Cambridge.

Nelson, T., Nelson, J., Ariyaratnam, J. & Camroux, S. 2013. An analysis of Australia's large-scale renewable energy target: Restoring market confidence. *Energy Policy*, 62, 386-400.

Nelson, T., Bashir, S., McCracken-Hewson, E. and Pierce, M. 2017. The Changing Nature of the Australian Electricity Industry. Economic Papers: A journal of applied economics and policy.

Neuhoff, K. 2005. 'Large scale deployment of renewables for electricity generation', *Oxford Review of Economic Policy*, 21(1), pp. 88–110.

NIEIR, 1996. *Subsidies to the use of natural resources*. Department of Environment, Sport and Territories, Environmental Economics Research Paper No. 2. Prepared by consultant National Institute of Economic and Industry Research (NIEIR).

Norman, J. 2015. Clean Energy Finance Corporation directed by Government to stop funding wind farms. The ABC News. Available at : http://www.abc.net.au/news/2015-07-12/government-lobbies-for-cefc-to-stop-wind-farm-funding/6613590 accessed on 30 May 2016.

Oberthür, S. & Roche Kelly, C. 2008. EU leadership in international climate policy: achievements and challenges. *The International Spectator*, 43, 35-50.

Otto, V. M., Löschel, A. & Reilly, J. M. 2006. Directed technical change and climate policy.

Parkinson, G. 2013. 'Funding cuts to ARENA confirmed, $435m gone', *RenewEconomy*. 13 November 2013. Available at http://reneweconomy.com.au/2013/funding-cuts-to-arena-confirmed-435m-gone-32670 accessed on 3 May 2016.

Parliament of Australia. 2007. *Prime Minister: Ratifying the Kyoto Protocol*. Canberra: Press Office.
http://parlinfo.aph.gov.au/parlInfo/download/media/pressrel/215P6/upload_binary/215p61.pdf;fileType=application%2Fpdf#search=%22media/pressrel/215P6%22

Payne, J.E., 2010. Survey of the international evidence on the causal relationship between energy consumption and growth. *Journal of Economic Studies* 37 (1), 53–95.

Pearse, G. (2007). *High & Dry: John Howard, Climate Change and the Selling of Australia's Future*. Camberwell, Victoria: Viking /Penguin.

Pearson, P.J. and Foxon, T.J. 2012. ‘A low carbon industrial revolution? Insights and challenges from past technological and economic transformations’, *Energy Policy*, 50, pp. 117–127.

Penney, K., Cuevas-Cubria, C. and Copeland, A. *Electricity generation: Major development projects – October 2008 listing*, Australian Bureau of Agricultural and Resource Economics, Canberra.

Perez, C., 2002. *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages*. Cheltenham, UK: Edward Elgar.

Perrigo, B. 2018. ‘Why Does Australia Keep Getting Rid of Its Prime Ministers?’, Time World News Australia. 24 August. Available at: http://time.com/5377190/why-australia-changes-prime-ministers/ accessed on 26/08/2018.

Pezzey, J., Mazouz, S., and Jotzo, F., 2010. The logic of collective action and Australia’s climate policy. *Australian Journal of Agricultural and Resource Economics*, 54, 185–202.

Pidgeon, N. and Henwood, K. 1997. Using Grounded Theory in Psychological Research. *In:* Haynes, N. (ed.) *Doing Qualitative Analysis in Psychology*. Hove: Psychology Press, pp.245-273.

Pietsch, J. and Mcallister, I. 2010. ‘A diabolical challenge’: public opinion and climate change policy in Australia. *Environmental Politics*, 19, 217-236.

Pitt, L., van Kooten, G.C., Love, M. and Djilali, N. 2005. Utility-scale wind power: impacts of increased penetration. Paper presented at International Green Energy Conference, 12–16 June, Waterloo, Ontario, Canada.

Pollitt, M.G. 2012. ‘The role of policy in energy transitions: Lessons from the energy liberalisation era’, *Energy Policy*, 50, pp. 128–137.

Polzin, F., Migendt, M., Täube, F. A. & Von Flotow, P. 2015. Public policy influence on renewable energy investments—A panel data study across OECD countries. *Energy Policy*, 80, 98-111.

Popp, D., Hascic, I. & Medhi, N. 2011, Technology and the diffusion of renewable energy, *Energy Economomics* 33: 648-662.

Porter, A.L., Ashton, W.B., Clar, G., Coates, J.F., Cuhls, K., Cunningham, S.W., Ducatel, K., van der Duin, P., Georgehiou, L., Gordon, T., Linstone, H., Marchau, V., Massari, G., Miles, I., Mogee, M., Salo, A., Scapolo, F., Smits, R. and Thissen, W. 2004. ‘Technology futures analysis: toward integration of the field and new methods’, *Technological Forecasting and Social Change*, 71, pp. 287–303.

Ragin, C.C. 1987. *The comparative method: Moving beyond qualitative and quantitative strategies*. Oakland California: University of California Press.

Rasmussen, M.G., Andresen, G.B. and Greiner, M. 2012. 'Storage and balancing synergies in a fully or highly renewable pan-European power system', *Energy Policy*, 51, pp. 642–651.

Raven, R., and Geels, F.W. 2010. 'Socio-cognitive evolution in niche development: comparative analysis of biogas development in Denmark and the Netherlands (1973–2004)', *Technovation*, 30, pp. 87–99.

Readfearn, G. 2014. What does Australian prime minister Tony Abbott really think about climate change? The Guardian. Monday 16 June 2014. Available at: http://www.theguardian.com/environment/planet-oz/2014/jun/16/what-does-australian-prime-minister-tony-abbott-really-think-about-climate-change accessed on 3 May 2016.

Reece N. Behold one of history's greatest policy failures. The Sydney Morning Herald. November 18, 2013. Available at: http://www.smh.com.au/federal-politics/political-opinion/behold-one-of of-historys-greatest-policy-failures-20131117-2xp0g.html accessed on 16 March 2017.

REN21, 2013. *Renewables Global Futures Report 2013*, Renewable Energy Policy Network for the 21st Century, Institute for Sustainable Energy Policies.

REN21, 2017. *Renewables 2017 Global Status Report*. Paris: REN21 Secretariat. ISBN 978-3-9818107-6-9

REN21, 2018. *Renewables Global Futures Report 2018*, Renewable Energy Policy Network for the 21st Century, Institute for Sustainable Energy Policies.

RepuTex. Behind the numbers: adding up to the Direct Action plan, September 12, 2013. Available at:http://www.reputex.com/publications/behind-the-numbersadding-up-to-the-direct-action-plan/ accessed on 16 March 2017.

Reputex Carbon. Direct action vs. ETS: achieving our emissions objectives. August 29, 2013. Available at:http://www.reputex.com/research-insights/directaction-vs-emissions-trading-achieving-our-emissionsobjectives/ accessed 16 March 2017.

Reser, J. P., Bradley, G. L., Glendon, A. I., Ellul, M. C. and Callaghan, R. 2012. *Public risk perceptions, understandings and responses to climate change in Australia and Great Britain*, Gold Coast, Qld: Griffith Climate Change Response Adaptation Facility.

Reuters, 2017. 'Australian government supports public funding for "clean coal": media', Reuters 4 February. Available at: https://www.reuters.com/article/us-australia-coal/australian-government-supports-public-funding-for-clean-coal-media-idUSKBN15J07O accessed on 07/05/2018.

Riedy, C. and Diesendorf, M. 2003. 'Financial subsidies to the Australian fossil fuel industry', *Energy Policy*, 31, pp. 125–137.

Rihoux, B. and Grimm, H. 2006. *Innovative comparative methods for policy analysis: Beyond the quantitative-qualitative divide*. Springer Science & Business Media: New York, USA.

Ringel, M., Schlomann, B., Krail, M. & Rohde, C. 2016. Towards a green economy in Germany? The role of energy efficiency policies. *Applied Energy,* 179**,** 1293-1303.

Rip, A., Misa, T., and Schot, J. 1995. *Managing Technology in Society. The Approach of Constructive Technology Assessment.* London: Pinter .

Rotmans, J., Kemp, R. and van Asselt, M. (2001) 'More evolution than revolution: transition management in public policy', *Foresight*, 3 (1), pp. 15–31.

Rotmans, J. and Loorbach, D. (2010) 'Towards a Better Understanding of Transitions and Governance: A Systemic and Reflexive Approach', In: Grin, J., Rotmans, J. and Schot, J. 2010. *Transitions to sustainable development: New directions in the study of long-term structural change*. New York: Routledge.

Rutovitz, J., Peterseim, J., Elliston, B., Harris, S., Mohr, S., Lovegrove, K., Want, A., Langham, E. & Macgill, I. 2013. Breaking the solar gridlock. Potential benefits of installing concentrating solar thermal power at constrained locations in the NEM. Prepared for the Australian Solar Thermal Energy Association (AUSTELA) by the Institute for Sustainable Futures, UTS.

Saaty, T.L., 1977. A scaling method for priorities in Hierarchical Structures. *Journal of Mathematical Psychology* 15, 234–281.

Sansom, M. 2014. 'ARENA: the renewable energy agency that just won't die ...', *Government News*. 8 December 2014. Available at: http://www.governmentnews.com.au/2014/12/cormann-cant-kill-arena/ accessed on 3 May 2016.

Scott, J., Edwards, A. 2015. Coal Price Decline to Impact Aussie Investment, Frydenberg Says. Bloomberg News - October 2, 2015. Available at: http://www.bloomberg.com/news/articles/2015-10-02/coal-price-decline-to-impact-aussie-investment-frydenberg-says accessed on 28 May 2016.

Scrieciu, Ş., Bristow, S. and Puig, D. 2011. MCA4climate: A Practical Framework for Planning Pro-Development Climate Policy. United Nations Environment Programme.

Shaw, K. 2011. Climate deadlocks: the environmental politics of energy systems. *Environmental Politics,* 20, 743-763.

Simpson, G. & Clifton, J. 2014. Picking winners and policy uncertainty: Stakeholder perceptions of Australia's Renewable Energy Target. *Renewable Energy,* 67**,** 128-135.

Sivaraman, D. & Horne, R. E. 2011. Regulatory potential for increasing small scale grid connected photovoltaic (PV) deployment in Australia. *Energy Policy*, 39, 586-595.

Smil, V. 2016. ‘Examining energy transitions: A dozen insights based on performance’, *Energy Research & Social Science*, 22, pp. 194–197.

Smink, M.M., Hekkert, M.P. and Negro, S.O. 2015. ‘Keeping sustainable innovation on a leash? Exploring incumbents’ institutional strategies’, *Bus. Strategy Environ.*, 24(2), pp. 86–101.

Smith, M.L. 1986. ‘The Whole is Greater: Combining Qualitative and Quantitative Approaches in Evaluation Studies’, in D.D. Williams (ed.) *Naturalistic Evaluation*, pp. 37–54. San Francisco, CA: Jossey-Bass.

Smith, A. 2007. ‘Translating sustainabilities between green niches and sociotechnical regimes’, *Technology Analysis & Strategic Management*, 19, pp. 427–450.

Smith, A., Stirling, A. and Berkhout, F. 2005. ‘The governance of sustainable socio-technical transitions’, *Research Policy*, 34, pp. 1491–1510.

Smith, A., Voß, J.P. and Grin, J. 2010. ‘Innovation studies and sustainability transitions: the allure of the multi-level perspective and its challenges’, *Research Policy*, 39, pp. 435–448.

Smith, A., and Raven, R. 2012. hat is protective space? Reconsidering niches in transitions to sustainability’, *Research Policy*, 41, pp. 1025–1036.

Snyder, L. D., Miller, N. H. & Stavins, R. N. 2003, The effects of environmental regulation on diffusion: the case of chlorine manufacturing, *American Economic Review* 93(2): 2003.

Sovacool, B. K. 2016. How long will it take? Conceptualizing the temporal dynamics of energy transitions. *Energy Research & Social Science*, 13**,** 202-215.

Spencer, T. & Guerin, E. 2012. Time to reform the EU Emission Trading Scheme, European Energy Review, 23 January 2012

Sorrell S., and Sijm J. 2003. ‘Carbon trading in the policy mix’, *Oxf Rev Econ Policy*, 19(3), pp. 420–437.

Stake, R. 1995. *The Art of Case Study Research.* Thousand Oaks, CA, USA: SAGE.

Stake, R. E. 2003. Case studies. In N. Denzin & Y. Lincoln (Eds.), *Strategies of qualitative inquiry* (2nd Ed.), Thousand Oaks, CA, USA: SAGE, pp. 134-164.

Steentjes, K., Pidgeon, N. F., Poortinga, W., Corner, A.J., Arnold, A., Böhm, G., Mays, C., Poumadère, M., Ruddat, M. and Scheer, D. 2017. European Perceptions of Climate Change (EPCC): Topline findings of a survey conducted in four European countries in 2016. March 2017. Cardiff: Cardiff University.

Stephens, J.C., Wilson, E.J. and Peterson, T.R. 2008. ‘Socio-Political Evaluation of Energy Deployment (SPEED): An integrated research framework analyzing energy technology deployment’, *Technological forecasting and social change*, 75, pp. 1224–1246.

Stern, D. I. & Kander, A. 2012. The role of energy in the industrial revolution and modern economic growth. *The Energy Journal*, 125-152.

Stirling, A. 2010. ‘Multicriteria diversity analysis: A novel heuristic framework for appraising energy portfolios’, *Energy Policy*, 38, pp. 1622–1634.

St John, A. 2014. *The Renewable Energy Target: a quick guide*. Parliamentary Library.

Stock, A. 2014. Australia's Electricity Sector: Ageing, Inefficient and Unprepared. Climate Council of Australia. Available at: http://www.climatecouncil.org.au/uploads/f9ba30356f697f238d0ae54e913b3faf.pdf accessed on 10 March 2016.

Stock, A., Flannery, T. and Stock, P. 2015. *The global renewable energy boom: How Australia is missing out*. Climate Council of Australia.

Stock, P., Alexander, D., Stock, A., and Greg Bourne, G. 2017. Renewables Ready: States Leading the Charge. Climate Council of Australia. ISBN: 978-1-925573-28-2 (web).

Strauss, A.L. and Corbin, J. 1990. *Basics of Qualitative Research: Grounded Theory Procedure and Techniques*, Newbury Park, London: Sage.

Strauss, A.L. and Corbin, J. 1998. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*, Thousand Oaks, CA: Sage.

Szulecki, K. 2018. Conceptualizing energy democracy. *Environmental Politics*, 27, 21-41.

Talberg, A., Hui, S. & Loynes, K. 2013. *Australian climate change policy: a chronology*. Research Paper Series, 2013–14. Department of Parliamentary Services. Parliamentary Library. http://parlinfo.aph.gov.au/parlInfo/download/library/prspub/2875065/upload_binary/2875065.pdf;fileType=application/pdf

Tashakkori, A. and Teddlie, C. 2003. *Handbook of Mixed Methods in Social and Behavioral Research*. Thousand Oaks, CA: Sage.

Taylor L. Climate policy uncertainty could cost as much as 1% of GDP, report finds. The Guardian. April 30, 2016. Available at: http://www.theguardian.com/environment/2016/apr/29/climate-policyuncertainty-could-cost-as-much-as-1-of-gdp-reportfinds accessed on 16 March 2017.

Thalman, E. & Wettengel, J. 2017. Factsheet – The story of "Climate Chancellor" Angela Merkel. Clean Energy Wire CLEW. Available at: https://www.cleanenergywire.org/factsheets/making-climate-chancellor-angela-merkel accessed on 6/12/2017.

To, H., Wijeweera, A. & Charles, M. Energy consumption and economic growth–The case of Australia. Australian Conference of Economists, 2013.

Toman, M.A. and Jemelkova, B. 2003. ‘Energy and Economic Development: An assessment of the state of the knowledge’, *The Energy Journal*, 24(4), pp. 93–112.

Tranter, B. 2011. Political divisions over climate change and environmental issues in Australia. *Environmental Politics*, 20, 78-96.

Truffer, B., Voss, J.-P., Konrad, K. 2008. 'Mapping expectations for system transformations: lessons from sustainability foresight in German utility sectors', *Technological Forecasting and Social Change*, 75, pp. 1349–1460.

Turnheim, B. and Geels, F.W. 2013. 'The destabilisation of existing regimes: Confronting a multi-dimensional framework with a case study of the British coal industry (1913–1967)', *Research Policy*, 42, pp. 1749–1767.

Twomey, P. and Gaziulusoy, A.I. 2014. Review of System Innovation and Transitions Theories. Visions and Pathways 2040 project, the CRC for Low Carbon Living, Melbourne, Australia.

Umbach, F. 2010. Global energy security and the implications for the EU. *Energy Policy*, 38, 1229-1240.

UN-Comtrade, 2015. International Trade Statistics Yearbook Volume I Trade by Country. Department of Economic and Social Affairs Statistics Division. United Nations New York, 2016. Available at: http://www.keepeek.com/Digital-Asset-Management/oecd/international-trade-and-finance/international-trade-statistics-yearbook-2015-volume-i_0459b2d7-en#page2 accessed on 30/01/2018.

UNEP, 2008. *Global Trends in Sustainable Energy Investment 2008*, UNEP's Division of Technology, Industry and Economics (DTIE).

UNEP, 2009. *Global Trends in Sustainable Energy Investment 2009*, UNEP's Division of Technology, Industry and Economics (DTIE).

UNEP-BNEF, 2010. *Global Trends in Sustainable Energy Investment 2010*, UNEP's Division of Technology, Industry and Economics (DTIE) and Bloomberg New Energy Finance (BNEF).

UNEP-BNEF, 2011. *Global Trends in Renewable Energy Investment 2011*, United Nations Environment Programme (UNEP) and Bloomberg New Energy Finance (BNEF).

UNEP-BNEF, 2012. *Global Trends in Renewable Energy Investment 2012*, United Nations Environment Programme (UNEP) and Bloomberg New Energy Finance (BNEF).

UNEP-BNEF, 2013. *Global Trends in Renewable Energy Investment 2013*, United Nations Environment Programme (UNEP) and Bloomberg New Energy Finance (BNEF).

UNEP-BNEF, 2014. *Global Trends in Renewable Energy Investment 2014*, United Nations Environment Programme (UNEP) and Bloomberg New Energy Finance (BNEF).

UNEP-BNEF, 2015. *Global Trends in Renewable Energy Investment 2015*, United Nations Environment Programme (UNEP) and Bloomberg New Energy Finance (BNEF).

UNEP-BNEF, 2016. *Global Trends in Renewable Energy Investment 2016*, United Nations Environment Programme (UNEP) and Bloomberg New Energy Finance (BNEF).

UNEP-BNEF, 2017. *Global Trends in Renewable Energy Investment 2017*, United Nations Environment Programme (UNEP) and Bloomberg New Energy Finance (BNEF).

UNEP-BNEF, 2018. *Global Trends in Renewable Energy Investment 2018*, United Nations Environment Programme (UNEP) and Bloomberg New Energy Finance (BNEF).

UNFCCC 2015a. Analysis Note national contributions COP21. http://www.cop21.gouv.fr/wp-content/uploads/2015/10/DP-INDC-EN.pdf

UNFCCC 2015b. COP21 Adoption of the Paris Agreement. In: UNFCCC (ed.) CP/2015/L.9/Rev.1. UNFCCC. Available at: http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

UNFCCC 2015c. Synthesis report on the aggregate effect of the intended nationally determined contributions. COP21. UNFCCC. http://unfccc.int/resource/docs/2015/cop21/eng/07.pdf

UNFCCC 2016. Paris Agreement - Status of Ratification. https://unfccc.int/process/the-paris-agreement/status-of-ratification

Unruh, G.C. 2000. 'Understanding carbon lock-in', *Energy Policy*, 28, pp. 817–830.

Unruh, G. C. and Carrillo-Hermosilla, J. 2006. 'Globalizing carbon lock-in', *Energy Policy*, 34, pp. 1185-1197.

van den Bergh, J.C. and Gowdy, J.M. 2000. 'Evolutionary theories in environmental and resource economics: approaches and applications', *Environmental & Resource Economics*, 17, pp. 37–57.

van den Bergh, J. C. and Bruinsma, F.R. 2008. *Managing the transition to renewable energy: theory and practice from local, regional and macro perspectives*. Cheltenham, UK: Edward Elgar Publishing.

van Rooijen, S.N. and van Wees, M.T. 2006. 'Green electricity policies in the Netherlands: an analysis of policy decisions', *Energy Policy*, 34, pp. 60–71.

van Siclen, S. 2004. *Germany: Regulatory Reform in Electricity, Gas and Pharmacies*, OECD Regulatory Reform Programme Reports.

van Vuuren, D., Nakicenovic, N., Riahi, K., Brew-Hammond, A., Kammen, D., Modi, V., Nilsson, M. and Smith, K. 2012. 'An energy vision: the transformation towards sustainability—interconnected challenges and solutions', *Current Opinion in Environmental Sustainability*, 4, pp. 18–34.

Velasquez, M. & Hester, P. T. 2013. An analysis of multi-criteria decision-making methods. *International Journal of Operations Research*, 10, 56-66.

Verbong, G. and Geels F. 2007. 'The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004)', *Energy Policy*, 35(2), pp. 1025–1037.

Vivid Economics. 2013. *Analysis of electricity consumption, electricity generation emissions intensity and economy-wide emissions*, report prepared for the Climate Change Authority, October.

Voß, J.-P., Bauknecht, D. and Kemp, R. 2006. *Reflexive Governance for Sustainable Development*. Cheltenham, UK: Edward Elgar.

Voß, J.-P., Smith, A. and Grin, J. 2009. 'Designing long-term policy: rethinking transition management', *Policy Sciences*, 42, pp. 275–302.

Waissbein, O., Glemarec, Y. and Bayraktar, H. 2013. *De-risking Renewable Energy Investment: A Framework to Support Policymakers in Selecting Public Instruments to Promote Renewable Energy Investment in Developing Countries*. New York: United Nations Development Programme.

Warren, B., Christoff, P. & Green, D. 2016. Australia's sustainable energy transition: The disjointed politics of decarbonisation. *Environmental Innovation and Societal Transitions*, 21, 1-12.

Watanabe, R., & Mez, L. (2004). The development of climate change policy in Germany. *International Review for Environmental Strategies*, 5(1), 109-125.

Wehrmann, B. 2017. Factsheet – Vote2017: German parties' energy & climate policy positions. Clean Energy Wire CLEW. Available at: https://www.cleanenergywire.org/factsheets/vote2017-german-parties-energy-climate-policy-positions accessed on 7/03/2018

Weidner, H. & Mez, L. 2008. German climate change policy: A success story with some flaws. *The Journal of Environment & Development*, 17, 356-378.

Weber, K.M. 2003. 'Transforming large socio-technical systems towards sustainability. On the role of users and future visions for the uptake of city logistics and combined heat and power generation', *Innovation*, 16, pp. 155–176.

Weishaar, S. 2007. The EU ETS: current problems and possible ways to move forward. Metro/University of Maastricht, 28.

Weiß, T. and Schulz, D. 2013. Germany: Overview of the Electricity Supply System and an Estimation of Future Energy Storage Needs, Helmut-Schmidt-University.

White, W., Lunnan, A., Nybakk, E. & Kulisic, B. 2013. The role of governments in renewable energy: The importance of policy consistency. Biomass and Bioenergy.

Whitmore, J., Hopkin, M., Hall, S. 2014. Carbon tax repealed: experts respond. The Conversation. 17 July 2014. Available at: https://theconversation.com/carbon-tax-repealed-experts-respond-29154 accessed on 3 May 2016.

Wigand, F., Amazo, A., 2017. *The German energy transition and the Polish energy system - Factsheet*, Ecofys 2017 in cooperation with Instytut Jagielloński. Available at: https://www.ecofys.com/files/files/ecofys-2017-the-german-energy-transition-and-the-polish-energy-system.pdf

World Bank. 2015. World Development Indicators: GDP growth (annual %) code NY.GDP.MKTP.KD.ZG. available at: http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG).

World Bank, 2016. World Bank's open data catalog – Germany country profile. Available at: http://databank.worldbank.org/data/Views/Reports/ReportWidgetCustom.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=DEU accessed on 30/1/2018.

Wright, M. & Hearps, P. 2010. Zero Carbon Australia 2020- Stationary Energy Plan. The University of Melbourne Energy Research Institute, Beyond Carbon Emissions.

Würtenberger, L., Bleyl, J., Menkveld, M., Vethman, P. and van Tilburg, X. 2011. Business models for renewable energy in the built environment. Written for the IEA-RETD.

Zachmann, G. 2007. A Markov switching model of the merit order to compare British and German price formation. Discussion papers, German Institute for Economic Research.

Zahedi, A. 2010. A review on feed-in tariff in Australia, what it is now and what it should be. *Renewable and Sustainable Energy Reviews*, 14, 3252-3255.

Zindler, E. & Locklin, K. 2016. Mapping the gap: The road from Paris Finance paths for a 2-degree future. Ceres and Bloomberg New energy Finance.