A Framework for Energy Policy Evaluation and Improvement Incorporating Quantified Social Equity

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PhD Thesis

A Framework for Energy Policy Evaluation and Improvement Incorporating Quantified Social Equity

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Abstract

This thesis is focussed on the relationship between energy policy and sustainability and how societal considerations, specifically equity can impact this relationship through a holistic evaluation of energy policy sustainability.

Chapter 1 provides an assessment of current approaches to evaluation of energy policy from the viewpoint of sustainability and an outline of energy policy approaches and goals in the case study nation of Australia is presented. Gap identification is undertaken bringing issues of social equity to the fore, and identifying the lack of quantitative evaluation undertaken to date. The need for a methodology to quantitatively measure social equity impacts and the need for an improvement in the policy making process not only in the case study nation but also more broadly, particularly in nations which share common energy policy goals and approaches is clarified as the key goal of the thesis.

Chapter 2 aims to address the issue of inconsistent approaches to energy policy making in the OECD which lead to unsatisfactory sustainability outcomes. This is achieved by identifying the nature and sustainability priorities of the energy policy making process in the OECD through Qualitative Content Analysis (QCA) of 8 OECD nation's energy policy processes, government documents and third party evaluation documents. The analysis identifies a congruous 'OECD representative' energy policy cycle and is able to extract specific weaknesses and inconsistencies leading to a suggestion for improvement in the form of a pre-implementation sustainability evaluation. It is proposed that this addition can improve the energy policy making process by allocating expertise and streamlining post-implementation evaluation processes engendering improved sustainability outcomes.

Chapter 3 provides a comprehensive analysis of the case study nation of Australia from the point of view of its energy policies, goals and resultant economic and environmental outcomes. The case study identifies strengths and weaknesses in the case study nation with regard to renewable energy deployment, achievement of intermediate goals and the flow on effects of these achievements. In addition to

extracting key environmental and economic impacts, the case study highlights emerging social issues which are exacerbated by certain energy policy mechanisms. The need for a measure of the level of impact on social aspects of sustainability is highlighted by the case study.

Chapter 4 builds on the energy policy findings from the OECD and Australian case study, developing a methodology to quantitatively measure the social aspects of sustainability. The 'Energy Policy Sustainability Framework' is proposed, bringing together energy system data, societal equity preferences, and energy policy scenario analysis using the case study nation of Australia in order to quantitatively measure the equity impacts of participation, electricity price increases, environmental improvement, subsidy allocation and employment alongside economic and environmental energy policy impacts to provide a holistic sustainability assessment, and to derive more efficient yet sustainable energy policies.

Chapter 5 outlines an Energy Policy and Social Equity Hearing, undertaken using respondents working in energy policy related roles in Australia. The hearing clarifies energy policy expert's views on social equity and its importance within energy policy as well as augmenting the equity impacts considered important in sustainability evaluations in order to test and improve the Energy Policy Sustainability Framework. Two additional equity factors of health and fossil fuel industry impacts are identified and incorporated into the comparative equity evaluation tool within the proposed framework, providing a more comprehensive view of the overall equity impacts resultant from energy policy implementation in Australia.

Chapter 6 provides a thorough sensitivity analysis of the comparative equity evaluation tool from both an equity factor weighting and conditional factor analysis point of view in order to test the tools robustness and the impact of exogenous factors.

Chapter 7 is the conclusions of the thesis and summarises the important findings obtained throughout, as follows:

1. Identification of sustainable policy development weaknesses in OECD nation's policy cycles.
2. The derivation of a revised policy cycle which incorporates pre-implementation sustainability evaluation.
3. The development of an energy policy evaluation framework which integrates social equity into energy policy evaluation.
4. The demonstration of social equity as an integral component of holistic energy policy sustainability evaluation and development.

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Important Abbreviations Used

Abbreviation	Full Form
CF	Capacity Factor
FiT	Feed-in Tariff
FTE	Full Time Employee
GHG	Greenhouse Gases
LCOE	Levelised Cost of Electricity
LGA	Local Government Area
LRET	Large-scale Renewable Energy Target
NEM	National Electricity Market
NSW	New South Wales
NT	Northern Territory
OECD	Organisation for Economic Cooperation and Development
PM	Particulate Matter
PV	Photovoltaic
QCA	Qualitative Content Analysis
QLD	Queensland
RE	Renewable Energy
REC	Renewable Energy Certificate
RET	Renewable Energy Target
SA	South Australia
SRES	Small-scale Renewable Energy Scheme
STC	Small-scale Technology Certificate
TAS	Tasmania
VIC	Victoria
WA	Western Australia

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1. Introduction

1.1 Background

This research is concerned first and foremost with the sustainability of energy policy. Sustainability is elegantly described by Campbell (1996) as a conflict between economic development, environmental protection and, equity and social justice. It is further suggested that a balance of these three factors defines sustainability (Wheeler, 2002). Whilst it is generally agreed that there are three key tenets or 'pillars' of sustainability, economic and environmental factors are the best understood. Because of their ease of quantification, economic and environmental factors have been the focus of sustainability evaluation and also of sustainability goals. This is most evident in the initiation of the 'sustainable development' movement at the Brundtland Commission in 1987, where the belief that the three tenets of social equity, economic growth and environmental maintenance are simultaneously possible, was expressed. In spite of this assertion, the final report stated that "economic growth is essential… but that there should be a switch to 'sustainable development', which would be environmentally sound" (adapted from Du Pisani, 2006). From its origins, the idea of sustainable development has been focused on the readily understood and measurable economic and environmental tenets of sustainability.

Additionally, the Brundtland Report states that 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development, 1987). This assertion suggests that sustainability should be considered from an intergenerational point of view. It is apparent that from the beginning of the transition from previous development approaches to a sustainable development approach that these ideals have guided the way nations plan and measure sustainability.

Based on this lack of social equity consideration within sustainability, a technique is required to bridge the difference in the nature of economic, environmental and social equity aspects of sustainability. In order that social equity aspects of sustainability can be incorporated into the concept of sustainable development, they are required to be quantifiable in order to be interchangeable with the existing aspects. Without a quantification of social equity aspects in terms of the environment and economy, they will remain external to quantitative sustainability evaluations, relegated to a secondary level of concern.

With regard to the current inter-generational focus of sustainability evaluations, this thesis is focussed on energy policy which by its design, goal timelines and the length of political cycles which create it needs to be considered intra-generationally so that the current generation can benefit from more equitable and effective energy policy. If intra-generational equity is maintained from policy cycle (or policy goal timeline) to policy cycle, it follows that inter-generational equity will also be maintained and improved.

The novel contributions of this thesis aim to incorporate social equity considerations quantitatively into sustainability evaluation in order to improve energy policy making processes and their outcomes. The benefits of this new approach will improve sustainability and societal equity, firstly for the current generation and then, incrementally over successive policy approaches, for future generations to come.

1.2 Thesis Focus

This thesis focusses on energy policy, the processes which underpin policy development and the holistic evaluation of energy policy sustainability performance, including not only economic and environmental aspects, but also a quantitative appraisal of the social impacts of energy policy implementation.

The key point that this thesis seeks to address is the lack of quantitative assessment undertaken with regard to the social aspects of energy policy sustainability. The investigation of recent approaches to sustainability evaluation provides the evidence base on which this gap in quantitative evaluation is established. The evidence shows that in all cases, the environmental and economic factors of sustainability are readily quantifiable and broadly agreed upon across national borders and within international frameworks, however the nature of social factors considered within these same assessments are almost exclusively qualitative in nature. As the goal of this research is to bring all three aspects of sustainability into a holistic evaluation, there is a need to express them synonymously. In order to achieve this, the approach taken uses the distribution of costs and benefits across societal layers (income levels) as an expression of quantitative social equity. This approach is reasoned upon the basis of the energy justice tenets of distributional justice and justice as recognition, explained in detail within the literature review.

The thesis' case study nation is Australia, however the investigation of policy processes, policy issues and sustainability priorities goes further than an investigation of just this one nation and includes a thorough investigation of a selection of Organisation for Economic Cooperation and Development (OECD) nations in order to find commonalities and contrasts in energy policy approach and to assess the applicability of the findings and methodologies outlined in this thesis.

Within the OECD, Australia is a resource rich country which has enjoyed moderate to high levels of energy security in terms of fossil fuels, natural gas, and the electricity market (Department of Resources, Energy and Tourism, 2011). However, due to an abundance of fossil fuels, Australia's greenhouse gas emissions are among the highest in the world per capita (including emissions from land use, land use change and forestry; Garnaut, 2006).

The challenge to transition the energy sector to include lower greenhouse gas intensive options and to increase renewable energy deployment in order to generate a greater portion of the fossil-fuel dominated electricity supply has been identified as one of the key risks to Australia's energy security into the future (Department of Resources, Energy and Tourism, 2011). In order to address this risk, Australian Federal and State governments have introduced a raft of energy policies, primarily in order to reduce greenhouse gas emissions and to transition to renewable energy (RE) generation sources. These energy policies often use economic tools or subsidisation in order to achieve policy goals. As a result of the subsidisation of preferred renewable energy and low carbon technologies, a series of economic, environmental and societal issues are imparted.

From a social point of view, two of the most prominent issues which were considered directly relevant to energy policy evaluation and improvement were, firstly, the impact of feed in tariffs (FiT) on electricity prices, most heavily impacting low income households, and the barriers to participation in subsidisation schemes, including the pre-requisite of home ownership and financial capacity for initial investment.

Changing FiT settings, introduction of RE-specific low interest loan products and the introduction of new, innovative methods of participation in the deployment of renewable energy (e.g. community wind or solar farms) which avoided the use of such subsidization approaches suggested that societal equity was being impacted negatively by existing energy policies in Australia. This was also the case more broadly, particularly in the OECD in which many of the same policy measures are used, and similar social issues are being faced. It is for these reasons that a measure of the level of these social impacts is considered important as part of policy sustainability performance evaluation.

In order to clarify the role and importance of equity within energy policy development, it is essential to consider how equity is defined, and how it has been assessed in policy evaluation processes to date. The literature review in this chapter seeks to identify the current research regarding equity and sustainability analysis, and to identify the gaps which this thesis seeks to address. Equity will also be clearly defined for the purposes of this research and to facilitate the establishment of a method which will quantitatively measure equity in an overall assessment of the efficacy and, by incorporating equity, the sustainability performance of renewable energy policies in Australia.

The literature review is broken into two parts: firstly, an overview of Australian renewable energy policy and goals, and secondly, an investigation of pertinent research with regard to defining and evaluating equity in order to comprehensively assess energy policy sustainability.

1.3 Literature review

1.3.1 Defining Equity and Evaluating the Sustainability of Energy Policy

To date, many scholars have assessed RE policies and technologies considering economic, environmental and to some degree social measures to determine their efficacy and contribution to sustainability outcomes. For example, Liu et al (2013, 2014) propose a general sustainability indicator of RE systems, using Grey Relational Analysis (analysis which seeks to provide system solutions from various information sources with varying levels of veracity) and a triple bottom line approach. Whilst this work cites and recognizes the importance of the environmental, economic and social dimensions of sustainability in an energy system, the prioritization process gives precedence to environmental and economic factors, which both contain numerous (positive and negative) indicators. Social sustainability factors analysed include only two factors (both positive): the number of households benefited and new job numbers. In addition, these social factors are weighted overall at 0.0056 (less than 1%) of the overall sustainability index causing their impact to be insignificant on the final result.

Dombi et al (2014) also propose a method to assess the sustainability of renewable electricity and heat generation technologies using a multi criteria analysis and choice experiment to establish a priority for the technologies assessed. The use of qualitative measures across environmental, economic and social factors is laudable, however in this case study, social factors considered only include new jobs and local income, suggesting that social attributes of sustainability are only positive, do not contain equity measures, and are easily contrasted across scenarios. The joint use of techniques such as multi criteria analysis and choice experiment methods to determine systemic sustainability is well supported (Roche et al, 2010, Beria et al 2012), however it must also be recognized that multi criteria analysis such as the Analytical Hierarchy Process (AHP) (Saaty, 1977) are expected to produce reliable results when a diverse range of stakeholders are engaged (Yavuz and Baycan, 2013, Delgado-Galvan et al, 2014). In Dombi et al.'s study, 172 Hungarian professionals associated with ecological economics or environmental policy were selected for a choice experiment to rank RE system scenarios. This selection method does not represent a diverse group of stakeholders, and therefore outcomes of sustainability priorities are skewed according to a single group's point of view.

Evans et al (2009) in their assessment of sustainability indicators for RE technologies propose that sustainability is equally influenced by environmental, economic and social impact indicators. The economic and environmental factors assessed are inclusive, utilizing quantitative, well referenced data. Social impacts however are relatively arbitrary and represent only one seventh of the total sustainability score. The sub factors of social impact are qualitative, covering aspects of: amenity (noise, visual and odour), toxins, seismic activity, river damage, displacement, pollution and agricultural impact, all measured on a scale of minor to major. It could be argued that some of these sub factors are actually environmental concerns, and none of them are representative of equity. The technologies of wind, hydro, geothermal and solar PV are compared and ranked across seven factors of price, emissions, limitations, efficiency, land use, water consumption and the combined factors grouped as social impacts. Notwithstanding the limitations of the methodology proposed, the results are not significantly influenced by social factors in the overall appraisal of sustainability across RE technologies.

Although many authors use similar terms including sustainability, social impacts and equity, these words are often used inconsistently and conceptual confusion abounds (Ikeme, 2003). Whilst there is general agreement that sustainability consists of interdependent economic, environmental and social factors (IAEA, 2005, UN, 2005, Wheeler, 2002, Campbell, 1996) - equity (a key social consideration of sustainability) is the least understood, and given the least amount of attention (Tol, 2001). This may be for a number of reasons, not least of which is that terms associated with equity, such as 'fairness' are too vague to be agreed upon by all stakeholders (Been, 1993).

In addition to these academic appraisals of policy sustainability performance, international frameworks have also been assessed in order to clarify common factors which are currently evaluated within multilateral energy policy assessment.

The five frameworks chosen for their multinational collaborative nature and linkages between publishing authorities include:

1) 'Indicators of Sustainable Development' developed by the United Nations Commission on Sustainable Development (CSD), 2) 'Inclusive Green Growth – The Pathway to Sustainable Development' developed by the World Bank, 3) 'Contribution of Working Group III to the Fourth Assessment Report of the

Intergovernmental Panel on Climate Change' (IPCC), 4) 'Energy Indicators for Sustainable Development: Guidelines and Methodologies' provided by the International Atomic Energy Agency (IAEA), and 5) 'Sustainable Energy for All (SE4All) Accountability Framework', developed in partnership between the United Nations and the World Bank.

There are many linkages between each of these documents, ranging from direct partnerships, a common platform for the definition of sustainable development between the OECD, United Nations Environmental Program (UNEP) and the World Bank, to joint reporting over time to the United Nations Department of Economic and Social Affairs by both the UN CSD and the IAEA. Additionally, IPCC reporting shares intergovernmental linkages with both the UNEP and the World Meteorological Organisation, as shown in Figure 1.1.

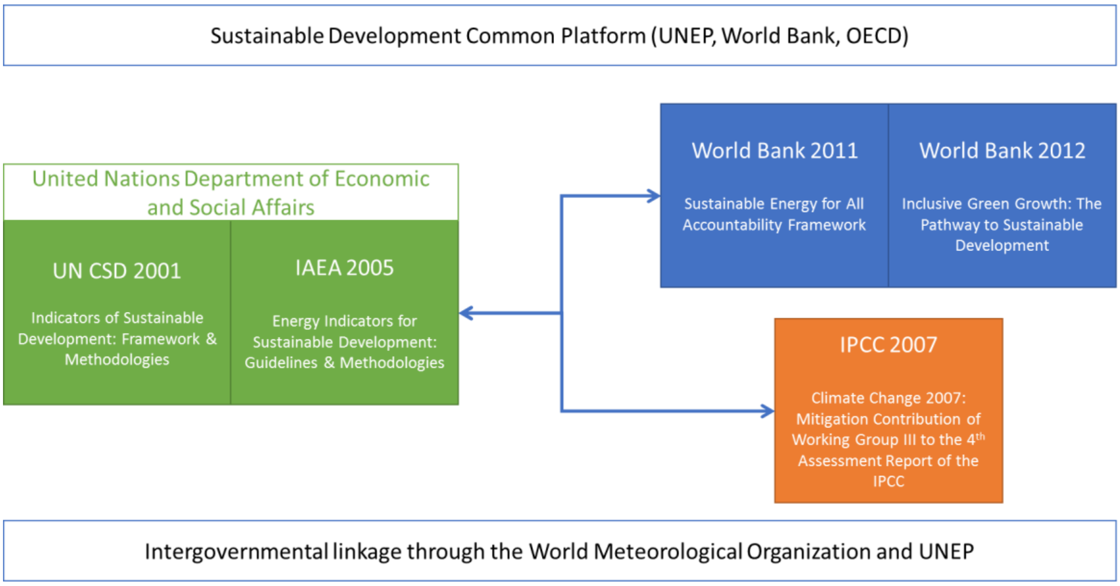


Figure 1.1 Linkages of Selected Sustainable Development Publications

The assessment of these frameworks and reports in this research aims to identify the common factors which can be quantified (and distributed) across environment, economy and equity in order to analyse the sustainability of energy policy. A brief summary of the assessed frameworks and reports is detailed below.

UN CSD Framework (2001)

The UN CSD Indicators of Sustainable Development Framework is focussed on providing guidance for decision making concerning sustainable development at the national level. The framework divides sustainable development indicators into the four broad categories of Social, Environmental, Economic and Institutional. In this research, the policies or institutional aspects are considered exogenous to the idealised policy sustainability framework, as the policy is considered to be the genesis for impacts which can be measured societally, environmentally and within the economy.

IAEA Energy Indicators for Sustainable Development (2005)

The IAEA publication defines a set of Energy Indicators for Sustainable Development and corresponding methodologies and guidelines. The publication was developed as part of an international collaboration between the IAEA, the UN Department of Economic and Social Affairs, the International Energy Agency, Eurostat and the European Environment Agency. It aims to provide end users with a consensus by leading experts on definitions, guidelines and methodologies for the development of energy policies which are in line with the UN definition of sustainable development; "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).

World Bank Sustainable Development Report (2012)

The World Bank inclusive green growth report declares that "inclusive green growth is the path to sustainable development" and further suggests that economic growth has increased income levels and lifted millions out of poverty. However, this economic growth is not without cost, and due to market, policy and institutional failures, this cost is most often borne by the environment, threatening the sustainability of economic growth and social welfare alike. This report also espouses the three sustainable development pillars of economy, environment and society, and suggests that policies must be designed in order to maximise benefits for and minimize costs to the most vulnerable sectors of society.

IPCC Climate Change Mitigation Report (2007)

As described in Figure 1.1 the IPCC report presents an assessment of existing scientific, technical and socioeconomic literature to the intergovernmental body established by the World Meteorological Organisation and the UNEP, in order to provide policy makers with objective scientific and technical findings in order to guide policy development. The key goal of this report is to assist in the mitigation of climate change through an in depth analysis of the costs and benefits of such mitigation, or avoidance. The assessment is broad so as to include the relationship between sustainable development and climate change mitigation.

UN and World Bank SE4All Accountability Framework (2011)

The SE4All Accountability Framework, launched in 2011 is a framework for global monitoring and reporting of three key sustainability objectives of energy access reach, the share of renewables and the rate of improvement in energy efficiency. The framework consists of two streams, firstly a global biennial assessment of progress on the three stated goals, and secondly an accountability framework at the level of individual commitments. These commitments are self-imposed but contribute to the three main goals in a bottom up fashion. By tracking progress at both a global and individual level, the agenda for action can be effectively updated to address changing global and national needs, and to maintain the relevance of the initiative to 2030 and beyond. Table 1.1 summarises the assessed reports' environmental, economic and social (equity) factors which make up each sustainability assessment framework.

In the case of environmental and economic policy sustainability factors, the academic papers, reports and frameworks all broadly agree on the nature of factors which are relevant, measurable, and important to establishing the efficacy of energy policy; i.e. the ability of an energy policy to achieve the desired result (e.g. a reduction in GHG emissions, progression of the learning curve), at the best cost (of implementation, effectiveness and incentives), or with the greatest positive impact on the economy (usually in terms of GDP). We can also observe some crossover between these two categories. With regard to social factors we also see some clear linkages and crossover with economic and environmental factors, however, the majority of these factors are concerned not only with the quantifying of impacts, but also with the distribution of these impacts across society.

In addition to academic and institutional assessment of sustainability, an examination of energy justice as a concept is beneficial, in order to clarify the concept of equity within energy policy and to highlight one of the focuses of this thesis.

Table 1.1 Framework and Report Identified Sustainability Factors Summary

Author, Year	Environmental	Economic	Social (Equity)
UNCSD, 2001	GHG emissions Ozone Layer depletion Air pollutants	GPD/capita impacts Energy Consumption Percentage of RE	Gini index of income inequality Unemployment rate
IAEA, 2005	GHG emissions Air pollutants Land and water quality impacts of energy use	Supply efficiency Energy use per capita & unit of GDP Reserve & resources to production ratio Sector energy intensity Energy supply fuel mix & RE % Energy prices & subsidies Energy imports	Share of household income spent on fuel and electricity Household energy use for each income group
World Bank, 2012	GHG emissions Resource management Air and water quality	Efficiency of RE Dissemination of RE Increase in GDP Energy intensity of production Learning curve	Job creation & dist. Poverty reduction Access to improved quality resources
IPCC, 2007	GHG emissions Climate change impacts Technology selection	Government incentives Market impacts Cost of implementation Cost-effectiveness Technology funding	Level playing field Allocation of funds Access to information Participation Bearing of costs
World Bank & UN, 2011	Share of renewables[1] Environment and climate change Water and related ecosystems Agriculture, aquaculture & forestry	Rate of improvement of energy efficiency[1] Job creation and enterprise development Trade and development Financial accessibility & management	Reach of energy access[1] Children, youth, and family welfare Community development Disability issues Health issues

[1] Main, required goals of the framework. Others listed are optional goals

Following on from the environmental and climate justice movements, energy justice has emerged as a concept which isolates energy issues from the wider range of topics examined in within environmental and climate justice (Fuller and McCauley, 2016). Energy justice is concerned with the three tenets of distributive justice, justice as recognition and procedural justice.

Distributive justice, which is the main theme of this thesis, is concerned with the distribution of benefits and ills, or burdens of energy projects and policy across society – including resources, wealth, pollution and poverty (Heffron et al, 2015, Sovacool and Dworkin, 2015). This thesis investigates equity issues associated with the energy system, along with the economic and environmental conditions which engender them (Sovacool and Dworkin, 2014).

Justice as recognition is concerned with the recognition of social, cultural, ethnic, racial and gender differences and to ensure that none of these groups are misrepresented, disrespected, degraded or devalued in comparison to others (Heffron et al, 2015, Jenkins et al, 2016). Section 4.2 of this thesis identifies some justice as recognition issues in Australia which require redress as part of an overall assessment of equity preferences, however the assessment tool only goes as far as the recognition of different income levels and home ownership impacts.

Finally, procedural justice is concerned with the meaningful engagement of all stakeholders and communities and the provision of unfettered access to government and industry information, in order to affect the policy decision making process (Heffron et al, 2015, Jenkins et al, 2016). Although procedural justice is touched on in this thesis, it is a topic for future research, specific to the improvement of the policy making process, rather than the evaluation of energy policies directly; recognizing that there is no single technical fix to the problems of energy injustice and that remedy must be sought through a combined social, political, economic and material approach (Bickerstaff et al, 2013).

This research assesses social equity intra-generationally, specifically considering the distribution of benefits and burdens as a result of differing energy policies, who benefits from this distribution, and how costs and burdens should be distributed (Sovacool and Dworkin, 2015).

1.3.2 Australian Renewable Energy Policy

Australian renewable energy policy is currently guided by the Renewable Energy Target (RET) which has three broad goals:

1. To encourage additional renewable-based electricity generation, ensuring that renewable energy sources are ecologically sustainable;
2. To reduce GHG emissions in the electricity sector; and,
3. To promote renewable energy industry development (Clean Energy Regulator, 2012).

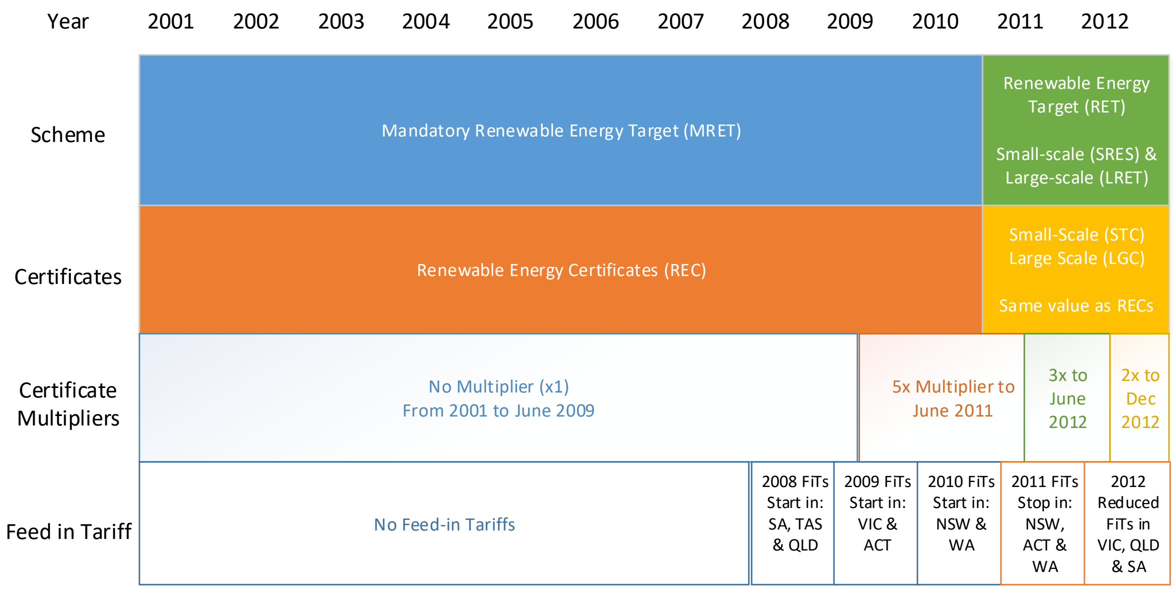
Prior to the RET, the initial renewable energy target established in Australia was the Mandatory Renewable Energy Target (MRET) which began in April 2001. The MRET was a federal target to be achieved by the subordinate State governments through additional generation of electricity from ecologically sustainable renewable sources and a reduction in greenhouse gas emissions (Renewable Energy (Electricity) Act 2001, s3). The MRET created a new entity, known as the Office of the Renewable Energy Regulator, responsible for accrediting renewable energy generators and allocating Renewable Energy Certificates (RECs; equivalent to one megawatt hour of renewable energy anticipated to be generated under specified modelling conditions) to each generator. These RECs are allocated for the life of the technology and can be claimed as a cash incentive (usually at point of purchase) in addition to financial benefits gained from generating or displacing grid-supplied electricity. These RECs are then purchased by electricity retailers and large electricity customers to meet their 'mandatory' renewable energy acquisition targets (Kent and Mercer, 2006).

From 1 January 2011 the MRET was renamed the Renewable Energy Target (RET) operating in two parts; the Large-scale Renewable Energy Target (LRET) and the Small-scale Renewable Energy Scheme (SRES). These two parts are operated individually to ensure that the LRET encourages the deployment of large scale renewables such as wind farms, whilst the SRES aims to increase the deployment of small scale renewable technologies such as solar photovoltaic (PV) panels and solar hot water heaters (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, 2011).

The RET aims to deliver at least twenty per cent of Australia's electricity from renewable sources by 2020, with 41 TWh of electricity generation to be sourced from large scale renewable energy sources, and to provide long term support for renewable energy industries through to 2030. The mechanisms in use to achieve these goals are modified RECs, called Large Generation Certificates for large-scale renewable energy generation and Small-scale Technology Certificates (STC) for small-scale renewable energy generation. STC's are issued for solar panel systems at the time of installation for 15 years of expected system output (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, 2011).

Prior to 2013, an additional financial benefit was available to installers of solar panels in the form of solar credits. Solar credits applied to the first 1.5 kilowatts (kW) of capacity installed and multiply the amount of STC's which can be issued. From 9 June 2009 to 30 June 2011, STC's were multiplied by five, from 1 July 2011 to 30 June 2012, STC's were multiplied by 3, and from 1 July 2012 to 31 December 2012, STC's were multiplied by 2. On 1 January 2013, the multiplier was removed, 6 months ahead of schedule (Clean Energy Regulator, 2012). Figure 1.2 outlines the schemes applicable to residential PV, and REC multipliers offered in Australia between 2001 and 2012. These multipliers were applicable at the time of purchase in the form of an additional point of sale rebate, during the stated periods.

In addition to the federally operated REC and Solar Credit Schemes, Feed-in Tariffs (FiTs) were introduced in 2008, administered by State governments as an additional incentive for householders to install rooftop PV. The FiTs varied in each state and were either offered as a gross FiT, where all electricity generated in the household is purchased at a set tariff, or as a net FiT, where only the electricity which is generated in excess of household consumption is purchased. The net FiT was most popular with the States, and sought not only to reward installers for the value of their exported solar electricity but also to encourage people to use electricity in the household outside of generation times in order to yield the greatest benefit from tariff payments. FiTs began at a generous 44 cents per kilowatt hour (net) in Queensland on 1 June 2008 (QCA, 2013) and in South Australia on 1 July 2008 (DMITRE, 2013), and a payment equivalent to the price of electricity in Tasmania through a single energy supplier (Aurora Energy, 2014). On 1 January 2009 Victoria introduced their FiT at 60 cents (DSDBI, 2014), and the Australian Capital Territory introduced the first gross FiT at 50.5 cents (ESDD, 2013). The last two States to introduce an FiT were New South Wales at 60 cents gross on 1 January, 2010 (NSW Trade and Investment, 2013) followed by Western Australia on 1 July at 40 cents net (WA Department of Finance, 2013). No centrally administered Territory-wide FiT was established in the Northern Territory (Access Economics, 2008).



Guide:

- In 2011, the MRET is renamed the RET; consisting of small-scale (SRES) and large-scale (LRET) targets.
- RECs are renamed to STC and LGC for small and large scale RE. Their value, and deeming as a point of sale rebate are unchanged.
- In June 2009, Solar Credits were introduced to multiply the number of RECs receivable for the first 1.5kWp of small-scale RE.
- Feed-in tariffs were introduced in 2008, and reduced over time (except TAS) or ended.

Figure 1.2 Renewable energy schemes and REC multipliers 2001-2012

Some states have their own renewable energy targets, which are supported by these FiTs, alongside other generation technologies. Tasmania has the most audacious goal of 100 per cent renewable based generation by 2020 (Reneweconomy, 2013). South Australia's goal is to generate 50 per cent of its electricity from renewable sources by 2025 with Queensland having an identical target by the year

2030 (Solarchoice, 2015). Other Australian states and the Norther Territory do not have individual goals, but report in alignment with the national target of 20 per cent generation from renewables by the year 2020. Table 1.2 outlines the introduction timeline and changing levels of FiTs across Australia. The FiTs shown are specific to the timing of solar installation, and vary in contract period. For example, a system installed in Queensland in 2008 is eligible for the 44 cent FiT until 2028, whereas one installed after 10 July 2012 is only eligible for the 8 cent FiT.

Table 1.2 Feed-in Tariffs in Australia 2008-2012

State	2008	2009	2010	2011	2012
SA	44c	44c	44c	44c ⇨ 16c (1 Oct)	16c
WA	No FiT	No FiT	40c	40c ⇨ 20c (1 Jul) ⇨ Closed (1 Aug)	No Fit
TAS	1 for 1	1 for 1	1 for 1	1 for 1	1 for 1
VIC	No Fit	60c	60c	60c	25c
NSW	No Fit	No Fit	60c Gross ⇨ 20c Net (27 Oct)	20c ⇨ Closed (28 April)	No Fit
ACT	No Fit	50.5c	50.5c Gross ⇨ 45.7c (1 Jul)	45.7c ⇨ Closed (30 May)	No Fit
QLD	44c	44c	44c	44c	44c ⇨ 8c (10 Jul)

(Notes: ⇨ shows a change in tariff, '1 for 1' means that the tariff is equal to the price of electricity)

Australia has one of the highest average solar irradiation levels of any continent in the world, approximately 58 million petajoules (PJ) per annum, equivalent to 16 trillion megawatt hours (MWh) per annum (Byrnes et al, 2013).Within the National Electricity Market (NEM), a one kilowatt household PV system has an average generation potential of 1460kWh per annum. Australian households can realise significant benefit from the deployment of solar technologies, and have proven to be very responsive to financial incentives for the deployment of PV (Access Economics, 2008) including RECs and FiTs as administered by State and Territory Governments.

A number of studies have critiqued the RET; in particular its overall success in achieving in excess of the targeted 9500 GWh of new renewable energy by 2010, achieved predominantly by large scale wind, followed by residential scale PV. This trend is likely to continue; under the RET, it is likely that Australia will be able to source a quarter of its electricity needs from renewable sources, mainly from wind and existing hydro-electricity resources by 2020 (Elliston et al, 2014). Whilst this current, and potential future achievement of significant renewable energy electricity supply has positive environmental ramifications, it has been identified as having an unequal impact on wholesale and retail electricity prices, with energy intensive industries who are partially exempt from RET costs enjoying lower electricity prices at the expense of households who generally pay a RET pass-through cost (i.e. 'green' surcharges on electricity bills) without a price reduction benefit (Cludius et al, 2014).

Australia is identified as a prime candidate for support to expand renewable energy sources to reduce reliance on a predominantly coal-fired, relatively cheap electricity supply (Moosavian et al, 2013; Zahedi, 2010); which is one of the key causes of Australia being the highest per capita GHG emitter in the developed world (Bahadori et al, 2013). In fact, due to Australia's reliance on coal-fired power, the electricity generated within the NEM is responsible for approximately one third of all national emissions (Garnaut, 2011). In spite of this need, and the opportunity to reduce GHG emissions via renewable energy deployment, PV has proven to be a high generation cost energy source (Effendi and Courvisanos, 2012), which requires generous support mechanisms to be competitive with fossil fuel generation sources (Buckman and Diesendorf, 2010). In addition, small scale PV is partially subsidised by state FiTs which are funded by all electricity customers within the local network. This has been shown to cause cross-subsidisation from non-solar households to solar households in the form of increased electricity bills. Further, as home ownership is a key criterion for the installation of solar panels, electricity customers who do not own their own home cannot take advantage of either the REC or FiT subsidies (Nelson et al, 2011).

Macintosh and Wilkinson (2011) assessed the public benefits of solar subsidies to 2010, and found that although government intervention did rapidly increase deployment off an almost zero base, the overall environmental impact was low, with an insignificant contribution from PV to grid based electricity, with a very high cost of CO_2 abatement. Further, the mechanism implemented, the REC, in combination with Solar Credit multipliers and the attribution of RECs to non-generating technologies (Solar hot water systems) caused a phantom supply (i.e. a significant number of RECs above and beyond the actual renewable energy generating capacity installed), which lead to a subsequent depression in the value of each REC. This may have reduced investment in small scale renewable energy.

Further, Simpson and Clifton (2014) suggest that this excess generation of RECs lead to retailers purchasing sufficient certificates to cover their RET liability for many years, further depressing the price of RECs, effectively stalling large scale investment for many years into the future. Valentine (2010) also investigated this phantom REC generation issue supporting small scale renewable technologies, and also criticises the RET as being too short, ill-structured and having insufficient generation targets out to 2020, (and no clear post 2020 support path) suggesting this regime is unlikely to stimulate large scale, long term investment.

The crowding of the REC market by small scale generators was somewhat rectified by the separation of the RET into the SRES and LRET, with separate generation targets and certificate types, however, stockpiles of RECs held by liable parties are estimated to stall investment in large scale generation out to 2015/16. Further, it is clear that each REC multiplier reduction caused large spikes in sales, leading to a decreased value of RECs, and a reduction in quality of system installations due to time constraints at the end of each multiplier period. Also, following each spike installers experienced uncertainty due to low installation rates and in some cases insolvency (Simpson and Clifton, 2014; Buckman and Diesendorf, 2010).

It became apparent that Australia's three level (local, State and Federal) governmental system caused an overly complex regulatory and policy framework for the administration of the RET. This was shown to have negative outcomes ranging from a socially sub-optimal incentive system with disparate motivations for policy development and intervention, and due to the complexity of this system, difficulties arose for the integration of new technologies and participants (Byrnes et al, 2013). A pertinent example of this is the state of Queensland, the major installer of PV in Australia.

Martin and Rice (2012) undertook stakeholder analysis to identify barriers to the development of renewable energy in Queensland, and identified that in the case of small scale generation such as PV, an inconsistent or unclear generation target and inconsistent levels of support were detrimental. Further, stakeholder analysis showed that Queensland's (and indeed Australia's) abundance of cheap coal fired power along with complex multi-tiered government approvals and lack of a skilled workforce were also barriers to developing the renewable energy supply. Additionally, an assessment of installations to the end of 2010 showed that two thirds of applicants to the program were from medium high, or high socio-economic status households (Macintosh and Wilkinson, 2011).

1.3.3 Identified Gaps and Purpose of Research

It was identified that Australian policies encouraged new RE deployment, however a significant portion of this new RE capacity has been made up of small scale, residential PV due to specific subsidisation regimes. The impact of such a deployment balance requires further investigation from a sustainability point of view which also considers social equity impacts. Additionally, residential PV installations exceeded State targets causing FiT and REC subsidisations to be reduced ahead of schedule, suggesting excessive cost impacts. The efficacy and equity impacts of these subsidisation regimes need to be investigated, and in addition the policy making process which engendered these negative outcomes need to be evaluated.

The sustainability of energy policy outcomes to date has predominantly been assessed based on economic and environmental factors, with social factors, especially equity overlooked or undervalued. It is contended that the assessments of renewable energy and renewable energy policy approaches reviewed within the energy policy realm represent a measurement of efficacy – the ability of a policy to achieve a result, and efficiency – to achieve this result at the best cost.

Further, gaps in current scientific knowledge have been made clear, particularly with regard to the quantitative incorporation of social equity into sustainability assessments, and also to an agreed set of values which define equity.

Equity is an important consideration within sustainability evaluation, often overlooked or considered inferior to economic or environmental concerns, as evidenced by the review of current approaches to assessment of energy policy and energy technology sustainability. An insufficient consideration of equity can lead to inequitable outcomes within society, and a measurable gap between the efficacy and overall sustainability of policies. By incorporating equity considerations into the policy evaluation process, more equitable policy can be developed. By improving economic, environmental and equity outcomes in a complementary manner, it follows that policy sustainability will also be positively impacted.

This thesis seeks to deal with the identified issues and gaps in knowledge, with the final goal of the study being to enable the development of evidence based energy policy which can meet policy targets whilst maintaining or improving societal equity. The layout of the thesis is as follows:

- Chapter 2 explores the energy policy in eight OECD nations from a governance, policy process and sustainability priority point of view. The eight nations chosen are nations which have a high level of income inequality and differing systems of government. Through the use of the Qualitative Content Analysis methodology, a broadly similar energy policy process is established in terms of policy goals, and the tools in place to achieve them. Building on these findings and an investigation of sustainability priorities in the explored nations, energy policy process weaknesses are identified. The remedy of an additional policy cycle stage which incorporates a policy sustainability pre-evaluation process is proposed in order to address these weaknesses. This proposal is tested theoretically in the case study nation of Australia in Chapter 4.
- Chapter 3 provides a detailed analysis of a specific energy policy in Australia: RE policy from 2001-2012, focusing on the subsidisation mechanisms of Feed in Tariffs and Renewable Energy Certificates. This chapter identifies the policy impacts of these subsidisation mechanisms in terms of RE deployment, employment, market, subsidisation settings and environmental benefits. Based

on the findings, an exploration of social impacts which have arisen as a result of recent RE policies in Australia is also undertaken. As with the findings of Chapter 2, the findings of this chapter are also built upon in Chapter 4.

- Chapter 4 is the central part of the thesis, and builds upon the preceding chapters through the establishment of an energy policy sustainability evaluation framework. The aim of the framework is to guide the policy maker in the evaluation of the national energy system, equity issues and preferences in order to inform evaluation criteria for the appraisal of multiple energy policy scenarios. Further, the appraisal of existing and a non-stimulatory policy approach lead to the development of an alternative (learning based) scenario which aims to achieve policy goals and to improve societal equity as well. The framework includes a tool which evaluates energy policy scenarios from both an efficacy (environmental and economic performance), and from a social equity point of view. Through the establishment of a quantitative measure of relative equity and distribution of social burden, energy policy scenarios can be evaluated in an objective manner. Additionally, the framework can provide guidance for the policy maker as to the equity and efficacy trade-offs inherent in energy policy, and identify which energy system factors have the greatest impact on policy outcomes.

- Chapter 5 seeks to improve the applicability of the framework outlined in Chapter 4, through an Energy Policy and Social Equity hearing. The hearing identifies respondent's equity preferences, and two additional social equity impacts to be incorporated into the framework. In addition to detailing the responses to the hearing, this chapter outlines the nature of the two new equity impacts to be incorporated into the framework, and the methodology followed to achieve this. Following the establishment of a hearing supported Energy Policy Sustainability Evaluation Framework specific to Australia, social equity and efficacy results are re-evaluated.

- Chapter 6 tests the revised framework through a battery of sensitivity analyses including both factor weighting and conditional (exogenous impact) settings.

Figure 1.3 outlines the flow and interconnected nature of the thesis.

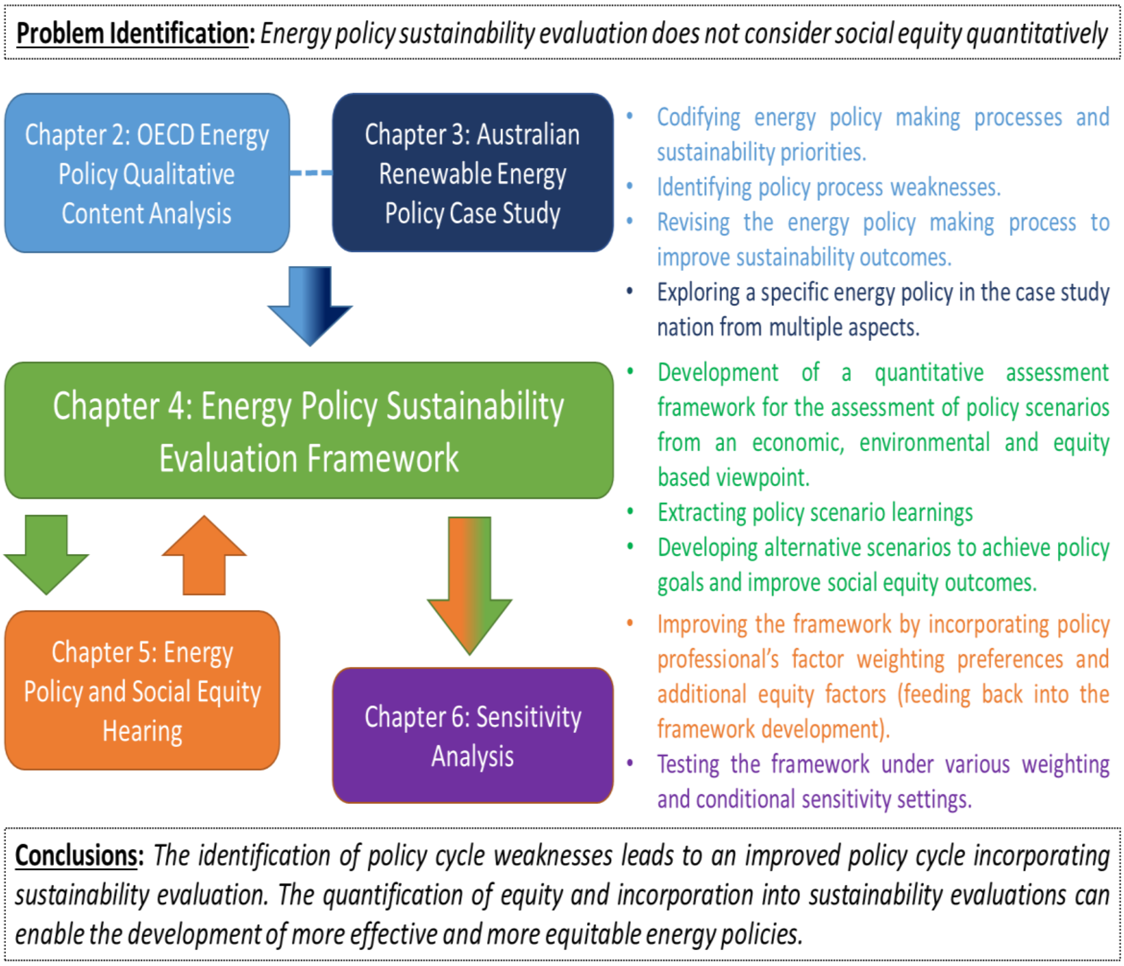


Figure 1.3 Thesis Flow Diagram

2. The Energy Policy Making Process in the OECD: Sustainability and Policy Design

2.1 Introduction

This chapter focuses on the energy policy making process, specifically with regard to addressing the effects of climate change and the associated transition to a larger share of renewable energy (RE) based generation. This is an important challenge being faced by many governments around the world, and labelled by the Organisation for Economic Co-operation and Development (OECD) as one of the most significant being addressed by the international community (OECD, 2015a).

The OECD incorporates 34 nations from around the world, from emerging countries through to the most advanced, with the mission of promoting policies that will improve the economic and social well-being of people and the goal of building a stronger, cleaner and fairer world. The OECD provides a forum in which governments can work together to share experiences and seek solutions to common problems in order to understand what drives economic, social and environmental change (OECD, 2016a).

This grouping of nations with common policy goals and a desire to develop policy which can be sustainable; incorporating the three aspects of economy, society and environment provides a suitable basis for research, comparison and ultimately improvement of sustainability outcomes resultant from the policy making process.

OECD nations account for approximately 41% of the world's greenhouse gas (GHG) emissions as a result of energy use, with a GHG intensity per capita approximately 2.5 times that of the rest of the world (IEA, 2012).

OECD nations which face the challenges of climate change have adopted a broad range of energy policies and policy tools in order to shift to a more sustainable energy system and to reduce climate change impacts. The policy tools in place across the OECD in order to meet energy policy targets include feed-in tariffs (FiT), RE or Green Certificates (REC), tax concessions and a number of other market-based instruments. Energy policy targets themselves have changed over time, often with a change of government, and a general inconsistency in energy policy approach is apparent in the OECD, evidenced by the large number of strategic policies and tools which have been employed over time within member nations (IEA and IRENA, 2016; LSE, 2015; IEA, 2012-2015).

This inconsistency may be due (at least in part) to shortcomings or unsuitable approaches to energy policy making within the OECD, (Chapman, 2016; Mundaca, 2013; White et al) which have led to the implementation of energy policies which were underdeveloped or poorly designed, with the weaknesses of these policies only being officially identified, and remediation begun post-evaluation, at the beginning of a new policy cycle. These approaches have led to less than optimal policy outcomes, not only in terms of the economy and environment but also with regard to the third pillar of sustainability; societal considerations.

This chapter seeks to address these issues by identifying the nature of the energy policy making process and national sustainability priorities within the OECD, and to identify any weaknesses with regard to sustainability outcomes inherent in these processes. Finally, the aim is to adapt these findings in order to develop an energy policy making process which prioritises policy design in order to maximise energy policy sustainability outcomes.

In order to achieve these aims, eight OECD nations, including four constitutional monarchies (Australia, The United Kingdom (UK), Canada and Japan) and four republics (the United States of America (USA), Greece, Chile and Mexico) are compared using a Qualitative Content Assessment (QCA, outlined in Section 3) process according to the policy cycle steps and policy sustainability priorities of each nation. These nations are chosen because of their comparatively high income inequality (evidenced by their respective GINI coefficients), suggesting that the social aspects of sustainability within their policy portfolios require additional attention in order to redress this issue.

The two hypotheses that the current energy policy development process is not robust from a sustainability point of view, and that policy mechanisms are poorly developed is investigated utilizing QCA, seeking to identify firstly whether or not the policy development process is consistent within the OECD, and secondly, how energy policy tools are formulated, implemented and evaluated within this cycle, and how well this process contributes to sustainable energy policy outcomes.

2.2 Public Policy Making Theory

The description of a 'policy cycle' dates back to 1956, initially proposed by Harold Laswell, incorporating the seven stages of intelligence, promotion, prescription, invocation, application, termination and appraisal (Jann and Wegrich, 2007). These stages have largely stood the test of time in public policy theory, however it is now generally agreed that appraisal follows application and that the overall process is cyclical and therefore excludes a 'termination' phase (Figure 2.2 visually describes this cyclical nature for a variety of nations). This may be because new policies are being developed in an already crowded policy environment, leading to policy succession rather than a wholesale replacement of policies already in place (Hogwood and Peters, 1983). Additionally, the policy cycle is deliberately iterative, in that evolving policy issues are addressed by a prescribed set of tools and activities over a period of time (Freeman, 2013).

Establishing that the policy making process is indeed cyclical and iterative, and includes discrete stages involving different actors and institutions in order to undertake deliberate problem solving, (Howard, 2005) the order and nature of these discrete policy making stages requires investigation. There is general agreement across the available literature that the policy process begins with agenda setting (also called problem or issue identification) and ends with evaluation before beginning anew (Howlett and Ramesh, 2003; Jann and Wegrich, 2007; Howard, 2005). The steps undertaken in between usually only vary in their nomenclature or level of separation. Table 2.1 gives a general overview of these steps and how they vary slightly dependent on the assessor's choice of terms. Figure 2.2 (see section 3.1) further reaffirms this commonality of steps and variety of granularity of nomenclature used across different nations. Each of the stages identified in Table 2.1 can subsequently be broken down into their constituent parts or sub-processes as follows.

Agenda setting or problem identification is the initial policy making step, and assumes the recognition of a policy problem. Although this stage of policy making is inherently political and not in the direct control of any single actor (Jann and Wegrich, 2007), it can occur in a bottom-up or top-down fashion, although it is unclear how successfully public opinion influences policy identification (Dye, 2008).

As there is limited capacity within society and political institutions to address all possible policy responses to identified policy problems, actors actively promote policy issues important to them in order to have them promoted to the policy agenda, and to remain prominent within the political debate (Birkland, 2007).

Table 2.1 Selected Overview of Policy Cycle Stages

Author	Howard, 2005	Howlett & Ramesh, 2003	Jann & Wegrich, 2007
Policy Cycle Stages	Agenda setting or problem identification	Agenda setting	Agenda setting: problem recognition and issue selection
	Analysis of the policy issue(s)		
	Formulation of policy responses	Policy formulation	Policy formulation and decision making
	Decision to adopt a specific policy response	Public policy decision making	
	Implementation of the chosen policy	Policy implementation	Implementation
	Evaluation of the policy	Policy evaluation	Evaluation and termination

Policy formulation, incorporating issue analysis includes the identification of policy proposals in order to resolve identified issues. This process occurs within government ministries, interest groups, legislative committees, special commissions and within policy think tanks (Dye, 2008). The policy formulation process precedes decision making, and is undertaken by policy experts who assess potential solutions and prepare them to be codified into legislation or regulation, along with initial analysis of feasibility, including but not limited to political acceptability and costs and benefits (Sidney, 2007). Policy experts are also responsible for interacting with wider society, their policy networks and other social actors undertaking consultation in order to further shape policy proposals. Once a policy proposal (or proposals) has been formulated, they are presented to decision makers, usually cabinet, ministers and Parliament, for consideration prior to implementation (Jann and Wegrich, 2007).

Implementation is the phase at which all of the preceding planning activity is put into practice (Howlett and Ramesh, 2003). Resources are allocated, departmental responsibilities are assigned and often rules and regulations are developed by the bureaucracy in order to create new agencies with the role of translating laws into operational procedures (Dye, 2008). The implementation phase is a technical process, whereby the 'street-level' bureaucrats need to interpret guidance from central authorities whilst providing everyday problem solving strategies in order to ensure a successful implementation structure (Pulzl and Treib, 2007).

Evaluation is the final stage of the iterative policy cycle, and policy outcomes are tested against intended objectives and impacts. In addition, an evaluation is made to determine any unintended consequences of policies, in order to establish whether a policy should be terminated or redesigned according to shifting policy goals or newly identified issues (Jann and Wegrich, 2007). The evaluation is undertaken by both governmental and societal actors in order to influence a reconceptualization of policy problems and solutions. This evaluation can be either administrative (managerial and budgetary performance), judicial (judicial review and administrative discretion), or political (elections, think tanks, inquiries and legislative oversight), or a combination of the three in order to influence the direction and content of further iterations of the policy cycle (Howlett and Ramesh, 2003).

Although a consensus can be established for the requisite stages of the policy making process, through this review of public policy theoretical literature, it is important to recognize that in some cases, policy cycle stages may be compressed, skipped, or enacted out of order (Howlett and Ramesh, 2003) and that deviations may occur within the proposed models (e.g. Althaus et al, 2012). This research attempts to be responsive to the fluid nature of the policy cycle by formulating research questions broadly across the policy cycle stages and using an analysis method which thoroughly describes each stage, as well as responsible bodies, capturing similarities between nations and also accounting for outliers or any irregularities between nations and their policy practices and priorities.

2.3 Methodology

QCA is used to evaluate policy making processes and priorities in the OECD. QCA is an organised, systematic analysis of text in order to reveal common elements, themes and patterns within procedures, and to interpret and make observations of assessed, relevant data. QCA can be used to assess a variety of social phenomenon, and in the past has been used to assess economic growth (Haapanen and Tapio, 2016), education (Gerbic and Stacey, 2005), nursing research (Graneheim and Lundman, 2004; Elo and Kyngas, 2007) and aesthetics (Cho and Lee, 2014) among others.

In this research, QCA is used to assess governance systems, policy processes and priorities across eight OECD nations. As data is readily available in the form of energy policy reports, academic papers and government publications, a deductive content analysis process is used (Marshall and Rossman, 2015) in order to assess key commonalities in the OECD policy development process and to discover any national peculiarities within these processes utilising 12 focussed research questions investigating governance, policy processes and policy priorities.

2.3.1 QCA Process Flow

In order to make a comparative analysis of governance, policy processes and priorities in the assessed nations, energy policy documentation (including policy targets, the development, implementation and review process) in the form of government documents and reports, third party and academic analysis is first collected and sorted by nation and type. In order to organise the data assessed and to identify similarities and any outliers, a structured categorization matrix is developed according to the key research questions to be clarified by this research.

Data extracted in response to the research questions from the sorted energy policy documentation is then incorporated into the categorization matrix, from which data can then be coded and summarised, identifying common and outlying themes in order to test the hypotheses stated in the Introduction. This is often an iterative process as new themes can also be identified throughout the data extraction process (Elo and Kyngas, 2007).

A visual representation of the stages of the QCA process flow is shown at Figure 2.1.

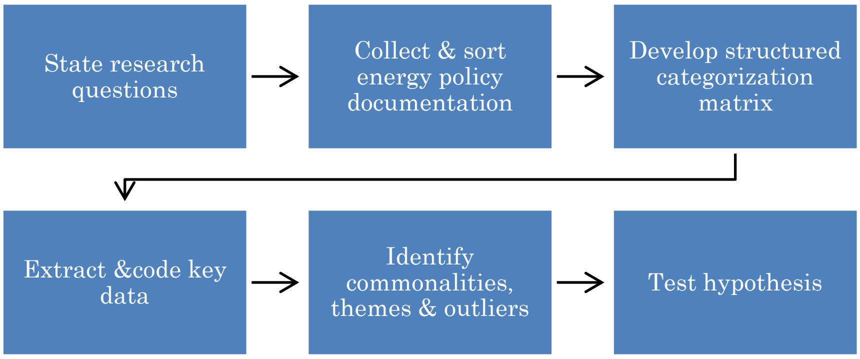


Figure 2.1 QCA Process Flow

2.3.2 Research Questions

The aim of the QCA process is to elicit the key factors of each evaluated nations policy making and governance structure and to identify policy priorities. These factors will be investigated through a series of research questions which are structured in order to derive conclusions which can assist in the development of a conceptual model of OECD governance, energy policy making processes and priorities. The questions are divided into two streams, the first of which assesses governance and policy making structures, and the second investigates the energy policy goals and sustainability priorities (across environmental, economic and social equity factors) within each assessed nation.

2.3.2.1 Governance and Energy Policy Making

The first set of questions (Governance and energy policy making) aim to elicit the energy policy making processes and responsible national government bodies in each jurisdiction.

Table 2.2. Governance and Energy Policy Making Questions

#	Research Question
1	What are the key government bodies responsible for energy policy development?
2	How and where are energy policy goals identified?
3	How are energy policy tools developed?
4	How is consultation undertaken?
5	How is energy policy implemented?
6	How and when is energy policy evaluated?

The questions are framed in order to identify the key national level governmental bodies which are responsible for the policy development process, and to elicit the key stages of policy making and how these are undertaken. The research questions identified in Table 2.2 are derived from theoretical approaches to policy making (discussed in detail in Section 2.2) which are broadly reflected in Australian, United Kingdom, United States and Provincial Canadian Policy Cycles, as shown in Figure 2.2.

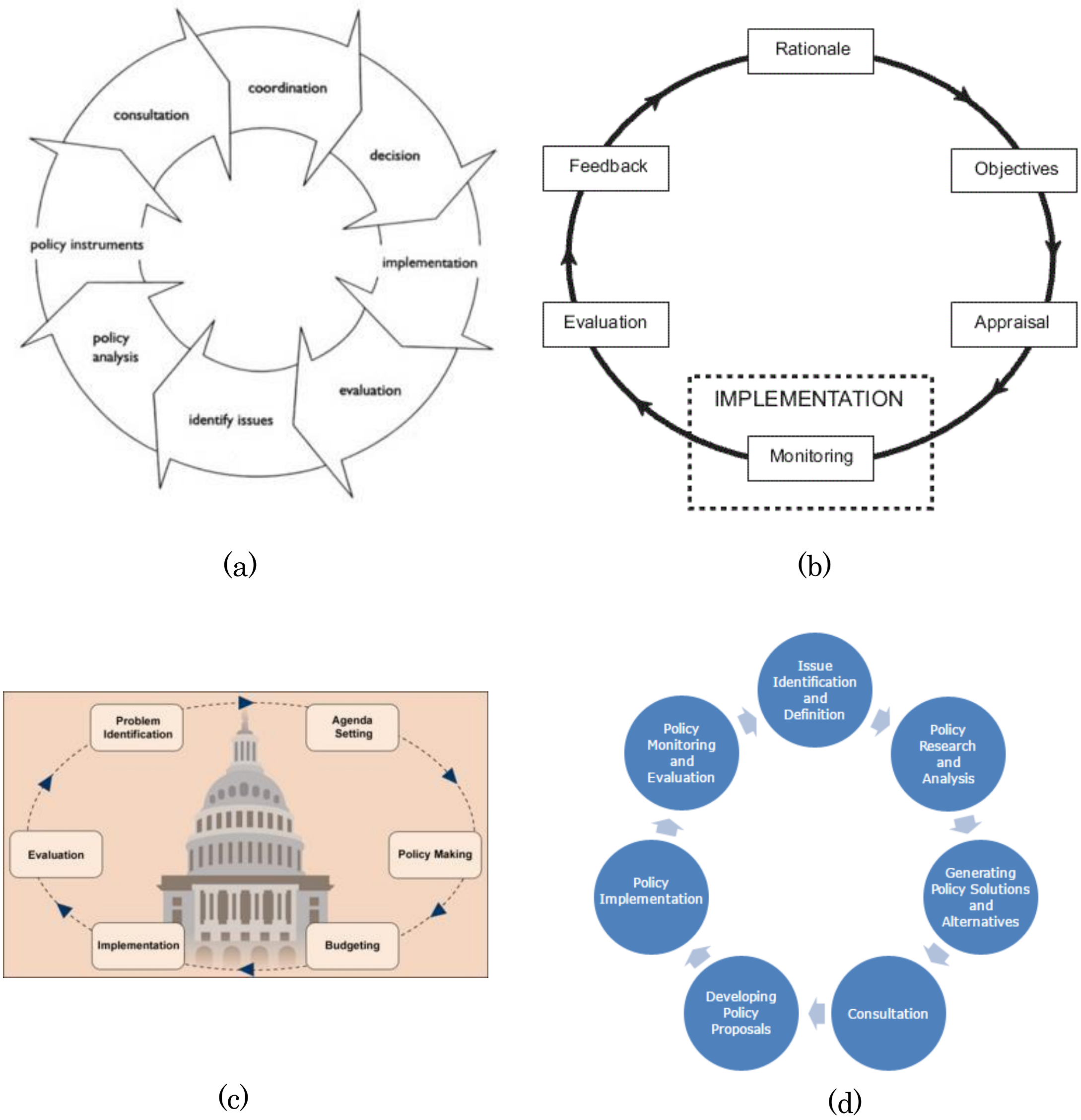


Figure 2.2. Policy Cycles: (a) Australia (Althaus et al, 2012); (b) UK (HM Treasury, 2015); (c) USA (LAITS, 2016); (d) Newfoundland & Labrador, Canada (PolicyNL, 2016).

Each of these policy cycles shows the key stages of policy development.

Research Questions 1 to 6 seek to clarify each nation's approach to policy making through a review of these steps in the policy making process. In order to capture data from non-identical policy cycles, terms for each of the steps (as described in Table 2.1 and Figure 2.2) are used interchangeably for each nation based on their individual cycles.

2.3.2.2 Energy Policy Goals and Priorities

The next set of questions (Energy policy goals and priorities) aims to elicit key energy policy goals across the eight nations and to assess policy implementation priorities.

Table 2.3. Policy Goal and Priority Questions

#	Research Question
7	What are the current energy policy goals?
8	How are energy policy goals set?
9	What are the policy tools in place to achieve goals?
10	Do energy policy goals incorporate environmental considerations?
11	Do energy policy goals incorporate economic considerations?
12	Do energy policy goals incorporate social equity considerations?

The questions are framed in order to capture not only the stated energy policy goals in each nation, but also to understand how these goals are set and what mechanisms are enacted in order to achieve policy success. Alongside quantitative policy targets, the consideration and priority given to the environmental, economic and social equity aspects of energy policy sustainability are also assessed.

2.3.3 Evidence Assessed

The evidence assessed in order to answer the research questions is summarised in Table 2.4 to Table 2.6 and comes from three sources: Government documentation, third party energy policy analysis and academic energy policy review papers.

2.3.3.1 Government Documents

For each of the eight nations, the RE legislation (Acts and laws), policy manuals and supporting Government based evidence is reviewed as summarised in Table 2.4.

Table 2.4. Assessed Government and supporting documents

Nation	Document	Ref. No.
UK	National RE Action Plan for the United Kingdom	U1
	Energy Act 2013	U2
	The Green Book: appraisal and evaluation in central government	U3
	The Coalition: Our programme for government	U4
Australia	RE (Electricity) Act 2000	A1
	Department of the Environment: The Renewable Energy Target (RET) scheme	A2
	Department of Industry and Science: Energy White Paper 2015	A3
	The Australian Policy Handbook, Fifth Edition	A4
	Clean Energy Regulator: How the scheme works, History of the scheme	A5
Canada	Provincial RE Acts: British Colombia Clean Energy Act, 2010	C1
	Ontario Feed-in Tariff Program, 2009	C2
	Quebec Climate Change Action Plan, 2006	C3
	The Policy Cycle, PolicyNL	C4
Japan	Strategic Energy Plan, 2014	J1
	Long-term Energy Supply and Demand Outlook, 2015	J2
USA	Energy Policy Act of 1992, Title XII – RE	US1
	The President's Climate Action Plan, 2013	US2
	The Public Policy Process, LAITS	US3
	Clean Power Plan, 2015	US4
Mexico	Energy Transition Law 2015	M1
	International Environment Reporter, Bloomberg	M2
	Mexico's Energy Reforms Become Law, The Brookings Institution	M3
Chile	Law No. 20.257 on Non-Conventional Renewable Energies	CH1
	Non-Conventional Renewable Energy in the Chilean Electricity Market	CH2
	Law No. 20.571 regulating the payment of electricity tariffs of residential generators	CH3
	National Energy Strategy 2012-2030	CH4
	RE in Latin America 2015: An Overview of Policies	CH5
Greece	RE Law 3851	G1
	National RE Action Plan for Greece	G2

2.3.3.2 Third Party Analysis

Three comprehensive, international publications were selected in order to evaluate each nation's policies, legislation and policy measures on an even playing field.

Table 2.5. Third party legislation, policy and policy measure analysis documents

Nation	Document	Ref. No.
All	LSE 2015 Global Climate Legislation Study	T1
	Energy Policies of IEA Countries 2012-2015	T2
	IEA/IRENA Joint Policies and Measures Database	T3

2.3.3.3 Academic Papers

Academic policy review papers were selected based on their comprehensive analysis of national RE legislation and for the provision of a contrast of domestic and foreign RE policy approaches, in order to supplement the Government and third party analysis, where necessary.

Table 2.6. Academic RE policy review papers

Nation	Document	Ref. No.
UK	UK energy policy – Stuck in ideological limbo? (Keay, 2016).	RU1
Australia	Picking winners and policy uncertainty: Stakeholder perceptions of Australia's Renewable Energy Target. (Simpson and Clifton, 2014).	RA1
Canada	The Role of Governments in Renewable Energy: The Importance of Policy Consistency. (White et al, 2013).	RC1
Japan	Inside Japan's Long-term Energy Policy. (IEEJ, 2015).	RJ1
USA	Why the United States Does Not Have a Renewable Energy Policy. (Elliot, 2013).	RUS1
Mexico	Renewable energy research progress in Mexico: A review. (Aleman-Nava et al, 2014).	RM1
Chile	Climate change and energy policy in Chile: Up in smoke? (Mundaca, 2013).	RCH1
Greece	Overview of challenges, prospects, environmental impacts and policies for renewable energy and sustainable development in Greece. (Mondol and Koumpetsos, 2013).	RG1

In order to answer each research question comprehensively, documents are added according to identified need throughout the QCA process. Documents are given a reference number in order to streamline the referencing process in the categorization matrices. The method of data extraction varies from question to question but involves comprehensive literature review, keyword mining and examination of energy policy documents and iterations. English translations of non-English national documents are used wherever possible, however, in some cases translations from external sources are used.

2.4 Results

2.4.1 Structured Categorization Matrices

Structured categorization matrices are developed, organising the research questions being asked and the responses extracted from the sources considered for each of the eight OECD nations. The categorization matrices are populated according to the evidence reviewed across government, third party and academic literature for each nation. This manual process is time consuming and assesses copious amounts of literature, leading to large tables requiring coding and summarising in order to be applied to the hypothesis and purpose intended. The categorization matrices raw data is provided below in Table 2.7 to Table 2.10. Section 2.4.2 summarises the results of this process and draws out key themes, similarities and identifies outliers.

Table 2.7 Research Questions 1-3 QCA Raw Data

Nation	Q1. Key Govt. Bodies	Q2. Identification	Q3. Tool Development
UK	•Parliament is the supreme legislative body and the government is drawn from and answerable to Parliament, which is bicameral, consisting of the House of Commons and the House of Lords. •Draft bills are issued for consultation before being formally introduced to Parliament. Following consultation Bills are introduced into either house for examination, discussion and amendment. •Once a bill is agreed in both houses, it is presented to the Monarch for royal assent, becoming an Act. [T1]	•Policies to deal with GHG emissions were first introduced in the early 2000's with the Climate Change Agreement and Climate Change Levy coming into effect in 2001. •EU directives: RE and emissions trading scheme. [T1] •Govt sets out clean energy and environmental policy priorities at the establishment of their govt. [U4]	•Govt White Papers set out details of future policy on a particular subject. They allow the govt to gather feedback before it formally presents the policies as a bill. •Devolved Govts develop their own policies and targets. •Govt Plans for Energy Market Reform. [T1] [T3]
Australia	•Westminster-based Parliamentary system. •Bills can be introduced into upper or lower house of parliament. •Upper house (Senate) can block bills from becoming Acts even with a govt majority in the lower house. •Royal assent is required for all Acts (formality). [T1]	•Climate change identified as an issue in the late 1990s. •Govt agencies are established to provide advice for environmental policy (GHG emissions, climate change mitigation etc.). •Kyoto Protocol signee 1998, ratified in 2007. [T1] •Currently the RE Target is administered by the Clean Energy Regulator – an independent statutory authority. [A2] •The Department of the Prime Minister and Cabinet provides policy advice on priority matters of public and govt administration. [T2]	•Govts provide an integrated Australian energy policy framework (Energy White Paper) which sets out the policy vision. [A3] •Statutory bodies given responsibility for market instruments. [A1] [A2] •State Govts implement additional policy tools to meet internal goals. [T1]

Canada	•Parliament is based on the British model, with a lower house (House of Commons) and upper house (Senate). •Bills can be introduced in the House of Commons or the Senate as public or private bills which are based on a petition. Hybrid bills also possible. •Bills become law following post-debate and amendment agreement in both houses through a series of three readings. Committees from both houses examine legislation and hear testimony on specific points. •The Sovereign of the United Kingdom formally enacts all laws. •Constitution divides legislative ability and responsibility between the federal and provincial govts based on topic. [T1] [T2]	•No comprehensive federal climate change legislation in place. •Attempts made at a parliamentary level since 2006, but unsuccessful in both houses. •Provinces have been active in passing their own climate legislation. [T1] •75% of Canada's electricity already comes from non-emitting sources (RE & Nuclear). [T2]	•Energy issues are a shared responsibility between federal and provincial governments, specifically the environmental regulation of energy projects. •Federal departments of Environment Canada and Natural Resources Canada regulate GHG and renewable resources, and set federal policy on clean energy supply. [T2]
Japan	•Parliamentary cabinet system. More than half of Cabinet members are MP's selected by the Prime Minister. The Prime Minister is elected by MP's. •National Diet is the law-making organ of the state, consisting of the House of Representatives (lower house) and House of Councillors (upper house). • MP's and Cabinet can submit bills, which are passed to a committee for deliberation which can include open hearings before voting – approval is given in a plenary session of the Diet. Compromise is often sought where agreement cannot be made, via committee. •Passed laws are promulgated by the Emperor, before gazetting. [T1]	•Oil shocks in the 1970's exposed Japan's weak energy self-sufficiency and lead to a 40% energy efficiency drive. [J1] •The Act on Promotion of Global Warming Countermeasures was enacted in 1998 as the first climate-dedicated law – arising from the Kyoto Protocol process. [T1] •The Cabinet formulated the Strategic Energy Plan, 2014 based on issues, long-term measures and basic policy approach to energy supply and demand, strategic technology development and communication with society. [T3]	•Strategic Energy Plan developed by the Cabinet in 2014. [J1] •Long-term Energy Supply and Demand Outlook is derived from this document, developed by the Ministry of Economy, Trade and Industry specifying future RE technology generation targets. [J2] [T3]
USA	•Bicameral legislature (Congress) consisting of Senate and House of Representatives. •Bills can be introduced in either house, usually following approval by a committee. •Once a Bill is approved in one chamber it is sent to the other for amendment, rejection or passing. Both houses must agree on an identical version of the Bill for it to be presented to the President. •To become law, Bills must be signed by the President, who has veto power. •Presidential veto can be overturned by a 2/3 majority in both houses. [T1]	•No dedicated climate change legislation. [T1] •The Clean Power Plan outlines the Environmental Protection Agency (EPA) role to reduce GHG emissions through the Clean Air Act and provisions on GHG emission limits for generators. [T3] •Presidential statements outline congress term plans; the President's Climate Action Plan of 2013 outlines responsibility to future generation s to meet the challenge of climate change and outlines mostly aspirational and some concrete policy plans. [US2] •Development of a national RE policy is impede by divided government – different parties controlling different houses of congress. [RUS1]	•Govt Act Based: Federal facility RE requirements; the Energy Policy Act, extended by the Energy Independence and Security Act requiring solar hot water and a phased reduction in fossil fuel consumption. [T2] •The EPA has a role applying laws to reduce GHG in the current and future energy supply system.[T3] •Govt manages GHGs through The Clean Air Act, executive orders and partnership programmes •In 2015, 32 individual States had their own legislation on climate change and the reduction of GHG. [T1]
Mexico	•Bicameral legislature (Congress) •Bills can only be introduced by the President or a member of Congress – however in practice most originate within the executive. •Lower house is the Chamber of Deputies and Upper house is the Senate •Approval in both houses is required for a bill to become law. [T1]	•National Climate Change Strategy first adopted by Govt in 2007. •Active participation in international GHG emission inventories and submission of Climate Action Plans. [T1] •Public Presidential support for passage of law and achievement of global warming mitigation objectives by incorporating clean energy. [M2]	•Ministry of Environment and Natural Resources administers the General Law of Climate Change and establishes entities to oversee GHG mitigation targets and incentives. •Energy Secretariat implements the National Energy Strategy with RE generation goals. •Guidelines for establishing and issuing Clean Energy Certificates are overseen by the Regulatory Commission of Energy. [T3]

Chile	•Multi party Republic Presidential System. Congress consists of the Senate and Chamber of Deputies. •Bills are approved first in the Chamber of Deputies, then the Senate and finally approved by the President. Once endorsed the Bill is promulgated and sent to the Comptroller-General for constitutional review. If declared constitutionally sound, the President publishes the bill as law. •The President has sole authority to introduce bills which are concerned with spending, public sector administrative entities duties, and modifying he political-administrative configuration. •The President can also grant initiatives priority status, requiring action from congress in 3, 10 or 30 days depending on urgency – giving the President exclusive power to set the legislative agenda. [T1]	•Established a National Advisory Committee for Global Change in 1996. •National Strategy for Climate Change was adopted in 2006. •Climate Change is one of the five thematic focuses of the Ministry. [T1] •Explicit policies that promote the use of non-conventional RE originate in 2004-5. [RCH1]	•National Energy Strategy 2012-2030 was developed by the Ministry for Energy and outlines strategic options to address energy challenges and the transition to a developed nation. [CH4] •Centre for RE Development established in 2009. [RCH1] •The Ministry of the Environment has a special mandate to propose and develop national climate policy.□ [T1]
Greece	•Unicameral legislature consisting of Members of Parliament and State Deputies. •Parliament elects the President of the Republic by a majority of two-thirds for a five-year term. •Government Ministers can introduce Law Proposals; MPs can introduce Draft Laws as bills. •Bills are passed through a two stage process in the Parliament before promulgation by the President of the Republic and publication in the Official Gazette of the Hellenic Republic. [T1]	•First National Climate Change Programme adopted in 1995. •Ministry of Environment, Energy and Climate Change established an Inter-Ministerial Committee on Climate Change in 1996. •Ratified Kyoto Protocol in 2002. [T1] •The development of RE sources in Greece first started to a significant degree in the 1990s with the development of solar thermal systems stimulated by a sizable tax deduction for final users. [RG1] [G2]	•National RE Action Plan outlines bodies, roles and tool administration for Greek targets as part of an EU approach. •Minister of Environment, Energy and Climate Change was established in 2009 to bring under a single administrative structure, the licensing function and considerations for energy, environment and the economy. •The Centre for RE Sources and Saving, supervised by the Minister of Environment, Energy and Climate Change, facilitates national energy planning and the formulation of energy policies. [G2]

Table 2.8 Research Questions 4-6 QCA Raw Data

Nation	Q4. Consultation	Q5. Implementation	Q6. Evaluation
UK	•The Office for RE Deployment works closely with delivery partners and stakeholders to help accelerate deployment. •Great Britain also works with devolved Governments of Wales, Scotland and Northern Ireland who contribute to the overall target. •The National RE Action Plan was developed following an extensive consultation exercise with the Devolved Administrations, regional and local Govt, other public groups, the private sector and members of the public. [U1] •UNFCCC Annex I nation.	•Ofgem the Office of Gas and Electricity Markets; a non-ministerial govt department and an independent National Regulatory Authority implements the feed in tariff for small scale renewables generation and Contracts for Difference (CfD) for large scale generation. •CfDs are concluded between the renewable generator and Low Carbon Contracts Company (LCCC), a govt-owned company. [T3] •Department of Energy and Climate Change's Office for RE Deployment is responsible within Govt to ensure RE targets are met. [U1]	•Department of Energy and Climate Change responsible for monitoring and reporting. •Independent UK Committee on Climate Change to review the renewables target and provide advice on increasing the level of ambition. Govt has committed to make an Annual Energy Statement to the UK Parliament [U1] •Annual Energy Statement to Parliament to set strategic energy policy and guide investment. [U4]
Australia	•Council of Australian Govts (COAG) collaborate over energy market reforms. [A3] •Climate Change Authority provides independent advice. [RA1] •Department of the Environment conducts stakeholder consultation. [A2] •Reporting to the UNFCCC (Annex-I). [T1]	•The Clean Energy Regulator oversees the Operation of the RET scheme according to the RET legislation. •This includes the REC Registry. [A2]	•Legislated to have a biennial review by the independent Climate Change Authority. [RA1] •The Act was revised in 2015 to replace the mandated biennial consultative review with regular status updates by the independent statutory authority, the Clean Energy Regulator. [A2] •Climate Change Authority •Department of the Environment modifies the RET over time based on consultation feedback and Govt policy direction. [A2]

Canada	•As a UNFCCC Annex I country, Canada signed and ratified the Kyoto Protocol (2002) but has subsequently withdrawn from the agreement in 2012. •Pursue formalised participation of provinces and territories in international energy relations by working towards a consistent approach and formal mechanisms with the federal government while giving a clear role for provinces (provinces directly engage in COP negotiations. [T1] [T2] •The federal government collaborates with provincial governments on issues of Pan-Canadian interest. [T2]	•Shared between province and federal govts. •Environment Canada and Natural Resources Canada administer programmes on clean energy and regulate GHG and pollutant emissions. [T2] •British Columbia Hydro and Power Authority administer the BC Clean Energy Act. [C1] •Ontario: Independent Electricity System Operator implements the FiT. [C2] •Ministry of Sustainable Development, Environment and the Fight against Climate Change administer the Quebec Climate Change Action Plan. [C3]	•Status Reports submitted to the minister. [C1] •Environment Canada and Natural Resources Canada administer programmes on clean energy and regulate GHG and pollutant emissions. [T2] •Fit Review in Ontario to provide policy certainty. [RC1]
Japan	•Govt established "Related Ministers' Cabinet Meeting on RE" for policy coordination & to promote cooperation among related ministries. •COP and UNFCCC (Annex I) are consultation partners for energy and climate change issues. [J1] •Strategic Policy Committee of the Advisory Committee for Natural Resources and Energy and subcommittees (including calls for public comment) decided the Long-term Energy Supply and Demand Outlook. [J2]	•The feed in tariff is revised each year by the Ministry of Economy, Trade and Industry's Agency for Natural Resources and Energy, for each technology. •Subsequently an electricity surcharge for all households is derived based on the tariff regime and combination of generating technologies. [T3]	•A Periodic Review of Long-term Energy Supply and Demand Outlook is scheduled to occur at least once every three years, considering the Strategic Energy Plan. Most recently delivered in 2015. [RJ1] [J2] •The feed in tariff is revised each year by the Ministry of Economy, Trade and Industry's Agency for Natural Resources and Energy, for each technology. •Subsequently an electricity surcharge for all households is derived based on the tariff regime and combination of generating technologies. [T3]
USA	•UNFCC/COP (Annex I). [T3] •Presidential announcement, direction of agencies. [T2] [US4] •EPA negotiates with the fossil fuel electricity generating industry to establish standards for GHG emissions from power plans and States then develop and implement plans to achieve the goals by 2030. •Clean Plan was negotiated through outreach to states, tribes, utilities, stakeholders and the public. [US4]	•The EPA is responsible for implementing the Clean Power Plan (implementation is currently stayed, pending judicial review). •The EPA aims to Reduce GHG emissions through 3 building blocks: 1 - improving the performance of existing power plants, 2- switching to natural gas or low carbon alternatives, and finally 3 - transitioning to emission-free RE generation. [US4] •RPS are implemented at State level. [T3]	•A quadrennial Energy Review led by the White House Domestic Policy Council and Office of Science and Technology Policy, supported by a Secretariat established at the Department of Energy, and involving the robust engagement of federal agencies and outside stakeholders – to ensure that federal energy policy meets economic, environmental, and security goals. [T2] [US2]
Mexico	•Inter-party negotiation in the Congress of the Union. •UNFCCC/COP consultation (Non-Annex I). [T1] •Legislation drafters consulted widely to develop the Energy Transition Law, learning from newly industrialized and high petroleum nations. [M3] •Energy Ministry collaboration with domestic and international bodies. [RM1]	•Energy Regulatory Commission administers Clean Energy Certificates obligation and acquisition. •Application of the law is the responsibility of the Ministries of Energy, Environment and Natural Resources, the Energy Regulatory Commission and the National Commission for the Efficient Use of Energy. [M1]	•Energy Regulatory Commission and Environmental Protection Agency are responsible for monitoring electrical industry members. [M1]
Chile	•Energy Strategy outlines the need to Work together with the public and private sectors, researchers and public representatives. [CH4] •UNFCCC Non-Annex I country. •Inter-ministerial Committee on Climate Change was set up, including the Ministers of the Environment, Foreign Affairs, Agriculture, Transport and Telecommunications, Energy, Economy, Finance, Mining and Public Works and two dialogue platforms, one for public–private partnerships and one for the civil society. •International research and cooperative agreements. [T1]	•Ministry of Energy (Strategy, Consultation, Centre for RE Development (Funding). [CH4]) •National Energy Commission enforces existing energy legislation. [RCH1] •Ministry of the Environment, set up as the State body in charge of cooperating with the President in the design and implementation of environmental policies, plans and programmes. [T1]	•Center for Economic Load Dispatch (CDEC) keeps a public record of all RE injections into the Grid as directed by the Law. [CH1] •Strategic Energy Plan outlines the need to review instruments over time. [CH4] •Limited post implementation evaluation. [RCH1]

Greece	•UNFCCC Annex I country. •Bills submitted to Parliament must include a report outlining the findings of public consultation. [T1] •EU member, targets based on (extended) EU obligations. •Consultation for development of the National RE Action Plan included regional and local authorities, scientific and RE development associations, NGOs, and the general public and institutional/market actors through a two stage consultation process in 2010. [G2]	•Regulatory Authority for Energy issues licenses to produce electricity from RE – except for small scale RE and non-grid connected RE. •The Ministry of Environment, Energy and Climate Change created an independent office for RE which assists investors and RE generators to install RE and deal with any legislative/regulatory issues. [G1]	•Decision on the desired proportion of installed capacity and distribution among RE technologies is to be reviewed at least every two years by the Minister of Environment, Energy and Climate Change. •An annual report is provided to the Ministry of Environment, Energy and Climate Change and the Regulatory Authority for Energy outlining issues with RE investment, along with proposed solutions. [G1] •Tariffs are reviewed annually and adjusted as needed. [T3]

Table 2.9 Research Questions 7-9 QCA Raw Data

Nation	Q7. Current Goals	Q8. Goal Setting	Q9. Tools in Place
UK	•15% of energy consumption from RE sources, meaning approximately 30% of electricity from renewables, with 2% of this to come from small scale sources. •EU wide greenhouse gas emission cut of 30% by 2020. [U1]	•European Union nation, supports the EU emissions reduction target of 30%. [U1] •Devolved Govts have introduced their own targets. [T1] •Parliament develop and update the Energy Act, which states the targets set out in the regulations for each mechanism. [U2]	•Feed in Tariffs for small scale renewables. •CfD for large scale renewables introduced in October 2014, aiming to replace the previous Renewable Obligations system. Awarded for 15 years. •Energy Market Reform tools: Capacity auctions to set a market for future capacity. Emission Performance Standard, Carbon Price Floor (CPF) designed to be gradually increased, to augment EU carbon price. [T3] •European Investment Bank funding for onshore wind projects. [U1]
Australia	•20% of all electricity by 2020. •Reduce GHG emissions. [A5] •Large-scale RE Target (LRET) 33,000GWh by 2020. (Reduced from 41,000GWh), the majority of the goal. •No specified target for small-scale RE. [A1]	•Negotiated in Parliament. •Targets vary according to Govt policy priorities and are reflected in amendment to Acts. •In 2015 the Australian Parliament amended the RE (Electricity) Act 2000 to reduce the RE generation goal from 41,000GWh to 33,000GWh by 2020. [A5] •Some States have their own emission reduction and RE generation goals, while others align with Federal targets. [T1]	•RE Certificates (REC), administered by the Federal Govt: Large scale RECs created in relation to generation of electricity by accredited power stations. Small scale RECs created in relation to installation of solar hot water and small generation units. [A1] •Oversight of the market supply and demand conducted by the Clean Energy Regulator using a REC registry to match supply and demand and to meet Govt targets. [A5] •Feed-in tariffs administered by the States. [T1]
Canada	•No Federal goal. Aspirational goals only. [T2] •BC: Generate at least 93% of electricity from clean or renewable sources by 2020 and reduce GHG emissions by 33% compared to 2007. [C1] •Quebec: Reduce GHG by 6% below 1990 levels. [C3]	•At Province level. [C1] [C2] [C3] [T1] •Overarching administration provided by Federal departments of Environment Canada and Natural Resources Canada. [T2]	•Feed-in tariff for small (<10kW) and large RE systems, guaranteed for 20 years. [C2] •Cap and trade schemes. [T1] •Federal level tax and depreciation concessions. [T2]
Japan	•CO_2 emissions from energy sources to be 21.9% lower than FY2013 levels by 2030. •Energy self-sufficiency to increase to 24.3% by 2030, this includes 10-11% nuclear and 13-14% RE based electricity generation. •Reduce energy demand to 13% below FY2013 levels by 2030 through energy conservation measures. [J2]	•The Strategic Energy Plan outlines Japanese Govt energy goals, however these are aspirational, not concrete. [J1] •The Long-term Energy Supply and Demand Outlook sets specific goals for GHG reduction compared to FY2013 levels and energy security levels including generation from renewable sources. [J2]	•Feed in Tariff for electricity generated from RE. •The purchase price per kWh is revised each year by the Ministry of Economy, Trade and Industry & the Agency for Natural Resources and Energy, for each technology. [T3]

USA	•no national RE target, however the policy environment is broadly supportive of RE. [T2] •Reduce GHG emissions by 32% by 2030 through building blocks: improving the performance of existing power plants, switching to natural gas or low carbon alternatives, and finally transitioning to emission-free RE. [T3] •20GW of RE on public land, 100MW RE capacity on subsidized housing stock by 2020, 3GW of RE on military installations by 2025. •Federal Govt to consume 20% of its elec. from RE sources by 2020.	•States, who regulate their own electric utilities, introduce their own Renewable Portfolio Standards (RPS). [RUS1] •State Based RPS outlines individual generation/ GHG reduction goals. [T3] •Presidential announcement, direction of agencies. [T2] [US4] •Presidential Action Plan. [US2]	•Incentive payments per kWh of renewables based electricity generation. [US1] •State-level RPS. [T3] •Residential tax credits: 30% tax credit (up to $2000) for solar PV and solar hot water installation, and 30% (up to $500 per 0.5kW) for fuel cell installation. [T3]
Mexico	•25% of electricity from RE by 2018, 30% by 2021 and 35% by 2024. [M1] •Reduction in emissions of 30% by 2020 and 50% by 2050 compared to 2000 levels. [T1]	•International climate change negotiations in Paris (COP21) around Mexico's Climate Action Plan set the basis for domestic policy to meet goals. •Energy Transition Law passed in Congress in 2015, clear majorities in both houses after more than a year of debate. [M2]	•Clean Energy Certificates are issued at the rate of 1 certificate per MWh generated post August 2014 with Penalties for non-compliance. •Certificate market is monitored by the Regulatory Commission of Energy. [T3] •Legal provisions, regulatory and tax conditions. [M1]
Chile	•20% of electricity from renewable sources by 2025 (for electric utilities with more than 200MW operational capacity, Hydro above 20MW not included). [CH1] •A target for traditional hydroelectricity to achieve 45% to 48% share of the electricity mix over the next decade. [T1]	•Ministry of Energy Strategic Energy Plan sets out high level goals for the energy industry. [CH4] •Centre for RE Development sets goals for deployment of non-conventional RE and facilitates funding.	•Quota System with auctions for capacity and a "Green Certificate" system. [T1] [CH5] •Feed-in tariffs and exemptions from transmission costs for small scale RE generation. [CH2] [CH3] •Economic support for Non-Conventional RE Development. Invest Chile Program for RE. [T1] [CH5]
Greece	•20% of gross final energy consumption, and 40% of gross electrical consumption to be produced by RE by 2020. [G1] •GHG levels to be 10% below 1990 levels in 2020. [RG1]	•European Union Nation, submitting a National RE Action Plan to the EU. [G2] •Parliament develops the RE Laws which outline goals, technologies and mechanisms to achieve them by target dates. [G1]	•Feed in Tariffs for small scale solar, wind, geothermal, biomass, landfill gas and biogas [T3] [G1] •Tax concessions for household consumers and producers of RE.

Table 2.10 Research Questions 10-12 QCA Raw Data

<u>Nation</u>	<u>Q10. Environmental</u>	<u>Q11. Economic</u>	<u>Q12. Social Equity</u>
UK	•Maintain energy security by utilising renewable resources to reduce depletion of fossil fuels. •climate change is one of the gravest threats we face, and urgent is required using a wide range of levers to decarbonise the economy. •The development of RE sources, alongside nuclear and CCS, will also enable the UK to play its full part in international efforts to reduce the production of harmful GHG. [U1]	•A new "challenge group" is being established in the Cabinet Office to come up with innovative approaches to achieving environmental goals in a non-regulatory way. •Provide opportunities for investment in new industries and technologies. [U1] •Financial support for renewables. [T3]	•A new "challenge group" is being established in the Cabinet Office to come up with innovative approaches to achieving social goals in a non-regulatory way. [U1] •Promote community based renewables that benefit the local people. [U4]
Australia	•To encourage the additional generation of electricity from renewable sources, to reduce emissions of greenhouse gases in the electricity sector, and to ensure that RE sources are ecologically sustainable, integrating environmental considerations. •If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be reason for postponing measures to prevent environmental degradation. •The conservation of biological diversity and ecological integrity should be a fundamental consideration. [A1]	•Effectively integrate both long-term and short-term economic considerations. •Improved valuation, pricing and incentive mechanisms should be promoted. [A1] •Stimulate investment in RE power stations. [A5]	•Effectively integrate social and equitable considerations. •The principle of inter-generational equity; that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations. [A1]

Canada	•Limit global warming by reducing GHG. [C3] •Recognise the importance of socially and environmentally responsible development, transportation and use of energy. [T2]	•To encourage economic development and the creation and retention of jobs. [C1] •Investing in RE through Green Fund duty collected from gasoline and fossil fuels. [C3] •Maintain a market-oriented approach to energy policies governed by effective, efficient and transparent regulatory systems. [T2]	•Encourage Aboriginal and community participation. [C2] •Public health and safety. [C3] •Recognise the importance of socially and environmentally responsible development, transportation and use of energy. [T2]
Japan	•Contribution to global warming countermeasures for reducing global greenhouse gas emissions. •Environmental acceptability is a criterion for energy sources introduced into the electricity market. •Environmental assessments to be streamlined. [J1] •Pursue environmental suitability. [J2] •GHG emission goals in line with the US and Europe. [RJ1]	•Stimulate new investment by introducing a competitive electricity market, liberalized and with the introduction of superior technologies. •Energy policies should consider economic growth as an important factor. [J1] •Ensure stable supply - energy security, and realize a low-cost energy supply by enhancing its efficiency. [J2] •Economic efficiency – reduce the cost of electricity. [RJ1]	•Reduce costs of RE, reduce electricity prices from current levels to inhibit public burden resultant from the new energy system. •The risk of an increase in public burden through one-side installation of solar power is recognized. •Review the system so as to allow well-balanced introduction between RE technologies. [J1] [J2] •Future generations should not be burdened. [J1] •Including safety in 3E+S. [RJ1]
USA	•Carbon pollution standards for new and existing power plants. [US2] •Protect Americans from harmful air pollution, reduce carbon and air pollution. [US4]	•$7.9B investment funding clean energy technology. •Reduce barriers to investment in energy efficiency. [US2] •Driving investment in clean energy strategies that can reduce CO2 emissions. [US4]	•Improve public health. •Reduce energy bills for families. [US2] •Ensure opportunities for communities, particularly low-income, minority and tribal communities. [US4]
Mexico	•Recommends the incorporation of social and environmental externalities into energy project evaluations. •To promote the use of RE sources and biofuels in economically, environmentally and socially responsible forms. [RM1] •Reducing polluting emissions in the electric power industry. [M1] •Mitigate the increase of GHG emissions.	•Economic viability. •Promote regulatory and tax conditions to facilitate achievement of goals. [M1] •Clean Energy Certificate's objective is to help Mexico achieve its goals for clean energy participation, while minimising costs as much as possible. •Increase public and private investment in generation, construction and extension of RE infrastructure. [T3] [M2] •To promote the use of RE sources and biofuels in economically, environmentally and socially responsible forms. •Creation of a fund to transition to clean and RE and a future green economy. [RM1]	•Recommends the incorporation of social and environmental externalities into energy project evaluations. [M1] •To promote the use of RE sources and biofuels in economically, environmentally and socially responsible forms. [RM1]
Chile	•Health and environmental protection. [CH4]	•Sustainable economic growth. •National energy security and independence, promotion of a market with greater levels of competition and lower prices. [CH4]	•Reduction of poverty, social growth and progress. •Efficiency and social commitment •Access and equity for everyone in Chile [CH4] •Fairness: the introduction of non-conventional RE should include both regulated and non-regulated customers. [CH1]
Greece	•The protection of the climate, through the production of electrical energy from RE sources. [G1] •Reducing national GHG emissions. [G2]	•Boosting the competitiveness of the economy, attracting investment capital – "Green" development. •Economic improvement of conditions in rural areas. [G2]	•Socio-economic and demographic factors should be taken into account when choosing RE technologies. [G2]

2.4.2 Summary of Results

In order to condense the data identified in response to each of the research questions posed and to identify key themes, similarities and outlying factors, a secondary critical review of the data for each question is undertaken. The summary of this coding process and outcomes are presented below for each research question in the form of key commonalities, outliers and a summary statement for each research question. The results are separated into the two streams of governance and policy making, outlined in Table 2.11 and energy policy goals and considered factors, outlined in Table 2.12.

Table 2.11. QCA Data Summary: Governance and Policy Making

Question	Key Commonalities	Outliers	Summary Statement
① What are the key government bodies responsible for energy policy development?	Parliamentary or Congress systems: uni, and bicameral. Two stage process for law assent. Party based or driven by the president. Assent of bills by President or Monarch.	Chile: President has sole authority to introduce bills and set the legislative agenda. USA: Presidential veto power.	All nations assessed use parliamentary or congress party based systems whereby laws, acts or bills are introduced into the legislature, requiring agreement between two legislative bodies prior to promulgation and presidential or royal assent.
② How and where are energy policy goals identified?	International bodies and agreements, Government prerogative.	Canada and the USA: No dedicated (federal level) climate change / RE legislation.	Most governments identify energy policy goals for the nation. These are often linked to international agreements. In some cases, no federal direction is given and states or provinces self-regulate.
③ How are energy policy tools developed?	Governments, Cabinets and White papers, strategic plans, acts and laws. Enacted and administrated in Departments and independent bodies.	Canada: Shared responsibility between federal and provincial governments. USA: Federal guidance and bodies, but States make own legislation.	Most governments develop policy within the Cabinet or ministry through national strategic plans which are then administered by prescribed bodies. In some cases, the Federal and State level governments share or separate responsibility.
④How is consultation undertaken?	Participation in UNFCCC/COP. State and Federal Government collaboration. Departmental and committee based stakeholder engagement.	None.	All assessed nations are UNFCC and COP collaborators. Federal direction decides departmental or committee based responsibility and engagement with States and other stakeholders.
⑤ How is energy policy implemented?	Ministries, government owned corporations and regulatory authorities.	Canada and USA: Shared between federal and state departments and ministries.	Federal ministries and departments bear responsibility for meeting targets and applying laws. Regulators and independent bodies are responsible for administration of market instruments.
⑥ How and when is energy policy evaluated?	How: Departmental monitoring and reporting. Through departmental consultation and feedback. Status Reports. Reviews. When: Ranging from annual to Quadrennial review. Other jurisdictions use vaguer terms such as 'over time' or 'regularly)	Timeline and method varies by nation and instrument or policy being reviewed.	All nations espouse post implementation review, either through departmental monitoring, reporting or feedback in the form of status reports or official reviews. The timelines for these reports and reviews varies across jurisdictions, where specified.

Table 2.12. QCA Data Summary: Energy Policy Goals and Considered Factors

Question	Key Commonalities	Outliers	Summary Statement
⑦ What are the current energy policy goals?	Electricity generated by RE, reduction of GHG emissions, specific technology and RE scale based generation targets	Canada and USA: No Federal goals, states self-regulate. Japan: Increased energy self-sufficiency policy goal.	The most common energy policy goals are an increase in RE based electricity generation and a decrease in energy system GHG emissions. Some nations favour specific technologies.
⑧ How are energy policy goals set?	In line with EU emissions targets. Parliamentary negotiation. Government priority, long term outlooks and strategic plans. Federal department guidance, state level settings. Federal direction of agencies. Government departments and official bodies set high level goals.	Each nation is unique in their approach, in the USA the president has a large voice in aspirational goal setting, Chile has a statutory body to set goals for RE deployment.	Generally speaking, the federal government sets the overall targets through either parliamentary debate or party platform priorities. These goals are usually formalised through action plans, Acts, strategies or trans-national agreements. Some states have their own targets, which are often in line with national level targets.
⑨ What are the policy tools in place to achieve goals?	Feed in tariffs, incentive payments, contracts for difference, pricing of carbon, RE certificates, quota system, economic support, cap and trade systems, tax and depreciation concessions. RPS. Non-compliance penalties.	Each jurisdiction implements a different combination of the noted policy tools.	All of the tools in place in the examined nations are economic tools, such as FiTs and incentive payments or, a form of RE Certificates, or, tax and depreciation concessions, non-compliance monetary penalties, RPS schemes, or, carbon market/cap and trade systems.
⑩ Do energy policy goals incorporate environmental considerations?	Considered a central consideration in energy policy in all nations, intensity varies, with all including environmental protection, with a broad variety of terms including: recognition, criteria, fundamental consideration and grave threat.	Each nation expresses these considerations in different terms.	All nations recognise the environment as being linked with energy policy, and the issues of climate change, energy sources and greenhouse gases are most prominent.
⑪ Do energy policy goals incorporate economic considerations?	Incentives, encouraging investment, sustainable economic growth, energy security with low(er) prices.	Each nation expresses these considerations in different terms.	Economic development is a central tenet of policy goals in all cases, by encouraging investment, market instruments and the economic promotion of specific technologies.
⑫ Do energy policy goals incorporate social equity considerations?	Intergenerational equity, benefit to local people, public health and safety, reduce public and future burden, access and fairness, and the consideration of socio-economic and demographic factors.	Each nation expresses these considerations in different terms.	Whilst social equity is incorporated in each case, the breadth of recognition of social equity issues is quite broad. Some specifically identify groups and demographics requiring extra support, specifying or describing inter-generational equity. Others use blander terms such as ‘incorporate’ or ‘take into account’. Reduction of burdens and costs was consistent throughout.

2.4.2.1 Governance and Energy Policy Making Summary

In this summary section, each statement is accompanied by the research question number from Table 2.11 in parentheses.

Firstly, with regard to governance (①), there are strong similarities in the parliamentary and congress style systems, with a bill or Act first introduced, followed by debate, approval and then assent by either a monarch or a president (usually a formality). In the case of the USA, presidential veto powers exist, however there is a check and balance for this veto power, in that a two-thirds majority of both houses can overturn it. In all nations but Chile, bills are introduced to the houses by members, usually from both parties. Only in Chile does the President have the sole authority to introduce bills and set the legislative agenda.

With regard to the identification of energy policy goals (②), in addition to each nation being a member of the OECD, they are also all members of the United Nations Framework Convention on Climate Change (UNFCCC), participating in Conference of Party (COP) sessions. These memberships influence high level policy goals, however national policy goals are identified by the national Government party in power according to their priorities and enacted at both a national and state level. Only in the case of the USA and Canada is there no dedicated national level climate change or RE legislation and in these cases, the states provide their own.

Energy policy tools (③) are developed in the same way as goals, by the Government of the day, often within the Cabinet or responsible ministries, enacted through national strategic plans and administered by responsible departments or in some cases statutory bodies. In the case of the USA and Canada, similar to goal setting, the federal and state level governments either share or separate this responsibility.

The consultation step (④) is similar in all cases. As each nation is a member of the UNFCCC and OECD, there is both international, national and state Government consultation. In addition, national Governments prescribe department or committee based stakeholder engagement and consultation responsibilities.

Responsibility for implementation of policies (⑤), including the application of laws and meeting of targets is usually the responsibility of federal ministries and departments (except in the USA and Canada where these are shared between federal and state departments and ministries). The administration of market instruments is the responsibility of regulators and independent bodies.

Energy policy evaluation (⑥) is undertaken following implementation in all cases, either through departmental monitoring, reporting or status report and official review based reporting. Each nation’s timeline for evaluation varies, with the most regular occurring annually, the most irregular every four years, with others falling somewhere in between or using non-specific evaluation timelines.

The QCA process has identified some key commonalities among the assessed nations, as well as some notable outliers. Figure 2.3 codifies the findings for the policymaking process with governance and policy making step commonalities and outliers labelled throughout.

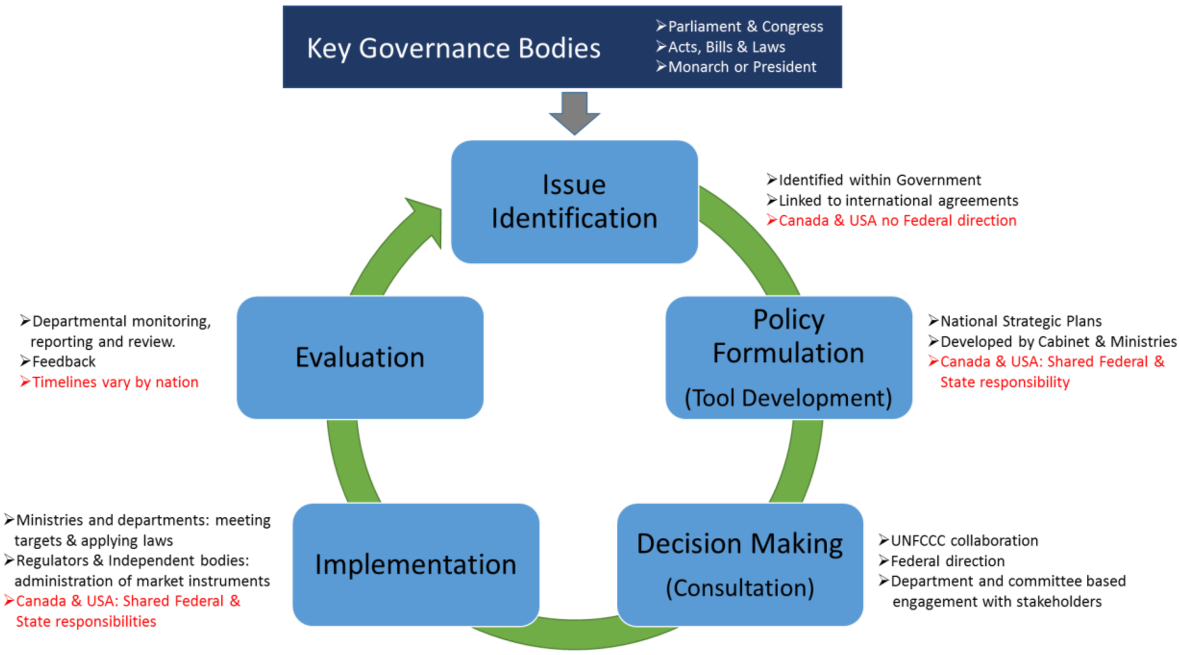


Figure 2.3. OECD Governance & Policy Making Process (sub-steps in parentheses)

Generally speaking, the process is congruous throughout the assessed nations with some minor differences, particularly the lack of Federal direction for the USA and Canada at the issue identification stage and shared State and Federal responsibility for policy formulation (including tool development) and implementation. Evaluation timelines vary from nation to nation but in all cases evaluation occurs post-implementation. The policy making approach is similar in all cases assessed, and therefore each assessed nation can benefit from an improved process which can address any identified weaknesses.

2.4.2.2 Energy Policy Goals and Priorities Summary

As was the case in section 2.4.2.1, each summary statement is accompanied by the research question number from Table 2.12 in parentheses.

Across all nations assessed (the states in the case of the USA and Canada), the current energy policy goals (⑦) include an increase in RE based electricity generation and a reduction in GHG emissions. Japan is a special case, specifically mentioning increased energy self-sufficiency as an energy policy goal. In order to achieve these goals, some nations favour specific technologies at various scales.

Although each nation is unique in their approach to setting energy policy goals (⑧), generally speaking the federal Government sets the overall targets through parliamentary/congress based debate or at a party (or presidential) platform level. Goals are formalised through different documents including strategies, action plans, Acts and laws or transnational agreements. State based targets are often in line with national level targets (aspirational or concrete).

The tools in place to achieve energy policy goals (⑨) are in all cases economically based, including FiTs, incentive payments, a form of REC or Renewable Portfolio Standard (RPS), tax or depreciation concessions and monetary non-compliance penalties. Some nations administer carbon markets or cap and trade type systems. Each of the assessed nations uses a different combination of these economic tools.

With regard to assessment of the sustainability priorities of energy policy across the assessed nations, it is clear that environmental considerations (⑩) are recognised and incorporated above all others into policy goals. All nations recognise the environmental issue of climate change (to varying degrees) and clearly identify the need for a reduction in greenhouse gases and a transition to RE sources. In the case of economic considerations (⑪), economic development is specifically identified as a central tenet of energy policy goals and nations describe the encouragement of investment in RE as a priority, through a variety of market instruments and in some cases selective prioritisation of certain RE sources. Sustainable economic growth, energy security and low or reduced energy prices are identified as priorities. In line with the economic goals, social equity (⑫) is also considered broadly by all nations. The nature of this consideration varies significantly from nation to nation, ranging from a general consideration of social issues when developing energy policy, to the specific identification of disadvantaged groups and the need for targeted support. Intergenerational equity and the need to reduce public and future burden considerations were expressed prominently among the nations assessed.

Bringing together all aspects of the energy policy QCA undertaken in this chapter, Table 2.13 summarizes the OECD policy cycle stages as shown in Figure 2.3, along with the identified key governance bodies and the priorities expressed at each stage of the energy making policy cycle.

Table 2.13. Summary of Policy Cycle, Governance, Policy Stage Priorities

Policy cycle stage	Key governance bodies	Policy stage priorities
Issue Identification	Parliament, Congress.	Climate change, transition to low carbon and RE. Reduction of GHG emissions.
Policy Formulation (Tool Development)	Ministry, Cabinet.	Stimulation of the economy. Reduction in carbon.
Decision Making (Consultation)	Designated government departments, committees and international bodies.	Federal government prerogative through strategic plans, acts or agreements.
Implementation	Ministries, departments, regulators and independent bodies.	Transition of the energy system to RE. GHG emissions reduction. Economic development. Reduce costs.
Evaluation	Departments.	Achievement of policy targets.

2.5 Discussion

Through an assessment of energy policy development and the processes followed in eight OECD nations, inconsistencies are brought to the fore. The most striking of these inconsistencies is the apparent misalignment of energy policy tools with energy policy goals, particularly with regard to the social aspects of sustainability. From the summary of the QCA process, provided in Table 2.13, there is a clear disconnect between issue identification, policy formulation (tool selection and target setting) and the latter steps through to evaluation. Quantitative targets proposed are all based on an increase in the share of RE generation and environmental improvement, with no commensurate quantitative targets in place to address the social implications of energy policies in any of the nations assessed.

The policy tools used reinforce this issue, with the economic tools identified rewarding RE generators only, and which are not bound in any way to reduce potential impacts on society. Although energy policy documents qualitatively mention ideals with regard to society and fairness, no check, balance or policy tool is in place to realise these aspirational goals in a measurable (quantitative) manner in any of the nations assessed. The QCA process also identified that the social factors of sustainability are prioritised lower than environmental and economic considerations at all stages of the energy policy making cycle.

As all nations assessed are members of the OECD, the fact that income inequality is at its highest level for the past half century (OECD, 2016b), provides a rationale for the prioritisation of this issue. Indeed, the OECD specifically encourages member nations to design policy packages to tackle high inequality and promote opportunities for all, and warns that high wealth concentration limits investment opportunities (OECD, 2015b) – linking social and economic aspects of sustainability within policy approaches.

In order to improve the policy making process and to align policy goals with policy tools and desired sustainability outcomes, the QCA evaluation of policy making in this research has identified the opportunity for the introduction of a "policy pre-evaluation" phase, in which different policy tools can be measured against not only environmental and economic goals but also from a social impact point of view. A specific sub step of this phase would be the introduction of a 'sustainability assessment' in order that economic, environmental and social equity impacts of a given policy (or several alternatives) can be measured against nationally desirable targets. This assessment will assist in the achievement of economic and environmental goals and the meaningful incorporation of the identified social equity ideals specific to each nation.

The introduction of a pre-implementation evaluation phase prior to decision making and implementation will enable policies to meet sustainability goals to a higher degree than is currently experienced. It will also improve the policy making process such that post-implementation evaluation can be reduced in severity, and to avoid policy termination in preference for radically different policy approaches. This will allow the final evaluation stage to be focused on balance, in order to re-align energy policies with changing national level goals or shifting national sentiment and to maintain energy policy sustainability.

Figure 2.4 outlines this proposed refinement to the existing process, specific to energy policy making within the assessed nations.

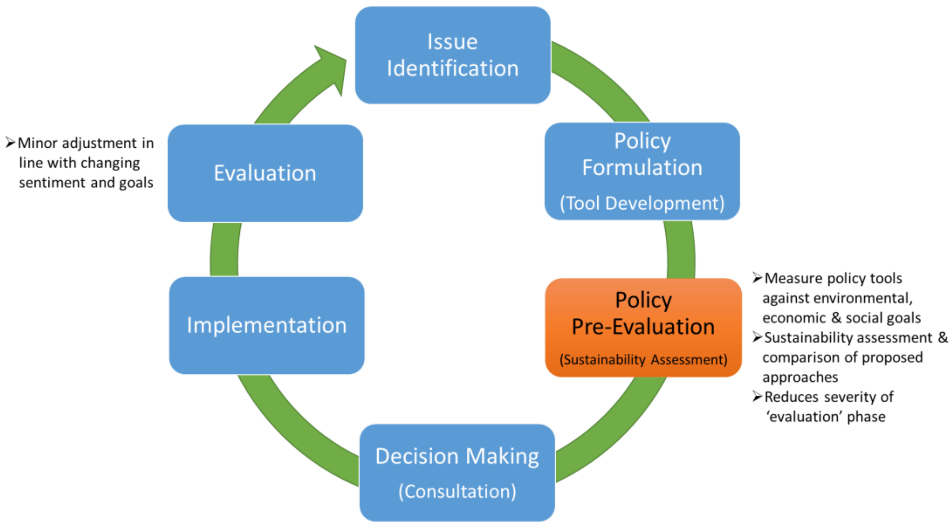


Figure 2.4 Revised Energy Policy Making Process

An additional stage entitled policy pre-evaluation is added to the energy policy cycle, in which a sustainability assessment of policy tools considering national environmental, economic and social goals is made, prior to decision making. This assessment prioritises sustainability, and allows current economic approaches and any technological approaches within the energy system to be tested against the abovementioned sustainability factors in order to derive policies which can best achieve goals in the most sustainable way.

The reason for the introduction of a separate step is twofold: firstly, the separation of policy formulation and policy pre-evaluation draws attention to the need for sustainability assessment prior to decision making and implementation. Secondly, by introducing a distinct policy pre-evaluation step in the policy cycle, specific expertise can be allocated to it, particularly if such expertise does not exist within the current bureaucracy.

2.6 Conclusions

In this chapter, eight nations, representative of constitutional monarchies, republics, parliamentary and congress style governance systems, each with high income inequality within the OECD were evaluated through a QCA process assessing both policy processes and sustainability priorities.

The hypotheses proposed by this research asked two questions: 1) Whether the energy policy development process is consistent across the eight nations assessed within the OECD, and 2) Whether policy mechanisms are poorly designed, lacking robustness in order to achieve sustainability goals.

Both hypotheses were shown to be true; for the eight OECD nations investigated, a fundamentally congruous policy making process was identified, in both the nature of policy goals and the variety of economic tools used to achieve them, as outlined in Section 2.4.2 and summarised at Figure 2.3. Secondly, building on these findings, policy processes in all assessed nations showed similar weaknesses. These were identified as the misalignment of policy tools and policy goals from a sustainability point of view, and a lack of focus on OECD identified important social issues such as inequality.

A remedy is proposed in order to address these issues through the addition of a discrete 'policy pre-evaluation' phase in the OECD policy cycle, as shown at Figure 2.4. This is an important revision because it not only addresses the identified shortcomings of current practice, but provides an evidence base for the improvement of policy making within the OECD through better policy design and improved sustainability outcomes resultant from energy policy implementation.

3. Australian Residential Renewable Energy Policy Case Study

3.1 Introduction

Governments in the OECD, and indeed around the world have attempted to stimulate the installation of renewable energy at the community level as part of an overall strategy to achieve energy security (Cherrington et al, 2013) and address climate change by reducing GHG emissions (Buckman and Diesendorf, 2010). In order to achieve desired installation targets, governments use a variety of stimulatory policies and tools including Feed-in Tariffs, point of sale rebates, including Renewable Energy Certificates, and tax benefits. These policies have been successful in increasing installations around the world, most prominently for solar PV systems within the residential sector (e.g. Japan (Muhammad-Sukki et al, 2014) and the United Kingdom (Cherrington et al, 2013)). Following on from an overall evaluation of OECD nation's energy policies, in this chapter, the Australian case is analysed as a useful example with good data availability, in a country that has a very high GHG emissions intensity in its electricity generation mix among its OECD peers, and comparatively high potential for the deployment of solar energy.

This chapter brings together analysis of five criteria which are impacted directly by State and Federal PV policy settings: installation rates and impetus for installation, employment, market development, a gross and net FiT analysis and environmental outcome evaluation. Rather than an overall high-level policy or single factor analysis, this chapter provides a detailed analysis of the impacts within each of the five criteria and provides a definitive determination of the successes, failures and impacts of residential PV policies in Australia, when measured against stated government targets.

Whilst FiT and REC settings have fluctuated over time, key goals of Australian renewable energy policy have been met, including the installation of significant amounts of new renewable energy sources, in this case residential PV. In addition, this installation of PV systems has ensured that a small proportion of the environmental target of greenhouse gas reduction, as part of Australia's Kyoto Protocol commitments has been met, and some fossil fuel based electricity generation will be subsequently displaced within the Australian electricity market.

The achievement of these goals is noteworthy, however it is also apparent from this case study that the rapidly changing, unstable nature of policy settings has not boded well for industry development, indeed Australian PV-related employment levels are significantly lower than in Europe and America, and growth is not being sustained due to ever-decreasing, and in some cases disappearing FiT regimes.

3.2 Parameters of the Case Study

The case study uses Australian Government data, previously undertaken research, and various databases across national and international energy agencies, industry bodies, electricity suppliers and Australian PV reporting and regulatory organisations to describe the key outcomes of residential PV policies from 2001 to 2012. these include: installation rates, system sizes, employment, market growth and maturity, FiT and REC impacts and environmental outcomes. Analysis of these outcomes is undertaken, followed by a discussion of the ramifications of policy settings during this period which highlights the successes and failures of the policies according to national targets, and highlights salient issues which require further investigation from a societal equity point of view. The case study focuses on the NEM states, of Queensland, New South Wales, Australian Capital Territory, Victoria, South Australia and Tasmania, shown in Figure 3.1.

Figure 3.1 Map of the Australian NEM

3.2.1 Installations and System Size

The most immediately apparent outcome of the REC and FiT policies is the high per capita uptake of household PV. Figure 3.2 shows the nationwide total yearly installation rates from 2001-2012 and demonstrates the period of the Federal REC scheme, and State FiT schemes.

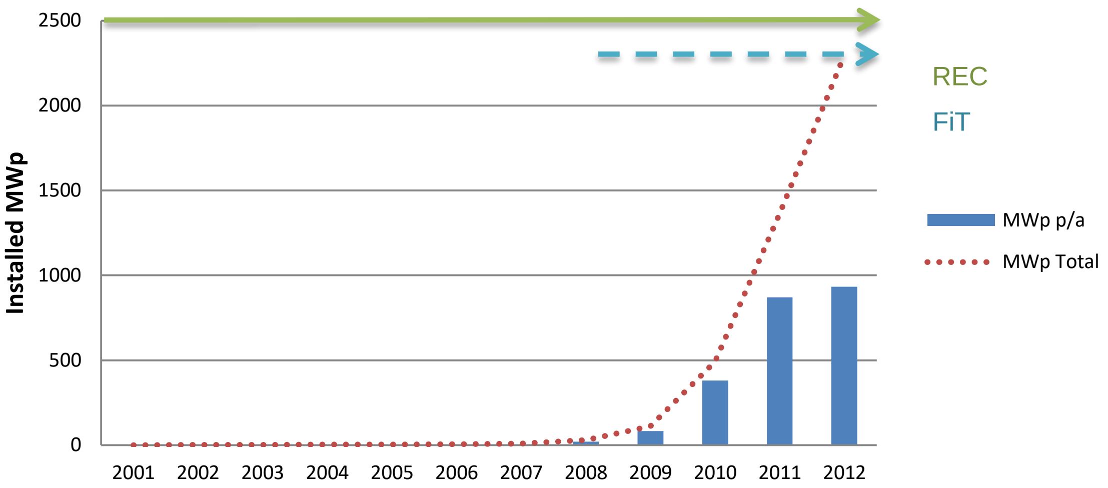


Figure 3.2 Cumulative & Annual Installed Residential PV Systems (CEC, 2013)

At the end of 2012, Queensland had almost one-third of all PV capacity in Australia, followed by New South Wales with 22 per cent. Other states with significant levels of PV installation were Victoria, South Australia and Western Australia with 18, 15 and 12 per cent respectively. Tasmania and the Australian Capital Territory both accounted for just one per cent, as outlined in Figure 3.3.

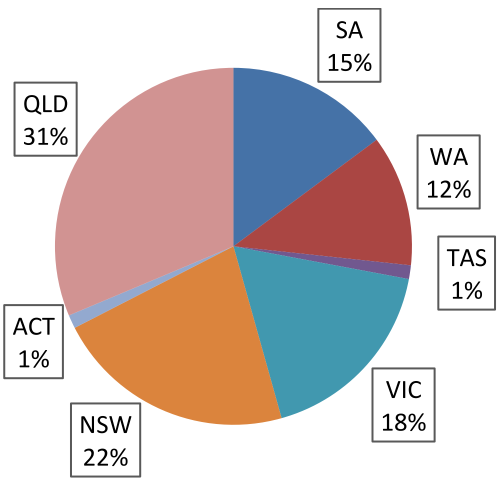


Figure 3.3 State Share of PV Installations at the End of 2012 (CEC, 2013)

On a per household installation basis, Queensland had the greatest installation density with approximately one in 14 households having a solar system, followed by South Australia (one in 17), Western Australia (one in 22), Victoria (one in 33), Tasmania (one in 35), New South Wales (one in 52), the Australian Capital Territory (one in 97) and the Northern Territory (one in 158). The Australian average was one in 26 solar households by the end of 2012 (household numbers derived from ABS Household and Family Projections, 2015).

Over the same time period, the average PV system size being installed in each state also changed (Clean Energy Council, 2013) to take advantage of REC and FiT benefits as shown in Figure 3.4 (States with market shares less than one per cent are not shown).

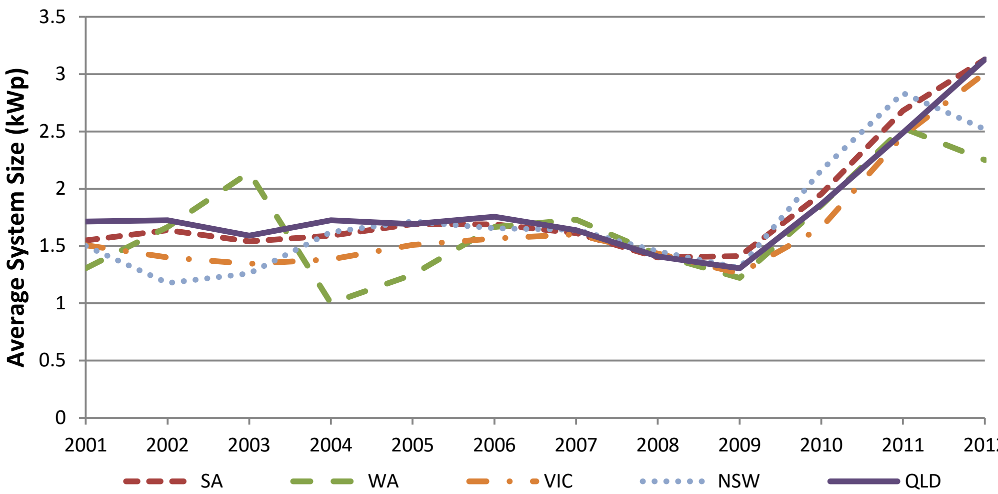


Figure 3.4 Average PV System Size 2001-2012 (adapted from CEC, 2013)

3.2.2 Employment

Alongside installation growth in Australia, employment also boomed between 2008 and 2012. Full time equivalent (FTE) employment numbers for PV in Australia are broken down across five groups: public research, education and training, manufacturing – including company research and development, sales, design, engineering and consulting, installation and maintenance, and electricity utility, industry support and government positions. The changing numbers of jobs as expressed in Figure 3.5 are adapted from data in 'PV in Australia' reports, as part of the International Energy Agency's Co-operative Program on Photovoltaic Power Systems (APVA 2002-2013).

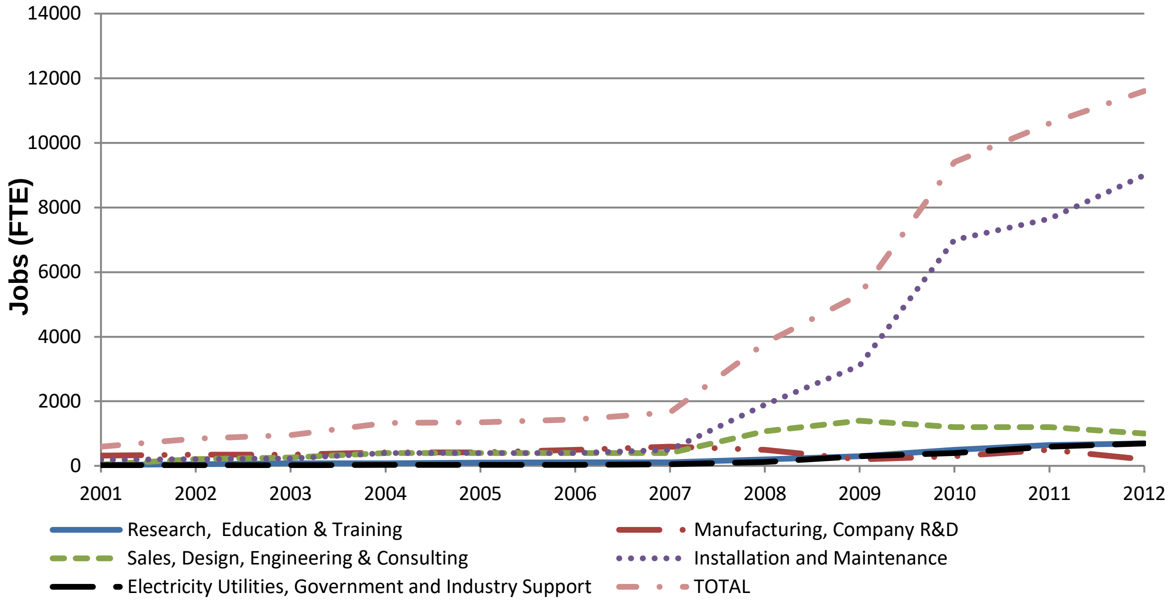


Figure 3.5 PV Jobs 2001-2012 (adapted from APVA, 2002-13)

The total number of jobs, ranging from just 600 in 2001, up to 11,600 in 2012 includes all four PV sub-markets including off-grid domestic, off-grid non-domestic, grid connected centralised, and the focus of this chapter and most dominant sub-market of grid-connected residential PV. Approximately 78 per cent of total jobs in 2012 are made up by installation and maintenance positions.

Evidence of the domestic PV industry, dominated by installation and maintenance roles is shown in Figure 3.6. The number of accredited PV system installer and designers increased rapidly from just 108 in 2001, to 4,821 in 2012 to support the growing national demand for household PV systems. Accreditation has been administered by the Clean Energy Council since before the year 2000 when there were only 4 nationally accredited installers, and includes training through a registered training organisation, application for provisional accreditation, holding an electrical licence and sufficient public liability insurance. Transition from provisional accreditation is facilitated through the submission of a system installation case study which is assessed by a technical expert prior to full accreditation being conferred (Clean Energy Council).

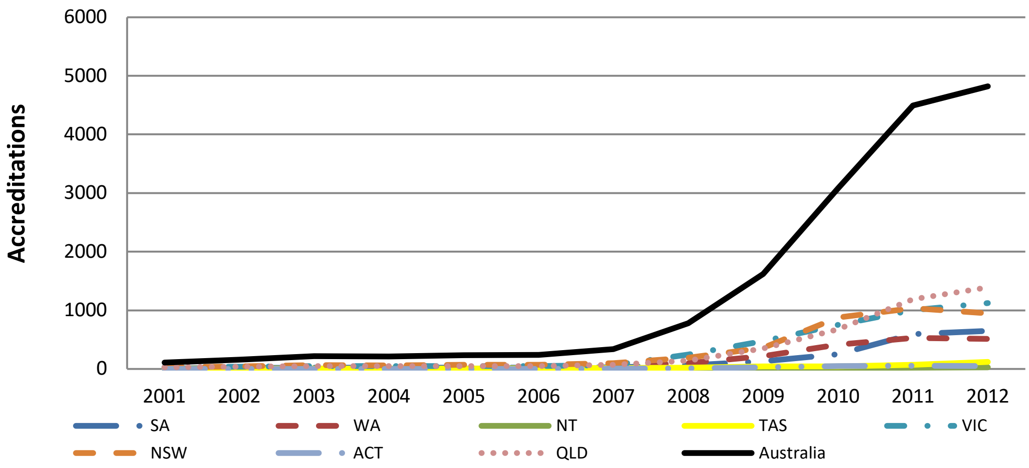


Figure 3.6 Accredited PV Installers and Designers 2001-2012 (CEC, 2013)

As demonstrated in Figure 3.7, from 2001 to 2007, a majority of PV industry jobs are attributed to off-grid systems. However, the year 2008 marks the beginning of the acceleration of the grid-connected residential distributed (domestic) PV market, and by 2012 this market accounts for approximately 95 per cent the amount of PV installed, and total PV jobs in Australia.

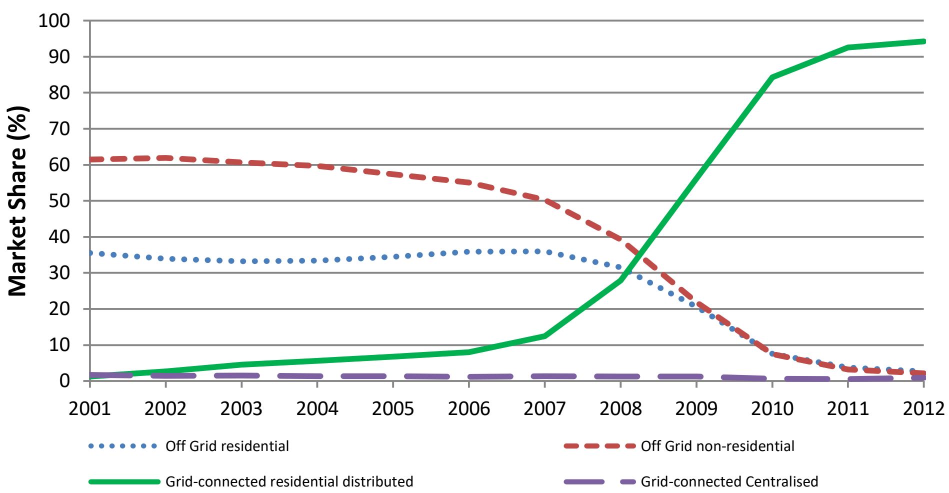


Figure 3.7 PV Market Share for Four Sub-markets 2001-2012 (APVA, 2013)

It is important to note that the size of these sub-markets are vastly different, the off-grid markets which were dominant from 2001-2007 had a combined size of approximately 30MWp in 2001, growing to approximately 66MWp by the end of 2007. During the same period, the grid-connected residential sub market accounted for between 3 and 15MWp, however from 2008 onwards this sub-market grew rapidly, and by 2012 accounted for almost 2300 MWp, whilst the two off grid sub-markets grew to a combined total of just 118MWp (APVA, 2013).

3.2.3 Price Performance with Market Maturity

As a result of the rapid growth of the residential PV market in Australia, the installed price of solar systems between 1.5 and 3kW decreased from a high of $15 per watt installed in 2004, to a low of $3 per watt in 2012. Over the same period, the module price reduced from $8 per watt to $1.80 per watt due to global panel cost reductions (APVA, 2013). The number of overall jobs steadily increases as demonstrated in Figure 3.9, however after a sharp increase between 2008 and 2009, the total number of full time employees (directly related to PV) per MWp decreases from a high of 48 in 2008 to a low of approximately 11 by the year 2012. The majority of these jobs are in installation and maintenance, reaching a high of 24 FTE/MWp in 2008, reducing each year to approximately 8.5 in 2012. Figure 3.8 and Figure 3.9 show the reducing cost of PV modules and systems alongside the overall and installation FTEs per MW installed, and the number of systems installed from 2001-2012 (APVA, 2013, CEC, 2014).

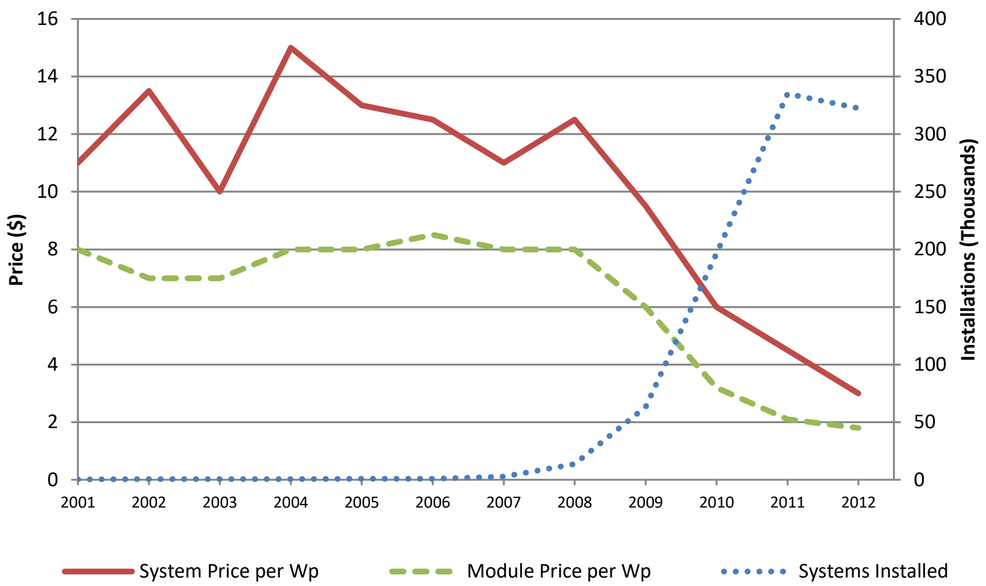


Figure 3.8 Systems Installed and Price

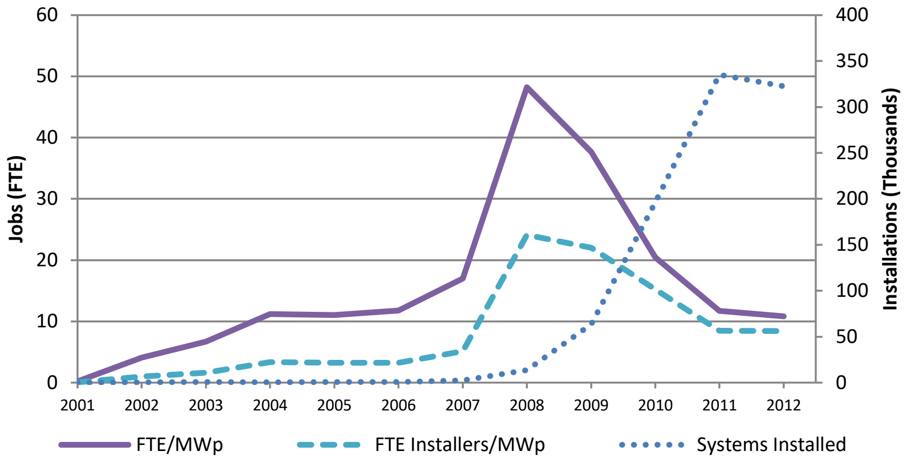


Figure 3.9 Systems Installed and FTE/MWp

3.2.4 Gross and Net FiT Income

Australian states embraced many different FiT levels, across two distinct types: gross and net. A gross FiT rewards the household with the value of 100 per cent of electricity generated, irrespective of the usage pattern or time of use. Under a net FiT, the household is only remunerated for electricity which is exported to the grid. Electricity used within the household during times of PV generation offsets the use of fossil fuels, and reduces the overall electricity bill, but only at the same value as the cost of electricity. Only excess electricity is rewarded at the (usually) higher FiT rate.

In New South Wales, the largest installer of PV under a gross FiT, an assessment of 30-minute generation data of 300 households (data provided by Ausgrid Network, 2011) was conducted to determine the average monthly PV generation, shown by season in Figure 3.10.

Analysis showed that each kWp of installed PV generates between approximately 2kWh (July, winter) and 4.6kWh (January, summer), for an average of about 3.5kWh per day (Figure 3.11). The systems assessed are all eligible for the 60c/kWh gross FiT.

In contrast, under a net FiT, utilising the same group of households, during the same time period, with an average system size of 1.6kWp, approximately 35 per cent of all annual PV generation is exported to the grid (IPART, 2012). Figure 3.12 demonstrates an example of the PV generation curve and electricity consumption pattern for June 2010.

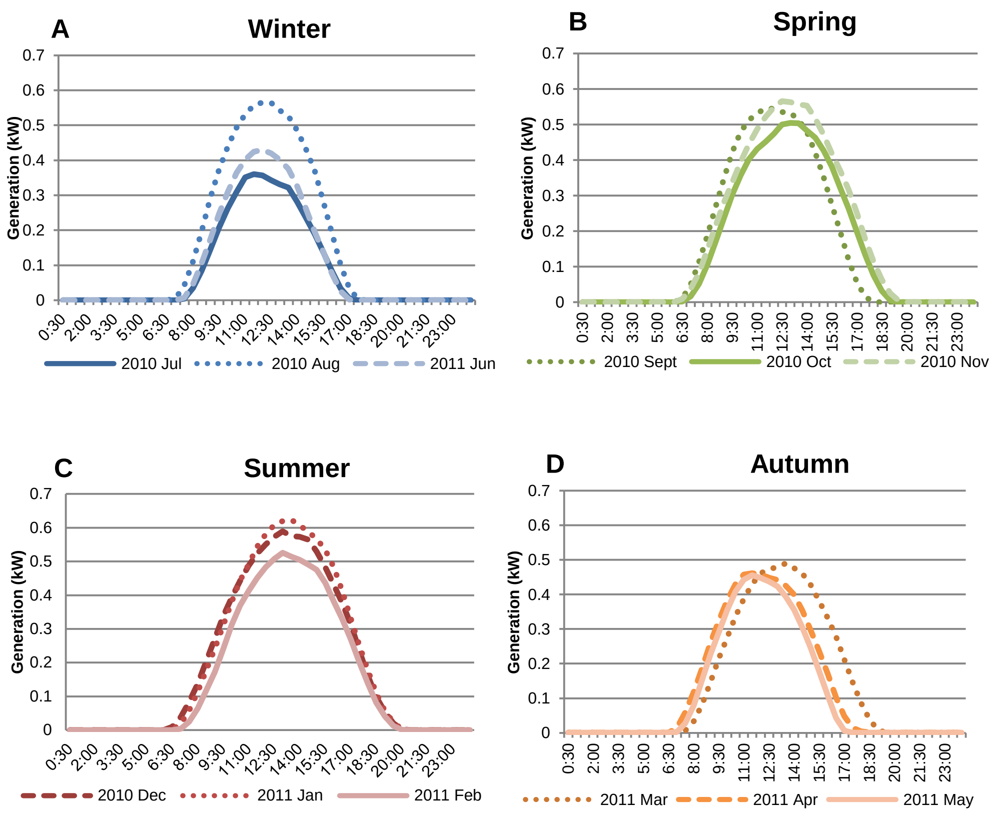


Figure 3.10 NSW Average Monthly PV Generation per kWp

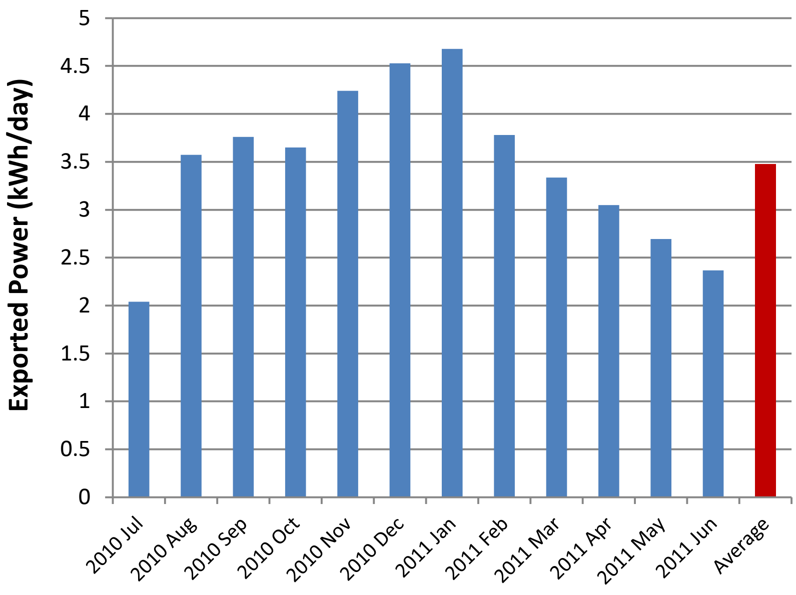


Figure 3.11 Average Gross PV Electricity Exports

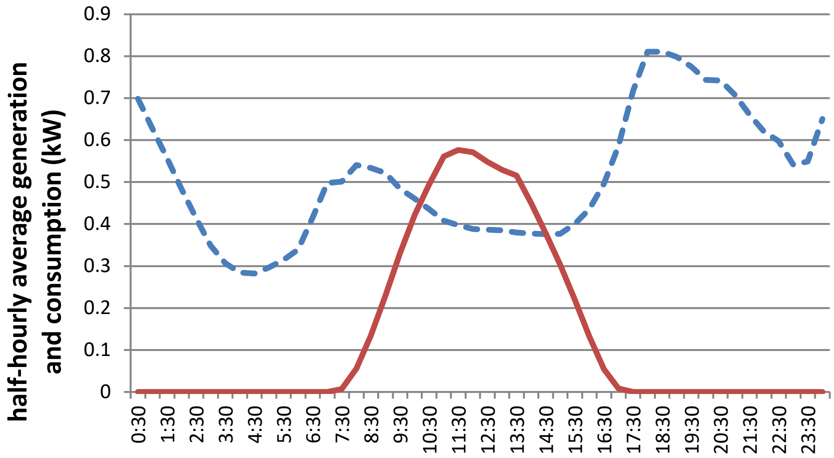


Figure 3.12 Example Net PV Export and Electricity Consumption (June 2010)

The net FiT, eventually introduced in NSW on 27 October 2010 was set at 20 cents, approximately equal to the retail cost of electricity.

Net and gross FiTs and FiT levels have markedly different impacts on the price of electricity. The nature and scale of these impacts are described within the analysis section of this chapter.

3.2.5 Environmental Benefits

By the end of 2012, within the NEM states PV installations amounted to approximately 2019 MWp. Using assumed best case electricity generation scenarios for each of the state's PV totals (Clean Energy Council, 2011), an estimate of the best case MWh output for the NEM states can be determined, as outlined in Table 3.1.

Table 3.1 PV electricity generation 2012

State	MWp Installed	MWh per MWp/Day	Total Generation (GWh)/Year
SA	339.61	4.2	520.6
TAS	28.44	3.5	36.3
VIC	405.81	3.6	532.2
NSW	499.37	3.9	710.9
ACT	28.14	4.3	44.2
QLD	717.94	4.2	1100.6
NEM Total	2019.31	4	2944.8

The total installed capacity of the NEM is 48,321MW, meaning that residential PV accounts for some 4.2 per cent of this capacity, however the respective total generation within the NEM in 2012 was approximately 199 terawatt hours (AER, 2013), meaning that residential PV accounts for just under 1.48 per cent of total electricity supplied to the grid (under a best case scenario) during 2012.

Ignoring the embodied energy and lifecycle costs of PV panels, all of the electricity generated is carbon free, and where this offsets the consumption of fossil fuels, it represents a reduction in GHG of approximately 0.79t per MWh (Vivid Economics, 2013).

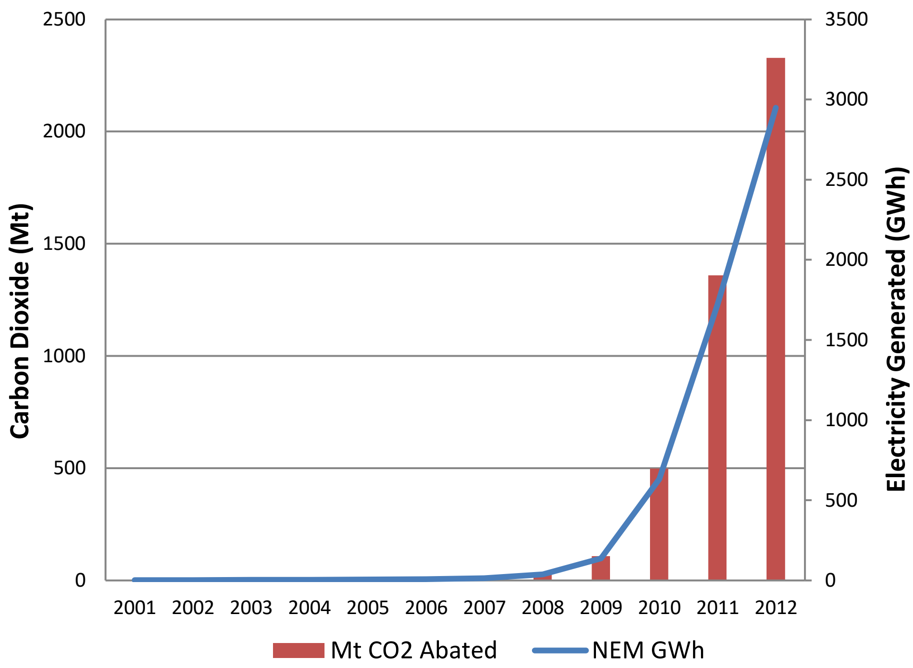


Figure 3.13 NEM Residential PV Electricity Generation and CO2 Reduction

Assuming that each yearly total amount of installed PV generates electricity over the same year, over the period of 2001-2012, the NEM States offset approximately 2330Mt of CO_2 (Figure 3.13). This represents a carbon dioxide offset of just over 1.48 per cent of the total NEM emissions for 2012, which are generated by a 75 per cent black and brown coal based network (AER, 2013).

3.3 Analysis, Discussion and Implications

Following from the presentation of data which describes key outcomes in Australia during 2001-2012 in section 2.2, this section analyses these outcomes and presents the key findings of Australian PV policy with regard to its successes and failures and any future ramifications resultant from policy settings.

3.3.1 Key policy drivers of PV installations

Based on a comparison of REC and FiT outcomes as described in Section 2.2.1, it is reasonable to assume that the state-administered FiTs had a markedly higher effect on the deployment rate of residential PV, as evidenced by the rapid jump in installation rates from2008, the year FiTs were introduced.

Further, the high level of correlation with FiT levels and annual PV installation MWp within the NEM (as shown in Figure 3.14) suggests that investors in small-scale renewable energy are looking for long term support of their purchase, through income from the export of energy to the grid, or reducing consumption of grid based electricity through efficient use of the electricity generated by their PV system. REC prices, although providing a point of sale rebate and reducing the overall cost of a PV system, do not appear to provide a significant portion of the consumers' incentive for initial installation of PV at the household level. This premise is supported again by the PV system size reduction observed in both WA and NSW in 2012, when their respective FiTs were removed (Figure 3.4).

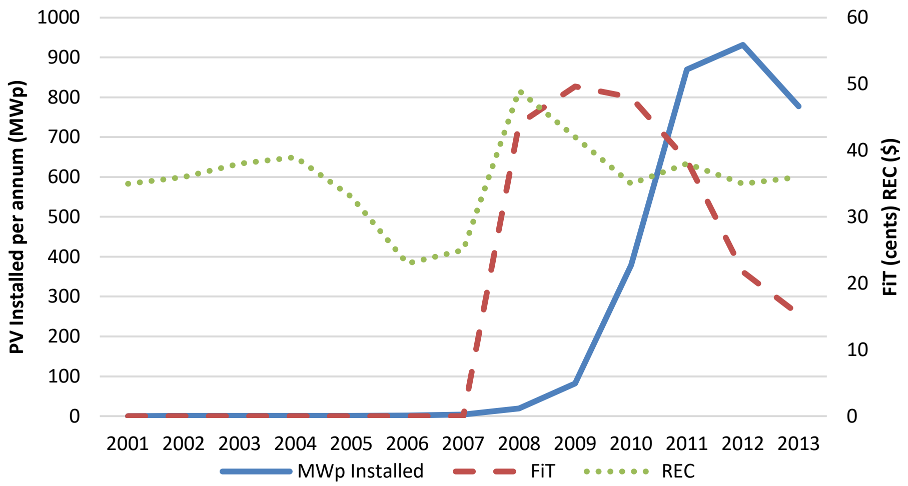


Figure 3.14 Correlation Between FiT levels & Annual PV Installations (CEC, 2014)

As FiT levels decline, annual installation levels also decline. It is therefore reasonable to assume that a continued decline or indeed cessation of FiTs will lead to a further decline in annual installations. This decline will likely have a negative impact on industry development and employment levels.

3.3.2 Employment and industry development

Analysis of the direct PV employment data (CEC, 2014) (Figure 3.5) within Australia from 2001-2012 identifies that:

1. The employment market is dominated by installation and maintenance jobs (just under 78 per cent);

2. In support of these installation and maintenance jobs, the second largest industry group is sales, design, engineering & consulting, making up almost 9 per cent of all FTEs; and, as a result

3. Manufacturing, company research and development account for less than 2 per cent of all PV jobs.

Australia is clearly shown to be a country which exclusively imports household PV modules from other countries, and although limited research and development activity is occurring indigenously, this is not translating to the invigoration of local manufacturing. Further, as the vast majority (more than 86 per cent) of jobs within Australia are related to sales, system design, installation and maintenance of PV systems, these jobs are reliant on sustained installation rates, which are in turn dependent on sufficient FiT levels into the future.

In addition, Australia's directly employed 10.8 FTE per megawatt installed is low when compared to that of Europe, specifically Germany, a PV powerhouse with some 7604MW installed in 2012 (Eurobserv'er, 2013). Although the directly employed figures are similar for system installers per MWp installed, Germany enjoys significant additional FTE for module production (3-7 FTE/MWp), and also manufactures inverter and Balance of System components (2-3 FTE/MWp respectively). The existence of these additional manufacturing jobs alone increases the required number of resultant administrative roles including sales and marketing (2-4 FTE/MWp). The total number of directly PV related jobs in Europe for manufacturing nations such as Germany is up to 20 FTE/MWp (EPIA, 2012; excluding R&D which can add an additional 1-2 FTE/MWp), approximately double that of Australia in 2012. The European Photovoltaic Industry Association (EPIA) estimates that for every direct PV job, two indirect jobs are created meaning that a contraction in the PV industry will have significant flow-on effects for external support industries.

This effect on employment numbers may be a result of the different strategic purposes of renewable energy targets, which in Australia are somewhat passive and aim only for the "promotion of the renewable energy industry". Countries like Germany on the other hand, have a more active stance which includes the national objective of "economic prosperity through jobs and innovation" for their renewable energy industry (WWF and WRI, 2013).

With FiTs being reduced and REC multipliers being phased out in Australia, direct PV FTE numbers are also declining. Further, PV jobs are vulnerable to contraction of the industry at differing rates for different types of jobs. The main employer in Australia, installation and maintenance, is considered relatively safe, as employees in this stream have transferrable skills (i.e. electrical contractors). It is estimated that 75 per cent of these employees could be relocated across other industries. The most vulnerable jobs are wholesalers and retailers, of which only 25 per cent are expected to be able to transition to alternative activities (Intelligent Energy Systems, 2012).

3.3.3 Market Development and Maturity

The maturing of the Australian residential PV market has important, directly observable impacts. Firstly, over time, even as installation rates increase year on year, following an initial spike when the FiT is introduced in 2008 the jobs to MWp ratio declines significantly each year before stabilising around 2011-12. Further, over time, installation and maintenance jobs account for an ever increasing percentage of total jobs.

Secondly, this installation and maintenance centric employment market develops over time, through an increasingly skilled workforce, economies of scale, and a decrease in system mark-up (system price – module price), demonstrated by the shrinking gap between module price and system prices, shown in Figure 3.15.

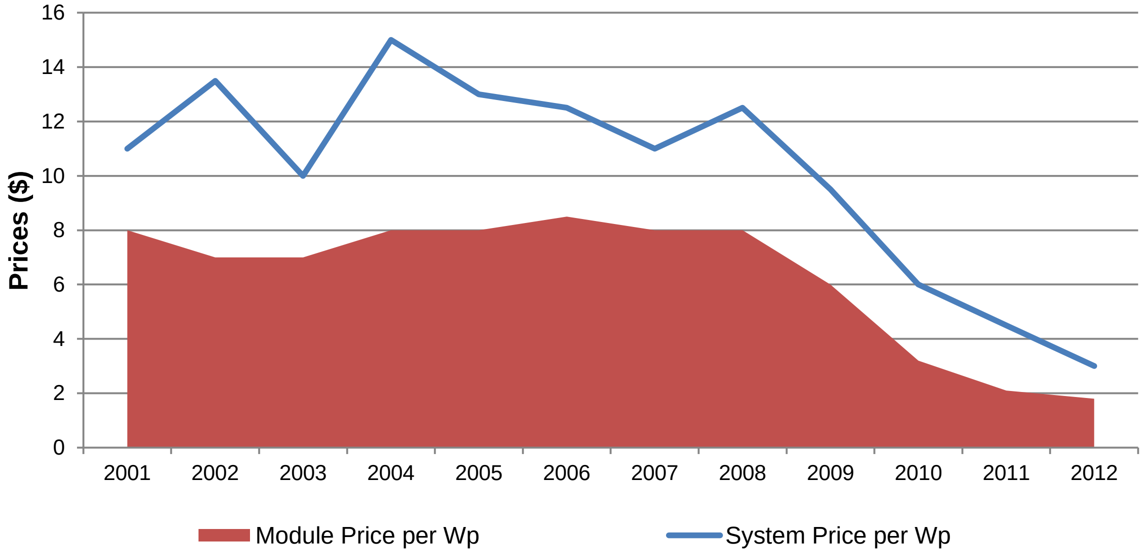


Figure 3.15 Comparison of PV System and Module Prices

The maturing of the installation workforce is clearly demonstrated in Figure 3.16 which shows the declining trend of per system mark-up as the number of systems installed increases over time.

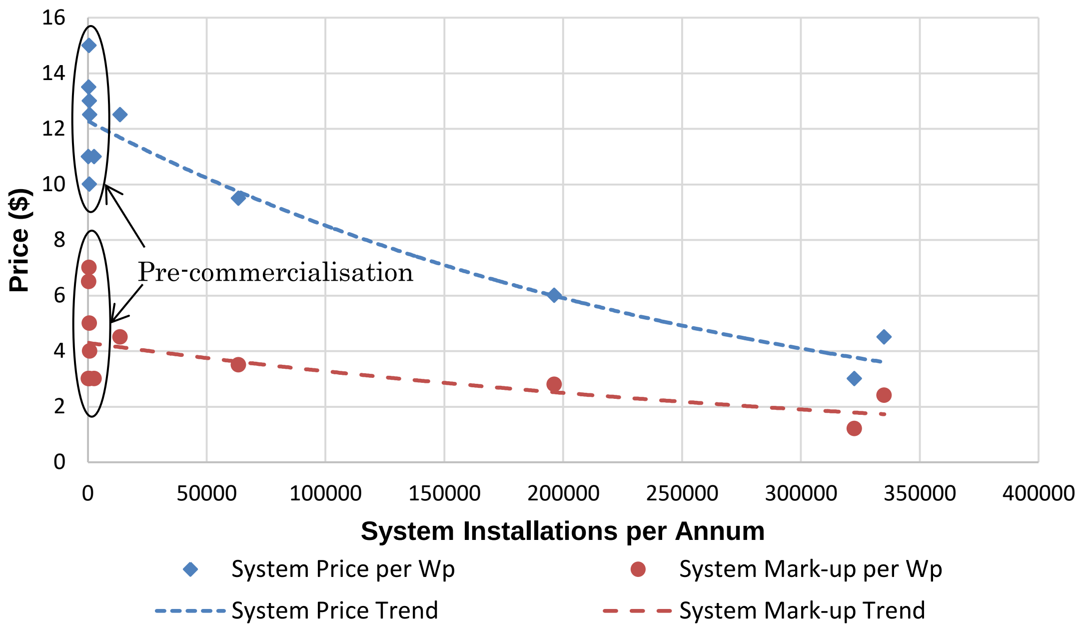


Figure 3.16 PV System Installations: Price and Mark-up Trends

Similarly, as system installations increase, and the commercialisation of PV installation occurs, coinciding with the introduction of the FiT in 2008, a rapid reduction in the number of installation and maintenance FTEs per MWp installed occurs as shown in Figure 3.17. Installers per MWp are divided into two groups; a pre-commercialisation group showing FTE per MWp prior to the introduction of the FiT, when installation numbers were insignificant, and, a post-commercialisation group to demonstrate the impact of rapid PV system deployment on installation FTEs per MWp.

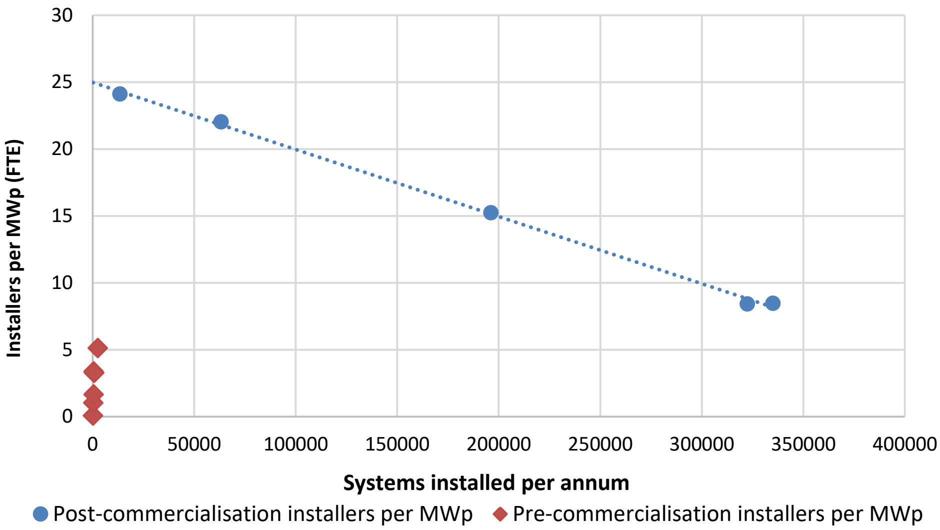


Figure 3.17 Market Maturity Impact on PV Installation & Maintenance Workforce

A unique factor of the Australian PV market is that the majority of learning is associated with installation and maintenance, over 77 per cent of all PV jobs are within this industry group, and in contrast to European markets, no learning is achieved in manufacturing. Reducing module costs are due to exogenous factors.

Learning by doing is shown to be the key endogenous factor in the Australian PV industry, reducing the number of installation and maintenance FTEs required per MWp over time.

Additionally, some system inefficiencies were overcome over time. For example, the large number of per MWp FTEs employed between 2008 and 2009 consisted of between 50 and 60 per cent installation and maintenance jobs, with over a quarter of all jobs accounted for by sales, design, engineering and accounting positions. This balance changed markedly in 2010, with sales, design, engineering and accounting jobs halving to account for under 13 per cent of the total, to eventually account for less than 9 per cent by 2012 (Figure 3.18).

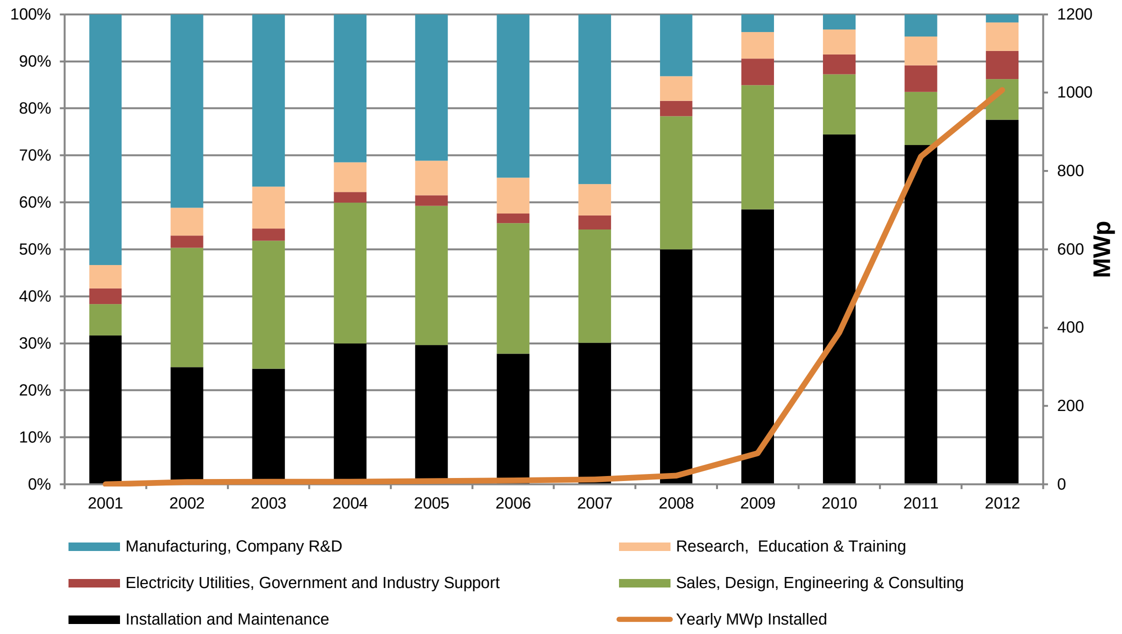


Figure 3.18 PV Industry Employee Percentages

This trend suggests that the transition to a FiT regime and the associated administrative burden and learning period required an additional employment base until learnings were made and efficiencies achieved. It is reasonable to assume that the incorporation of the FiT, adding an additional layer of government approval and administration (State) exacerbated this employment boom. The introduction of the FiT lead to an ever reducing percentage of manufacturing jobs, with no significant growth in FTE numbers. In fact, manufacturing jobs declined to their lowest level in 2012, even lower than as at 2001 levels. Figure 3.19 outlines the FTE numbers for each industry grouping (except for installation and maintenance), and compares their growth with annual PV MWp installations. During the period of the FiT, each industry group shows an increase in FTEs each year, except for manufacturing and R&D and sales and design, engineering and consulting jobs, which, after a brief spike in 2008-09 reduced to below 2008 levels by 2012 further demonstrating the streamlining within this industry sector.

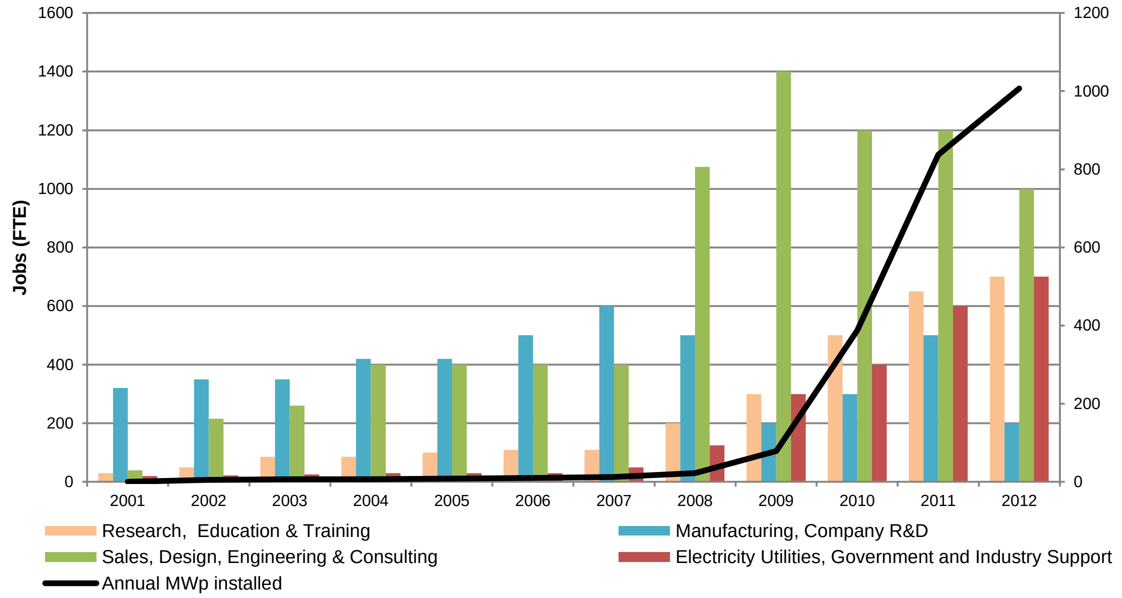


Figure 3.19 FTE Growth by Industry Group

3.3.4 FiT-based income and impact on electricity prices

The assessment of net and gross FiT regimes within NSW, as described in Section 2.2.4, allows for a determination of the overall cost of each type of FiT regime, and also gives a basis from which to estimate the overall impact on electricity prices within the investigated jurisdictions.

In the case of a gross FiT, as administered in NSW from 1 January to 27 October of 2010, the income per kWp installed is approximately $760.00 per annum at 60 cents per kWh exported. Assuming that all of the 149.19MWp installed in 2010 was eligible for this FiT (a reasonable and conservative assumption, as systems had only to be purchased by the end date of 27 October – installation could occur later (NSW Trade and Investment, 2013)), the total FiT payments would amount to $113.4 million dollars in 2010. Expressed as a cost per household, this comes to approximately $40.50 for every household within NSW for the year 2010 (household numbers derived from ABS Data, 2010).

The average annual electricity consumption per household in NSW was 7082kWh (ACIL Tasman, 2011), or 19.4kWh per household per day. In 2010-11 retail tariffs for electricity were approximately 19 c/kWh (Industry and Investment NSW, 2010). The average household bill (excluding supply charges) was approximately $1345 per annum. In Australia, the cost of FiT payments are firstly borne by electricity retailers and then passed onto residential customers through increased electricity bills. A comparison of gross and net FiT impacts, using data from NSW in 2010 under 3 FiT price scenarios is shown in Table 3.2.

Table 3.2 FiT setting comparison based on 2010 NSW PV generation data

Scenario	FiT type	FiT price/ kWh	Solar output/ kWp	Exported to grid/ kWp	FiT payment/ kWp	Impact on electricity bill per household p/a
1	Gross	60c	1267kWh	1267kWh	$760	$40.50 or 3.01%
2	Net	60c	1267kWh	443kWh	$266	$14.17 or 1.05%
3	Net	20c	1267kWh	443kWh	$89	$4.74 or 0.35%

Scenario 1 shows that under a gross FiT, as was in place in NSW in 2010, the annual impact on electricity bills is a significant 3 per cent increase. The introduction of a net FiT, even at the same generous rate as the preceding gross FiT, as in Scenario 2, reduces the burden on non-solar households by approximately 65 per cent, in the above example reducing the overall impact to a 1 per cent per annum increase for average electricity bills. This reduction in electricity bill percentage increase is directly proportional to the percentage of annually exported PV generated electricity. Scenario 3 demonstrates the further reduced electricity bill impacts under a net FiT with a lower FiT price of 20 cents per kWh (as occurred in NSW on 27 October 2010).

The impact of gross and net FiTs on electricity prices within NSW are cumulative and ongoing. Analysis provided by the Independent Pricing and Regulatory Tribunal describes how PV uptake has often exceeded levels anticipated by governments, and this can exacerbate the cost of FiT schemes (IPART, 2012). Complementary to this chapter's findings, IPART estimates that the costs incurred by retailers through FiT payments and REC purchases (not considered in this chapter, resultant from the SRES) added approximately 6 per cent to electricity prices in NSW during 2011, adding credence to the figure estimated under the gross FiT scenario.

Although all households experience the electricity bill increase due to PV FiT costs, a major equity issue of the FiT is the unequal sharing of costs between solar and non-solar households. In the above example of the 2010 gross FiT impact, approximately 70,000 solar households are deriving a benefit from the FiT, whilst the remaining 2.7 million non-solar households who do not receive FiT payments are required to compensate them. Indeed, under the gross FiT scenario, for each kWp of PV installed, the solar household receives a benefit of approximately $720 (value of exported PV electricity minus the increase in electricity bill), whilst households without PV are paying $40.50 per annum. This represents a cross subsidisation, being paid for by a majority of households, for the benefit of just 2.5 per cent of households which were able to install PV during 2010.

In an attempt to remedy these emerging impacts, FiTs (with the exception of Tasmania which maintained a 1 for 1 FiT to electricity price ratio throughout 2008-2012) were unanimously reduced between 2008 and 2012 in all NEM jurisdictions. Additionally, the REC multiplier was removed six months ahead of schedule, to lower the impact of the high uptake of PV on electricity costs for homes and businesses (Ministerial Media Release, Minister for Climate Change and Energy Efficiency, Minister for Industry and Innovation, 15 Nov 2012) and to ease pressure on electricity prices.

The costs incurred by each household due to the FiT yield the social benefit of reduced CO_2 emissions, shared equally across the NEM grid through a displacement of fossil fuel generation. The scale of these emission reductions is discussed below.

3.3.5 Environmental Benefits Comparison

An investigation of a best case scenario for PV generation within the NEM has shown that although residential PV accounts for approximately 4.2 per cent of the installed generating capacity within the NEM, it produces less than 1.5 per cent of the electricity consumed, with a capacity factor of approximately 16.7 per cent. Based on the NEM generation intensity of 0.79tCO_2e/MWh (Vivid Economics, 2013), this means that for every MWp of PV installed within the NEM we can expect a reduction in CO_2 of approximately 1.15 tonnes per annum.

The two alternative major sources of grid connected renewable energy within the NEM are wind power, prominently in South Australia, and hydroelectricity which is concentrated in the Snowy Mountains of NSW and throughout Tasmania.

Wind power accounts for 5.4 per cent of capacity within the NEM, but due to intermittency only accounts for 3.4 percent of output, with a capacity factor of approximately 29.6 per cent. Hydroelectric generation accounts for 17 percent of capacity and 9 per cent of output with a capacity factor of approximately 24.9 per cent. Based on these figures, wind power offsets approximately 2 tonnes of CO_2 per MW installed, per annum. Hydroelectric generation offsets approximately1.7 tonnes per MW/annum (AER, 2013).

Although these technologies are at differing levels of maturity, and require differing levels of support, at their current level of development and deployment, it is clear that household PV is not as effective in reducing CO_2 per MW installed as either wind power or hydroelectric generation as demonstrated in Figure 3.20.

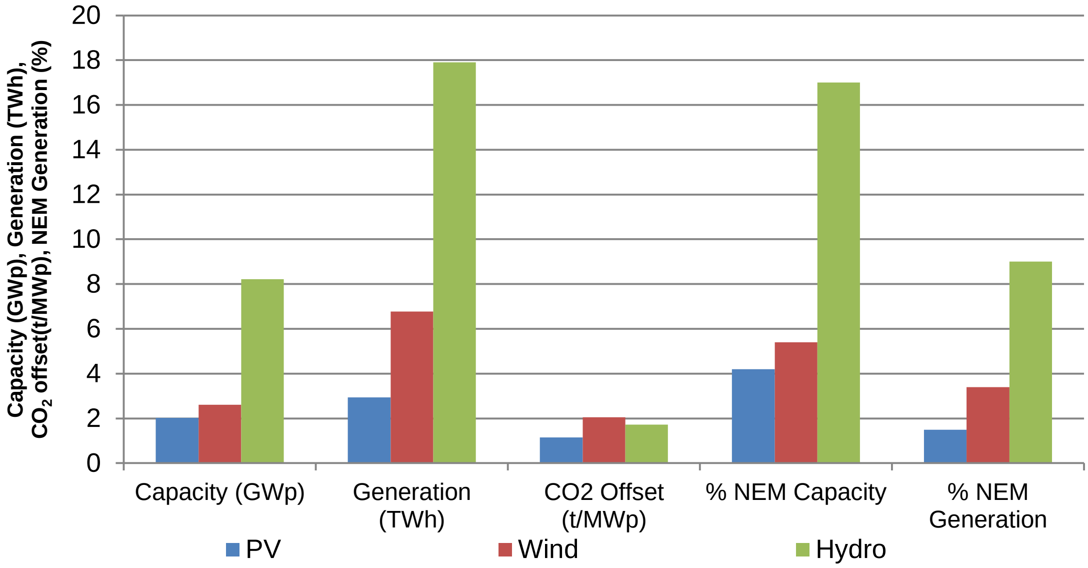


Figure 3.20 Capacity, Generation & CO2 Reduction for NEM RE Sources

These figures do not consider life cycle GHG emissions for each technology but show that wind and hydro, produce more electricity and reduce a greater amount of CO_2 per MWp installed. It is encouraging to note that in Australia, the most efficacious (from a CO_2 reduction per MWp point of view) renewable energy sources are also the most prolific. One risk of a sustained high subsidisation rate of small scale renewable energy such as PV is that a less efficacious form of renewable energy may be over-represented in the renewable energy mix.

3.4 Conclusions

This case study analysed five criteria: installation rates and impetus, employment, market maturity effects, gross and net FiT impacts and environmental outcomes to determine the successes, failures and ongoing impacts of Australian residential PV policies, when measured against the stated goals (in Section 1.1) of the Small-scale Renewable Energy Scheme within the Australian Renewable Energy Target (RET).

This case study has identified that the Australian Government was largely successful in meeting its first goal of significant new additional renewable energy. Through the addition of more than 2300MWp of residential PV from 2001-2012, a moderate reduction in electricity sector greenhouse gas emissions was achieved through the displacement of 1.5 per cent of fossil fuel based electricity generation by 2012. However, the CO_2 reduction resultant from this PV installation is overshadowed by the contributions of wind and hydro power, both in terms of tonnes of CO_2 offset per MWp installed, and overall displaced emissions. Even with significant federal and state government support over a significant period, which helped grow residential PV to account for some 16 per cent of all RE, it was not shown to be an ideal technology choice from an electricity generation or CO_2 reduction viewpoint. Further, as small-scale RECs were multiplied over a period of three years, investment into large scale RE was reduced, in turn reducing the generation and CO_2 reduction capacity of the NEM's renewable energy mix, and negatively affecting the efficient achievement of Kyoto Protocol greenhouse gas reduction goals.

With regard to promotion of the renewable energy industry, results of analyses show varied outcomes including irregular, and in all measured criteria, unsustained growth. This lead to a waxing and waning of industry groups, and an underdeveloped renewable energy industry dominated by installation and maintenance jobs, almost devoid of manufacturing activity. These outcomes can largely be attributed to inconsistent policy settings with varying levels of State and Federal Government support over time, including REC multipliers which were reduced ahead of planned timelines and the introduction of over generous FiT regimes, followed by rapid reduction and in some cases cessation of this support mechanism.

The stated goal of long term support of renewable energy industries has not been demonstrated by this case study, and indeed manufacturing and company research and development employment numbers are now lower than their 2001 levels, and sales and installation employment numbers are faltering due to this lack of ongoing support.

In addition to identifying the successes and failures of residential solar policy in Australia, policy impacts were also explored. Results of analysis over time suggest that FiTs influenced installation rates more than RECs, and were responsible for the sharp increase in installations post 2008 and also responsible for subsequent reductions in installation rates as FiTs tapered off or were removed. The differing impact levels of gross and net FiTs was explored to determine that a gross FiT is a more expensive approach than a net FiT to the deployment of PV, as all electricity generated is eligible for the tariff, and under a gross FiT there is no incentive for households to modify their electricity usage habits, by either reducing electricity consumption, or shifting the time of their consumption, as is expected under a net FiT arrangement. Additionally, FiTs caused inequitable societal outcomes, through the subsidisation of a single, non-centralised generation technology, most pronounced of which was the significant cross subsidisation from non-solar households to solar households in the form of increased electricity bills for non-participants.

As PV installations increased in Australia, it was observed that system prices and profitability of installed systems also reduced leading to a commensurate decrease of the installation and maintenance workforce per MW installed. Results showed that although Australia has similar installation and maintenance job numbers per MW installed as observed in European manufacturing nations such as Germany, only half as many people per MW installed are employed due to an almost complete lack of manufacturing or company research and development sector within the Australian PV industry.

Whilst this case study discusses the successes, failures and impacts of Australian residential solar PV policy from 2001-2012, the potential inequity of these policies warrants further investigation, considering not only the impact variation between high and low socioeconomic status groups but also factors such as support of alternative CO_2 reducing technologies, dwelling type limitations and policy development process impacts. These issues are discussed and analysed in detail in the remainder of the thesis.

4. Assessing the Sustainability of Energy Policy Performance

4.1 Introduction

The “sustainability of energy policy performance” in this thesis is defined as the degree to which policy can meet environmental and economic goals, without impairing societal equity. This definition is synonymous with the ideal of sustainability containing a subset of economic, social and environmental factors. By incorporating social equity, alongside economic and environmental factors, into policy efficacy (the ability of a policy to meet desired goals) and sustainability assessments, it is proposed that the impact of energy policy implementation on equity outcomes and overall sustainability performance can be determined.

The unique factor which will be applied to energy policy assessment in this chapter is social equity, primarily concerned with the distribution of environmental and economic costs and benefits of a policy’s implementation on society. For the purposes of this research, which considers the short-term impacts of policy decisions, equity is measured intra-generationally, focusing on the present policy scenario and projected outcomes to 2020 (a five-year period at the time of writing). In order to effect equal treatment across income levels within the examined jurisdiction, vertical equity is applied, so as to enforce a user-pays system, fair value of subsidisations and payments to participants, and to limit the burden on non-participants in subsidisation schemes – to improve equity between low and high income households.

In harmony with the ideal of maintaining balance between economy, environment and equity in order to determine holistic sustainability, each of these three key factors will be considered concurrently. It is important to note that equity is not necessarily synonymous with equality (Rose, 1990) but is uniquely determined within each society.

This chapter builds on the both the policy process findings of chapter 2 and the Australian case study outcomes detailed in chapter 3. The proposed assessment framework methodology will utilize the economic and environmental outcomes of the case study to measure both the sustainability and efficacy of energy policies, in addition to defining the role and quantification method of equity within these evaluations.

The main stimulatory measures for RE used in Australia under the Renewable Energy Target (RET) are Renewable Energy Certificates (REC) and Feed-in tariffs (FiT), suggesting that the policy sustainability assessment framework in this research could be readily applied meaningfully in other nations who utilise these stimulatory measures, have a similar structure of government and are concerned with injustices in energy and environmental matters. The OECD, previously discussed in chapter 2 provides a forum in which governments work together to share experiences and seek solutions to common problems (OECD, 2016a), of which Australia is a member. Within the OECD, there are several nations who employ similar energy policies to Australia, (including the UK, Japan and Canada among others) who also employ a similar form of government.

The aim of this chapter is to establish equity as a key consideration for energy policy development and pre-implementation sustainability evaluation, in order to provide a basis for the improvement of future energy policy design, with the aim of strong energy, environment and economic outcomes whilst decreasing inequity between societal income levels.

4.2 Establishing an Equitable Energy Policy Sustainability Framework

To demonstrate the development of an assessment methodology for the sustainability of policy performance incorporating equity, Australia was chosen, as it is a country with high greenhouse gas emissions per capita, thus requiring a shift to RE generation sources. Data is readily available with regard to RE deployment and is supported by the analysis of Australian residential RE policy from 2001-2012 outlined in chapter 3, which investigated economic and environmental impacts resultant from newly installed solar PV across this period. These impacts are discussed below.

With regard to economic factors, employment was explored including the number and types of jobs created in Australia, and the development of RE associated industries as a result of RE policies. A comparison to European solar PV component manufacturing nations is also included. The outcomes of this work links directly with the job multipliers used in this studies framework and are reflected as the employment impacts of the policy. Income and FiT impacts on pricing were explored considering the FiT approaches (gross or net) in each of the states and how RE installing households receive FiT payments according to electricity export and usage patterns. These FiT payments are recouped by electricity distributors and added to electricity bills – meaning a benefit for one group and a burden imposed upon another. This factor is incorporated into the framework as subsidy allocations and the impact on electricity prices. Learning curves were explored for the two RE technologies being rapidly deployed in Australia, wind and PV. These learning curves are reflective of the price reduction per watt installed as deployment increases, recognizing that these prices are influenced heavily by exogenous factors as Australia has a very small RE manufacturing capacity. Learning curves are summarised as market impacts in the proposed framework.

From an environmental perspective, three key factors were considered; the CO_2 reduction capacity of the three major RE technologies in the Australian market, Hydro, wind and PV. The CO_2 reduction capacity of each technology is dependent on the generation efficiency of each technology according to Australian conditions and enables the fossil fuel offset capacity of each technology to be derived. The proposed framework expands this analysis to incorporate fossil fuel CO_2 emissions and the generation efficiency, CO_2 reduction and fossil fuel offset capacity of other CO_2 reducing technologies currently deployed in the Australian market (predominantly bio-fuel and gas). Table 4.1 summarizes the economic and environmental impacts previously explored in chapter 3.

Table 4.1 Previously Investigated Australian RE Policy Impacts

Economic Impacts	Environmental Impacts
• Employment • Income • FiT impact on pricing • Learning Curves	• CO_2 reduction per technology • Generation efficiency per technology • Offset of Fossil Fuel

Additionally, Australia differentiates policy by state with regards to RE, in addition to an overarching national policy. Each state has defined their own FiT levels since 2008 along with the type of payment (net or gross), whilst the Federal Government administers the REC scheme for both large and small scale generators. FiTs pay RE generators for each kilowatt hour (kWh) of electricity exported to the grid, whilst RECs are issued and traded for cash (usually at the time of purchase, in the form of a discount for household level RE) for each megawatt hour (MWh) that the system will generate. These certificates are then purchased by energy retailers in order to meet their RE obligations under the RET.

4.2.1 Renewable Energy Policy Equity Findings

The equity impacts which have been observed post-implementation of RE policies within Australia will provide guidance for key equity factors to be incorporated into the proposed framework and are discussed below.

The equity issue most prominently identified in Australia was an increase in electricity prices due to subsidization. The analysis from chapter 2 highlighted in detail how a review by the Independent Pricing and Regulatory Tribunal (IPART) of the New South Wales State Government RE policies showed that subsidies such as the FiT can cause greater than expected installations and drive up retail electricity prices (2012). Further, the Queensland Competition Authority (QCA), in their consideration of a fair and reasonable FiT for Queensland - the state with the greatest number of residential PV installations - showed that current RE policies drove up costs for all consumers due to generous FiT levels and the need for network augmentation in order to accept significant deployment of residential PV (2013). In addition to independent third party reviews of the two states with the highest levels of subsidized RE, the Federal Government has also intervened to reduce favourable national subsidization schemes (REC multipliers) 6 months ahead of schedule, to reduce the impact of the high uptake of PV on electricity costs for homes and businesses and to ease pressure on electricity prices (Ministerial Media Release, Minister for Climate Change and Energy Efficiency, Minister for Industry and Innovation, 15 Nov 2012).

It is reasonable to assume that for any group of consumers, in this case home owners who could afford to install PV, to enjoy a benefit such as electricity prices below the cost of their consumption, that the remainder of consumers must pay for this benefit (whilst recognizing that there is an upfront investment by PV installing consumers). Third party analysis and Ministerial statements by those ultimately responsible for RE policy implementation recognized that those who can least afford to participate in subsidization schemes are likely subsidizing users who receive a benefit, identifying both inequitable participation and allocation of subsidies (Commonwealth of Australia, 2011, Ministerial Media Release, Minister for Energy and Water Supply, QLD, 26 June 2012, QCA, 2013).

It has been identified that the type and method of implementation of subsidies can have a marked effect on the technologies deployed, and therefore the environmental efficacy (ability to generate renewable energy based electricity and reduce greenhouse gases) and public benefits of RE policy. In Australia, there is evidence that the FiT lead to a very high cost of greenhouse gas abatement (Macintosh and Wilkinson, 2011) through specific support for less environmentally effective small-scale RE and non-generating technologies (such as solar hot water systems), and that Federal REC policies caused a stockpiling of certificates which stalled or deferred investment in large scale generation (Simpson and Clifton, 2014). Federal analysis of FiTs suggests that they are only likely to be effective in stimulating solar and wind based RE (Commonwealth of Australia, 2011).

Another factor which has been noted as having an influence upon societal equity in Australia is employment, both in the number and type of jobs provided and also through the provision of stable employment. With regard to RE policy in Australia, the previously noted changing Federal incentives and reducing state based FiTs due to excessive price impacts had the effect of drastically reducing the RE workforce (Ecogeneration, 2011, IPART, 2012). A consideration of the flow on effects of this reduction, primarily on sales and installation jobs in Queensland showed that whilst 75 percent of installers may be able to easily transfer to equivalent jobs in other industries, only 25 percent of wholesale and retail positions were likely to be re-employed elsewhere (Intelligent Energy Systems, 2012). In order to allow more households to install Solar PV and to sustain employment in the RE industry, State Governments are assessing alternative approaches to the deployment of RE which does not require a FiT, such as the retailer-household solar

PV purchase agreements proposed in Victoria (Minister for Industry, Minister for Energy and Resources, VIC, 2015).

Summarizing these findings from Government and independent third party analyses, the key equity impacts considered important with regard to RE policy outcomes in Australia are: electricity price impacts (the increase of electricity bills due to FiT costs), participation (the ability for households to participate in subsidisation schemes, in the case of the FiT meaning home ownership and the means to purchase solar panels), subsidization allocation (identifying those households who are receiving subsidisation, and those who are burdened with the costs), environmental benefits (reduction of generation based GHG emissions through the deployment of RE) and impacts on employment (the number, type and allocation of jobs).

4.2.2 Australian Equity Preferences

In order to assess an approximation of the 'Australian' preference towards social equity, within the current RE regime, a number of sources were investigated including survey results, workshop outcomes and case studies across desirable future environmental scenarios, equity and climate change investigations, water allocations and health and social justice viewpoints. Although a targeted survey can provide a more tailored response, the investigative review based assessment undertaken provides an approximate initial 'desirable equity state', sufficient for the purposes of this research, and development of the assessment methodology.

Although the concept of a 'fair go' (a phrase meaning that everyone should be given the best chance or opportunity without being unfairly hindered) has been a part of Australian culture for a long time (Herscovitch, 2013), Australia is at the high end of income inequality (OECD, 2016b), and the gap between the richest and poorest 20% is similar to that of the UK, USA, Singapore and New Zealand (Wilkinson and Pickett, 2010). Specific examples of social inclusion inequality issues which arise in Australia include: place-based disadvantage with regard to access, health care and employment, private schools, women's wage equality and indigenous health and housing (UNSW, 2011).

With regard to climate change, survey respondents stated that government policy should create fairness and balance in society, based on their belief that climate change affects low income groups the most (McManus et al, 2014). When asked to describe an ideal future for Australia, workgroup respondents across multiple locations identified many common factors including access to good education, participatory democracy, freedom, work-life balance, a healthy environment with climate change contained, sustainable industries and equitable access to services and resources. All respondents identified a preference for social equity (specifically full employment and wealth distribution) and preservation of the natural environment over economic growth (Boschetti et al, 2015). When assessing intergenerational distribution preferences, respondents understood that those who benefit from the implementation of a policy are unlikely to be the same people who are paying for them. Whilst a small portion (approximately 12%) of respondents chose the preservation of the societal status quo, the majority chose to favour younger, or future generations, even when 'non-trivial' amounts of money were involved. They reasoned that any investment would help the younger generation and their willingness to invest was based on the consideration of perceived impacts which would affect future generations negatively (Scarborough and Bennett, 2008). This future-oriented conservation focus was reinforced in a survey of acceptable risk and social values of water allocations which again identified strong support for intergenerational equity, and a preference for evidence based policies and plans managed for the public good (Syme, 2014). In addition, when health care decision makers were surveyed on desirable allocation of health gains a majority favoured the young, those of poor health and, where preference was specified, those of a lower socio economic status (Mooney and Jan, 1997). It should be noted that in some cases these preferences are assessed prior to implementation of policies and may be representative of respondent's desires rather than an approximation of their actual actions.

An examination of the Australian equity preference has shown that Australians predominantly desire that costs associated with policies (including climate change, environmental, water allocation, health and social justice policies) which include subsidisation should be borne by higher income households, whilst participation should be mostly equal, the allocation of subsidies, environmental improvements and employment benefits should be distributed with a bias toward lower income households, with an appropriate level of burden sharing according to household means.

4.2.3 Proposed Energy Policy Sustainability Evaluation Framework

Following an assessment of previous research, and taking into account the Australian equity impact findings and preference towards impact distribution, Table 4.2 outlines the factors which will be evaluated by the Energy Policy Sustainability Framework proposed by this research in order to effectively measure the economic, environmental and equity impacts of energy policies within Australia.

Table 4.2 Energy Policy Sustainability Evaluation Factors

Environmental	Economic	Social Equity
· GHG emissions (CO_2-e) · Resource management · RE Technology system efficiency	· Levelised cost of electricity (LCOE) · Impact of subsidisation on electricity price · Employment impacts · Market impacts	The distribution of economic and environmental costs and benefits across income levels: · Distribution of costs ➢ Electricity price increases ➢ Allocation of subsidies · Distribution of benefits ➢ Employment ➢ CO_2 emission reduction ➢ Participation

In order to demonstrate the framework's application, and to provide contrast with frameworks that do not quantify societal equity factors as part of sustainability assessment, the identified environmental and economic factors which impact upon jurisdictional equity will be evaluated, and used alongside projected energy system data to derive efficacy and societal equity impacts, in order to determine overall energy policy sustainability. Figure 4.1 outlines the steps undertaken in the framework for the given jurisdiction. The specific sections of this chapter which detail each step are also noted.

The framework incorporates the identified factors across the three critical elements of sustainability into the assessment process and allows the policy maker to use energy system, environmental and economic data to quantitatively derive the equity impacts upon each income level within a society. This is achieved through multiple scenario analysis considering varying policy approaches, specifically outlined in the methodology, enabling a holistic assessment of the sustainability of each energy policy scenario from the point of view of both efficacy and equity outcomes.

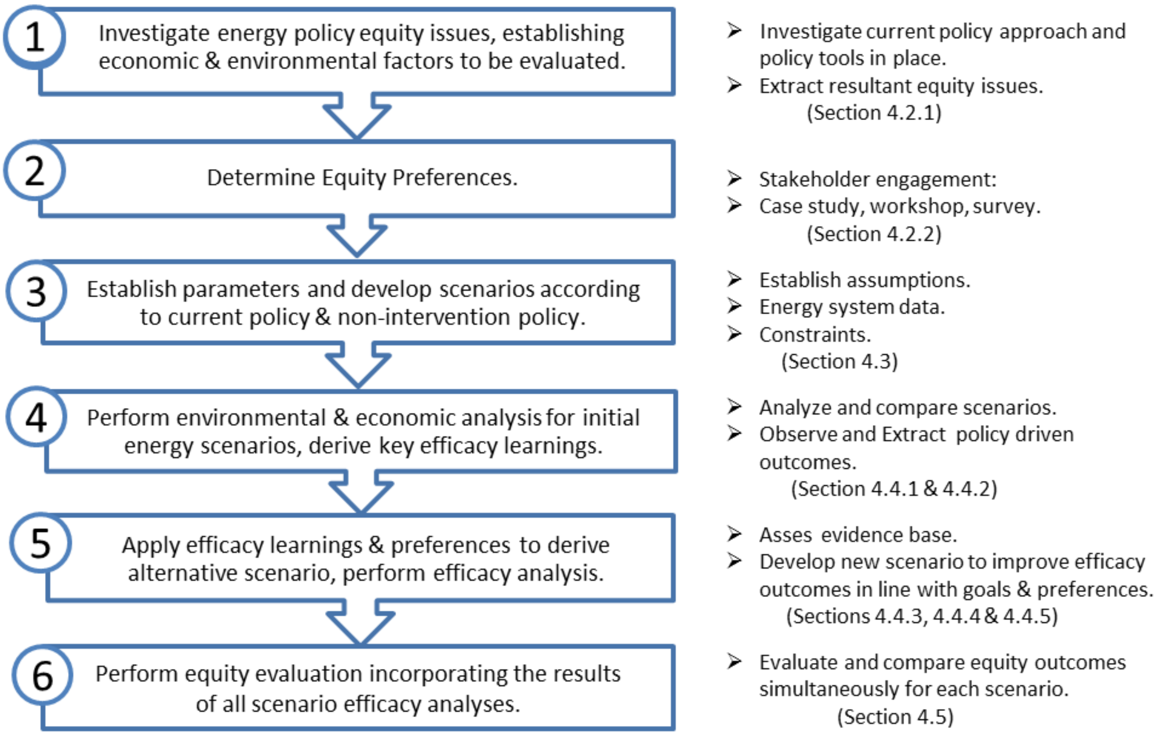


Figure 4.1 Energy Policy Sustainability Evaluation Framework

4.3 Methodology

The proposed methodology to evaluate the economic and environmental factors of energy policy sustainability is in three parts; firstly, a baseline case is established prior to the introduction of the residential solar PV FiT policy in order to develop a scenario representative of the 'preserving the status quo' policy option. Secondly, the FiT scenario is analysed to measure the changes in environmental and economic impacts when compared to the baseline scenario. Finally, utilising the outcomes identified from the FiT and baseline scenario analyses as an evidence base, an alternative energy scenario is developed in order to meet both the economic and environmental policy goals in Australia, and to do so in a manner which can at least preserve, and preferably improve societal equity outcomes.

Each of the scenarios' efficacy will be measured against the above defined Energy Policy Sustainability Evaluation Framework and stated Australian Government energy and environmental goals to 2020, namely the RET which aims to ensure that 20% of Australia's electricity comes from renewable sources by 2020, with 41,000GWh of electricity to come from large-scale RE (Department of the Environment, 2015). The data used to measure all energy consumption and production factors, technology specific emission and capacity factors and additional environmental and economic factors are derived from Australian national energy reporting bodies (e.g. AER, AEMO), industry peak, research and regulatory bodies (e.g. Clean Energy Council, Green Energy Markets, IPART) and recent peer reviewed academic research.

Common formulae, assumptions and methodologies for calculating each component within the environmental and economic factors are outlined below.

Environmental:

1. GHG emissions: $Generation\ Type_{(g)} \times tCO_{2-e}\ /\ GWh_{(g)}$
2. RE Deployment: $\sum GWh_{(RE\ Generation)} / \sum GWh_{(Fossil\ Fuel\ Based\ Generation)}$
3. RE technology system efficiency: $Installed\ RE\ Efficiency_{(Generation,GHG)} /$ $Maximum\ RE\ Efficiency_{(Generation,GHG)}$

Economic:

1. Cost of Generation: $LCOE_{Generation\ Mix}$
2. Electricity Price Impact: $FiT\ Payments\ /\ Non\ FiT\ Households$
3. Employment Impact: $New\ jobs\ arising\ from\ RE\ deployment$
4. Market Impact: *Energy generation technology learning curve price/W_p*

where: tCO_{2-e} = Tonnes of CO_2 equivalent. GHG = Greenhouse gas. LCOE = Levelised cost of electricity. g = Generation sources 1-8 within the NEM as defined in the assumptions below.

Social equity impacts are subsequently measured by evaluating the distribution of the above environmental and economic factors across the five income levels of society, as detailed in section 4.5.

Assumptions common to all scenarios:

1. The GHG intensity factors[2] of each power generation technology type is assumed to be constant over time (Fossil and Bio Fuels - AEMO, 2014; Farine et al, 2012; Solar - Fthenakis and Kim, 2011; Hydro - Varun and Prakash, 2009; Wind - Geuzuraga et al, 2012), as follows:
    1. Black Coal: 0.87 $tCO_{2\text{-}e}$/MWh
    2. Brown Coal: 1.25 $tCO_{2\text{-}e}$/MWh
    3. Gas: 0.46 $tCO_{2\text{-}e}$/MWh
    4. Liquid Fuels: 0.92 $tCO_{2\text{-}e}$/MWh
    5. Bio-Fuel[3]: 0.024 $tCO_{2\text{-}e}$/MWh
    6. Hydropower[4]: 0.0087 $tCO_{2\text{-}e}$/MWh
    7. Wind[5]: 0.0093 $tCO_{2\text{-}e}$/MWh
    8. Solar[6]: 0.036 $tCO_{2\text{-}e}$/MWh
2. Electricity consumption will reduce by 0.5% per annum from 2015 (based on 5-year average consumption trends; AER, 2009-2014, Green Energy Markets, 2014) due to energy efficiency improvements and reduction of energy intensive industry, leading to the retirement of fossil fuel generators.
3. Generation from Hydroelectric sources within the NEM will remain stable at historical average levels, ignoring impacts such as drought or high rainfall years, (Green Energy Markets, 2014) and no further installation will occur before 2020 (Elliston et al, 2013).
4. Liquid fuels' contribution to NEM generation will be locked at 0.01% of the total generation in each year, reflecting the approximate annual contribution to date.
5. Biofuels' growth is forecast using 2008-13 data, Gas' using 2008-14 data, both projected forward based on recent average yearly installation to 2020.

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[2] RE technology GHG intensity factors do not include GHG emissions from transportation.

[3] Lignocellulose to electricity (combustion).

[4] Run-of river system average life-cycle GHG emissions.

[5] Onshore wind turbines.

[6] Average life-cycle GHG emissions of Mono-Silicon, Poly-Silicon and Cadmium-Telluride panels.

6. It is assumed that each GWh generated from renewable sources will offset a GWh of fossil fuel generation. This offset will be divided across black and brown coal, dependent on the type and location of the installed RE (e.g. Black Coal for solar PV and Bioenergy installation – predominantly installed in Queensland and NSW, and Brown Coal for Wind, predominantly installed in South Australia and Victoria. AER, 2014). Reduction in annual electricity generation, and increases in Gas generation are reduced across Brown and Black Coal generation according to their market share and location within the NEM.

4.3.1 Baseline Scenario

FiTs were first introduced in Australia on 1 July 2008, so in order to negate the effect of the FiTs introduction, the baseline scenario will begin from January 2008 on a business as usual basis, i.e. with no exogenous stimuli for the installation of RE. Estimates of PV and Wind installations to 2020 are based on pre-FiT installation trends from 2001-2008.

4.3.2 FiT Scenario

The FiT scenario will use the outcomes of the case study, and project changes in electricity supply sources within the NEM to 2020 according to the following assumptions:

1. Solar and wind power deployment increases are calculated based on deployment trends to 2014 (Australian PV Institute, 2014, Clean Energy Council, 2012-14, IEA 2010-11, AER, 2009). Generation is determined based on average NEM solar and wind annual generation levels (Solar: ~1460GWh/GWp, Wind ~2600GWh/GWp).
2. In order to determine residential Solar PV net FiT payments, electricity export rates are normalised between 32 and 50% depending on the average annual size of PV systems installed as follows (IPART, 2012):
    1. 1kWp systems export 32% of generated electricity;
    2. 1.5kWp systems export 35% of generated electricity;
    3. 2kWp systems export 41% of generated electricity; and,
    4. 3~5kWp systems export 50% of generated electricity to the grid.

3. FiTs are payable based on the applicable FiT in the state and year of installation, for so long as the FiT is guaranteed[7].
4. It is assumed that FiTs in place in 2015 will continue unchanged to 2020.
5. As FiT households receive a financial benefit from the generation of RE (as a reduced electricity bill), calculation of the FiT burden considers non-FiT households exclusively.

4.3.3 Alternative Energy Scenario

The alternative energy scenario will use the environmental and economic learnings derived from the baseline and FiT scenarios (detailed in Section 4.4.3) in order to best achieve policy goals, whilst improving social equity outcomes according to Australian equity preferences according to the following constraints:

Social equity should be maximised (i.e. through a fairer distribution of costs and benefits of energy policy) subject to:

1. No increase in electricity prices for residential consumers, compared to 2014 levels (as policy settings are only modified from 2015 onwards);
2. RE technology is deployed with maximum practicable efficiency in order to meet RET targets;
3. GHG emissions are reduced to contribute to Australian cumulative (all sector) GHG reduction efforts; and
4. Job creation is maximised subject to 1, 2 and 3, maximising positive GDP impacts.

4.4 Results

4.4.1 Environmental Outcomes of Baseline and FiT Scenario

Using the assumptions outlined in the methodology, electricity generation and GHG forecasts are detailed, encompassing all fossil and RE based electricity sources for the baseline and FiT scenarios from 2008 to 2020 (Table 4.3 and Table 4.4). The change in fossil fuel based electricity generation levels for each scenario is detailed at Figure 4.2 and RE based electricity generation levels are detailed in Figure 4.3.

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[7] A summary of FiTs to the end of 2012 is available in chapter 3.

Table 4.3 Baseline Scenario generation and GHG forecast

Year	NEM Generation (TWh)	Black Coal	Brown Coal	Gas	Liquid Fuels	Bio-Fuel	Hydro	Wind	Solar	Gt CO_{2-e}	tCO_{2-e}/MWh
2008	207.90	118.80	55.50	17.50	0.20	0.20	12.90	2.70	0.04	181.11	0.87
2009	206.00	116.05	54.24	18.50	0.21	1.00	12.90	3.00	0.05	177.63	0.86
2010	203.70	113.26	52.75	19.60	0.20	1.50	12.90	3.37	0.06	173.85	0.85
2011	199.00	108.92	50.49	20.60	0.20	2.00	12.90	3.75	0.07	167.74	0.84
2012	199.00	107.93	49.79	21.60	0.20	2.30	12.90	4.12	0.09	166.46	0.84
2013	194.00	103.72	47.40	22.70	0.19	2.40	12.90	4.50	0.12	160.32	0.83
2014	191.80	100.37	45.44	25.30	0.19	2.50	12.90	4.87	0.15	156.16	0.81
2015	189.60	97.63	43.78	27.00	0.19	2.60	12.90	5.25	0.18	152.49	0.80
2016	188.65	95.32	42.33	29.30	0.19	2.70	12.90	5.62	0.21	149.74	0.79
2017	187.71	93.09	40.92	31.50	0.19	2.80	12.90	6.00	0.24	147.04	0.78
2018	186.77	90.78	39.48	33.80	0.19	2.90	12.90	6.37	0.28	144.30	0.77
2019	185.84	88.40	38.00	36.20	0.19	3.00	12.90	6.75	0.32	141.50	0.76
2020	184.91	86.00	36.56	38.50	0.18	3.20	12.90	7.12	0.36	138.67	0.75

Table 4.4 FiT Scenario generation and GHG forecast

Year	NEM Generation (TWh)	Black Coal	Brown Coal	Gas	Liquid Fuels	Bio-Fuel	Hydro	Wind	Solar	Gt CO_{2-e}	tCO_{2-e}/MWh
2008	207.90	118.80	55.50	17.50	0.20	0.20	12.90	3.75	0.04	181.12	0.87
2009	206.00	115.96	53.97	18.50	0.21	1.00	12.90	4.32	0.14	177.22	0.86
2010	203.70	112.69	52.54	19.60	0.20	1.50	12.90	4.63	0.63	173.13	0.85
2011	199.00	107.28	50.16	20.60	0.20	2.00	12.90	5.13	1.72	165.96	0.83
2012	199.00	104.93	49.34	21.60	0.20	2.30	12.90	5.62	3.10	163.42	0.82
2013	194.00	99.61	45.80	22.70	0.19	2.40	12.90	7.15	4.23	154.91	0.80
2014	191.80	95.33	43.69	25.30	0.19	2.50	12.90	7.67	5.19	149.80	0.78
2015	189.60	91.93	42.15	27.00	0.19	2.60	12.90	7.93	5.88	145.71	0.77
2016	188.65	89.07	40.81	29.30	0.19	2.70	12.90	8.19	6.47	142.64	0.76
2017	187.71	86.41	39.52	31.50	0.19	2.80	12.90	8.45	6.92	139.74	0.74
2018	186.77	83.77	38.19	33.80	0.19	2.90	12.90	8.71	7.29	136.86	0.73
2019	185.84	81.16	36.83	36.20	0.19	3.00	12.90	8.97	7.56	134.01	0.72
2020	184.91	78.57	35.50	38.50	0.18	3.20	12.90	9.23	7.80	131.16	0.71

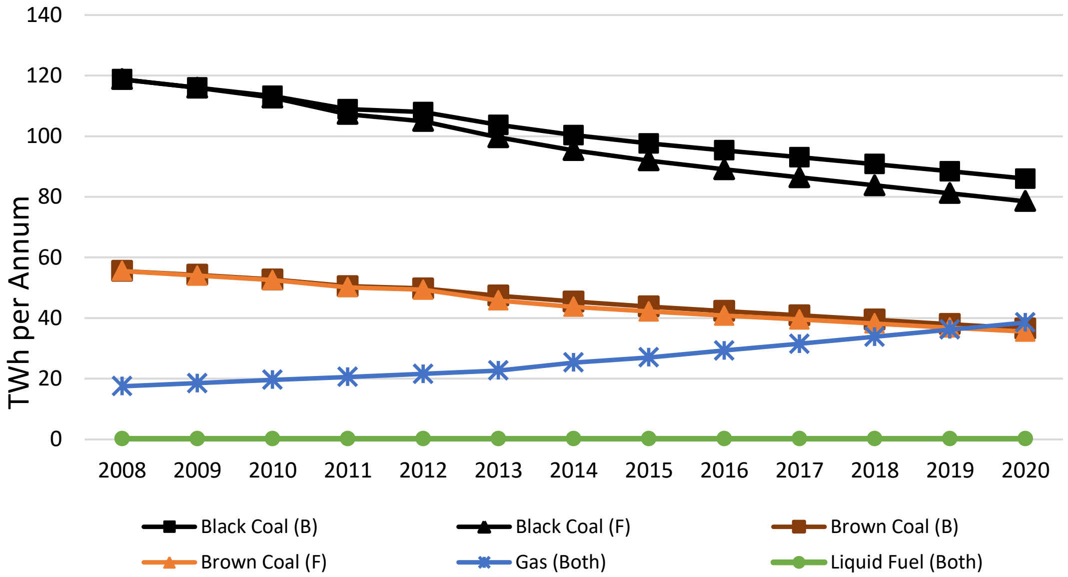

Figure 4.2 FiT (F) and Baseline (B) Scenario Fossil Fuel Generation Levels

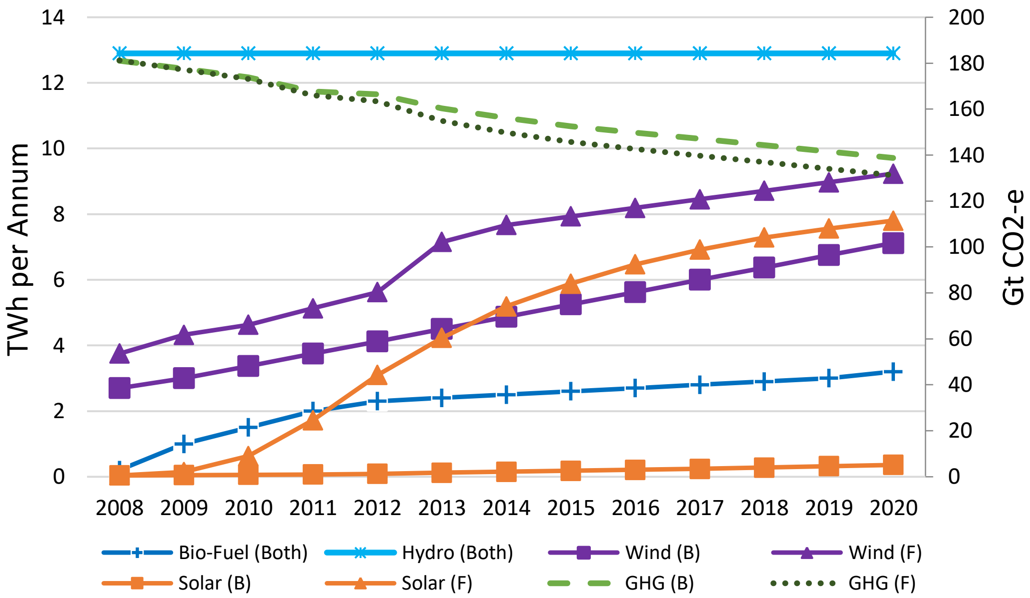

Figure 4.3 FiT (F) and Baseline (B) Scenario RE Generation Levels

As shown in Figure 4.2 and Figure 4.3, the FiT stimulates significant additional solar based generation, alongside a moderate increase in wind based generation. These increases lead to a moderate decrease in black coal generation, and a minor decrease in brown coal generation. Hydro, bio-fuel and gas based generation are the same in both scenarios. The GHG emission decrease for each scenario is also shown.

Under the baseline scenario, the major factors which influenced the reduction in GHG emissions were an increase in gas generation to more than double 2008 levels, a significant increase in Wind power generation to account for almost 4 per cent of all generation by 2020, and substantial growth in the biofuel industry. However, the most significant change across the NEM was the steady reduction in gross electricity generation from 2014, allowing for a commensurate reduction in both black and brown coal generation, in addition to that offset by RE based generation in both scenarios. Under the FiT scenario, significant installation of residential solar PV sees a greater offset of black coal based generation, whilst a moderately higher installation of commercial scale wind power sees a slight reduction in brown coal based generation, leading to a greater overall reduction in GHG emissions of approximately 7.5 giga-tonnes compared to the baseline scenario.

From an RE deployment point of view, under the baseline scenario, generation from renewable sources grew from a low of 7.6 per cent in 2008, up to 12.8 per cent in 2020. Large scale RE (Hydro, Wind and Bio) accounts for approximately 23,000GWh of total generation within the NEM. Under the FiT scenario, RE generation in 2020 accounts for almost 18 per cent of the NEM's generation, with large scale RE sources supplying approximately 25,000 GWh. Both scenarios fall short of the 2020 RE generation goal of 20% of all electricity generation, and significantly short of the large scale generation goal of 41,000GWh.

As for RE technology deployment efficiency, the four major types of RE generation technology of Hydro, Wind, Solar and Bio Fuels each have different GHG intensities and energy generating capacities which are used to calculate the overall efficiency of RE deployment within the NEM as follows: Hydro is the most efficacious from a GHG emission reduction per MWh standpoint, and is maximised in all scenarios. The next most efficacious is Wind, followed by Bio-fuel (also known as biomass), which is predominantly sourced from bagasse in Australia, with the remainder coming from agriculture and other waste products (CEC, 2014). 2010 estimates of Biomass potential in Australia at approximately 40.17 TWh per annum from Bagasse, agricultural and other waste biomass sources (Crawford et al, 2012). Further, Wind is superior from an electricity generation standpoint (CF≈29.7%), exceeding both Bio-fuel and Hydro under this scenario (CF≈29% and CF≈17.9% respectively).

Therefore, considering only the generation efficiency of RE technologies to achieve the 2020 level of RE generation under the baseline and FiT scenarios; the ideal mix of generation would be 100 percent sourced from Wind. From a GHG reducing standpoint, referring to the GHG intensity factors in Section 4.3, a mix of 12.9TWh (the maximum possible) from Hydro and 10.68TWh from Wind power sources for the baseline and approximately 20TWh for the FiT scenario would be optimal.

A summary of both scenarios' environmental outcomes including resultant GHG emissions, RE deployment and RE technology system efficiency for the target year of 2020 is outlined in Table 4.5.

Table 4.5 Summary of Baseline and FiT Scenario Environmental Outcomes in 2020

Factor	Baseline Scenario	FiT Scenario
GHG Emissions	Gross GHG Emission Reduction (%)	
	23.4	**27.6**
	NEM Generation GHG Intensity Reduction (%)	
	13.9	**19.6**
RE Deployment	RE Generation in NEM (%)	
	12.8 (63.8% of target)	**17.9 (89.6% of target)**
	Large Scale RE in NEM (GWh)	
	23,220 (56.6% of target)	**25,330 (61.8% of target)**
RE Technology System Efficiency	GHG intensity of RE ($tCO_{2\text{-}e}$/MWh)	
	0.011	**0.017**
	Capacity Factor of RE (%)	
	20.45	**23.32**

4.4.2 Economic Outcomes of Baseline and Fit Scenario

In order to assess the impact of each scenario on electricity prices, the Levelised Cost of Electricity (LCOE) is used. Calculations are based on average projected LCOE factors across generation sub-types from the Garnaut Climate Change Review (commissioned by Australia's Commonwealth, State and Territory Governments in 2007 and 2010, in order to conduct an independent study of the impacts of climate change on the Australian economy) and Australian Treasury modelling studies data, AEMO data (detailed in ATSE, 2014) and analysis of future OECD generation costs (West, 2012) distributed across the projected sources of generation in the target year of 2020. These are detailed for the FiT and baseline scenarios in Table 4.6.

Table 4.6 Baseline and FiT Scenario 2020 LCOE

	Baseline Scenario		FiT Scenario	
Fuel Source	**2020 TWh**	**LCOE$/MWh**	**2020 TWh**	**LCOE$/MWh**
Black Coal	86.00	$95	78.57	$95
Brown Coal	36.56	$100	35.50	$100
Gas	38.50	$82	38.50	$82
Liquid Fuel	0.18	$160	0.18	$160
Bio-Fuel	3.20	$63	3.20	$63
Hydro	12.90	$83	12.90	$83
Wind	7.12	$92	9.23	$92
Solar PV	0.36	$265	7.80	$265
Total	**184.91**	**$92.12**	**184.91**	**$99.45**

Under the FiT Scenario, there is an impact on electricity prices due to early FiTs exceeding standard electricity tariffs and the nature of FiT payment recuperation by electricity companies, through consumer's electricity bills. In some states, short term Gross FiTs were in place. Gross FiTs caused the greatest upward pressure on electricity prices, as all electricity generated by household PV was rewarded at the generous FiT level. Most states introduced, or switched to net FiTs, which only reward households for electricity exported to the grid, with the balance consumed in the home.

Figure 4.4 shows the growth of FiT payments to 2020, used to derive the cumulative impact of FiTs on electricity prices, averaged across non-FiT NEM households to 2020.

FiT payments increase significantly between 2009 and 2012, and then grow slowly to a peak in 2018, before gradually reducing to approximately $79 per non-FiT household in 2020. It is generally accepted that in Australia, the purchase of solar panels is undertaken by households with sufficient income to do so (Higgins et al, 2014, Bruce et al, 2009), whilst non-FiT households are generally lower income households, non-home owners or those living in apartment style accommodation. This burden of the

FiT style subsidisation is borne by those with lower means than those who benefit from it. This scheme affects equity through cross subsidisation from low to high income families. Electricity retailers recoup the cost of all FiT payments through electricity bills, irrespective of the nature or size of the FiT leading to increased electricity bills, even when the FiT for each kilowatt hour is lower than the gazetted tariff.

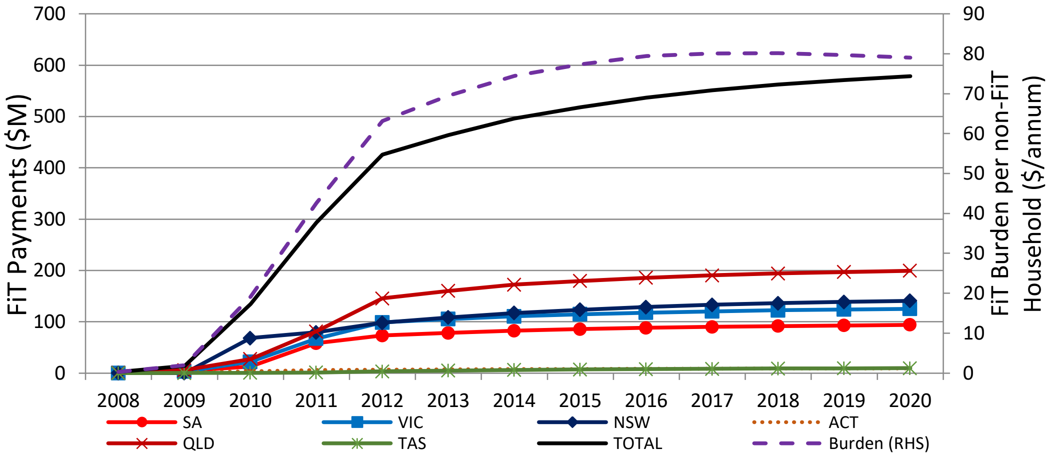

Figure 4.4 FiT Payments and non-FiT Household Burden, 2008-2020

The employment impact of each scenario in this research is described in terms of jobs directly resulting from RE deployment to the target year of 2020. To calculate these jobs, established 'job multipliers' (number of jobs per MWp installed) for each technology are used, as detailed in Table 4.7. Solar PV jobs[8] per MWp are derived from the Australian case study (chapter 3), whilst additional RE technology types' jobs per MWp are derived from national reports and assessments of clean energy installation impacts (SKM, 2012, The Climate Institute, 2011).

Table 4.7 Baseline and FiT Scenario 2020 RE Installation Jobs

RE Type	Jobs/MWp	Baseline Scenario 2020 MWp	Baseline Scenario Total Jobs	FiT Scenario 2020 MWp	FiT Scenario Total Jobs
Bio-Fuel	2.1	84	166	84	166
Hydro[9]	-	-	1,586	-	1,586
Wind	2.7	142	384	100	270
Solar PV	10.8	27	296	164	1,775
Total	**-**	**309**	**2,432**	**344**	**3,797**

[8] Solar PV jobs are assumed to come from small-scale PV installation (accounting for ~95% of all solar installation in Australia by 2012, Chapman et al, 2016)

[9] Average actual annual employment figures (ABS, 2015)

Market impacts are described in terms of technology learning curve impacts (system price per watt) for the two dominant RE types newly deployed in Australia; described for Solar PV in Figure 4.5 (derived from APVI, 2014 and Chapman et al, 2016) and for wind power in Figure 4.6 (derived from Junginger et al 2005[10], IEA, 2008 and Melbourne Energy Institute, 2011).

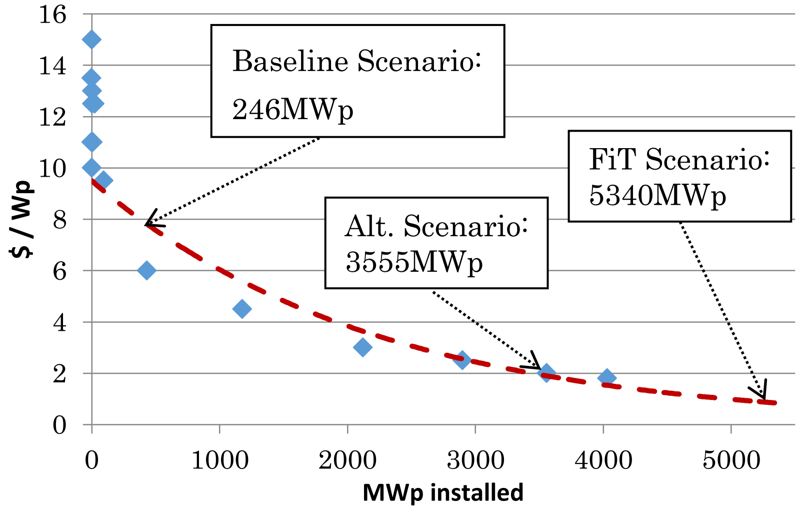

Figure 4.5 PV Market Impact Learning Curve: Scenario Specific Installation Levels and System Prices per Watt in 2020.

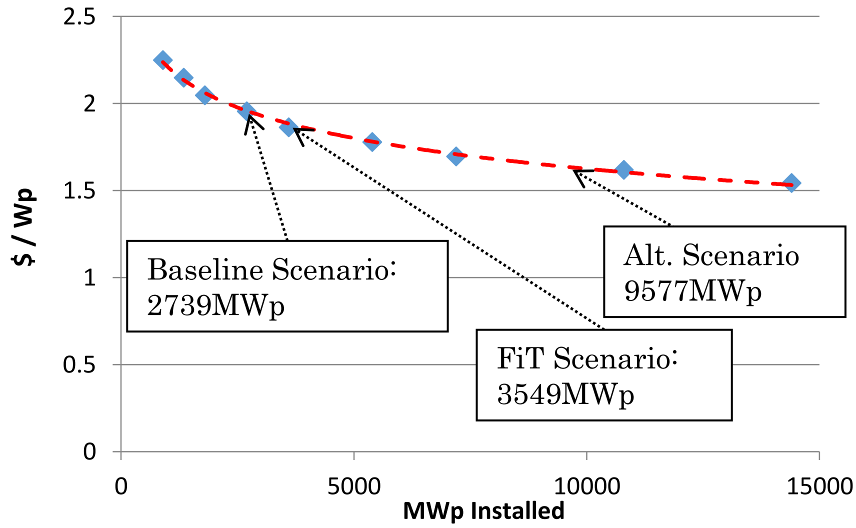

Figure 4.6 Wind Market Impact Learning Curve : Scenario Specific Installation Levels and System Prices per Watt in 2020.

[10] Using a conservative 9 per cent cost reduction per doubling of capacity

Under the baseline scenario, 246MWp of PV was installed, leading to an average system price of approximately $7 per watt installed, whilst under the FiT Scenario approximately 5300MWp of PV was installed, leading to a projected average system price of approximately $1 per watt installed in 2020. Further, 2739MWp of wind power was installed under the baseline scenario, leading to an average installed price of approximately $1.96 per watt installed whilst 3549MW of wind power was installed under the FiT scenario, leading to an average installed price of approximately $1.86 per watt installed.

The installation totals for the alternative scenario included in Figure 4.5 and Figure 4.6 are detailed in section 4.4.4.

A summary of economic outcomes for the baseline and FiT scenarios in the year 2020 are detailed in Table 4.8.

Table 4.8 Summary of Baseline and Fit Scenario Economic Outcomes in 2020

Factor	Baseline Scenario Outcomes	FiT Scenario Outcomes
Cost of Generation	LCOE ($/MWh)	
	92.12	**99.45**
Electricity Price	FiT Impact ($)	
	Non-significant Change	**79.01 per non-FiT NEM household**[11]
GDP Impact	Direct RE Jobs	
	2,432	**3,797**
	Growth from 2008 (%)	
	21	**52.5**
Market Impact	Solar PV ($/Wp)	
	7	**1**
	Wind ($/Wp)	
	1.90	**1.86**

[11] Using ABS household projection figures, revised to account for NEM and non-FiT household numbers.

4.4.3 Alternative Energy Policy Scenario Development

Following the vastly different results obtained from the baseline and FiT scenarios, both in terms of effectiveness; the environmental and economic benefits gained or costs incurred, we can begin to appreciate the impact policy settings have on sustainability outcomes within a society.

Whilst a wholesale revision of energy policy settings beginning in 2008 would be ideal in order to derive the most sustainable outcomes, one of the limitations of policy implementation is that we are unable to turn back the clock, and can only effect change moving forward, following an evaluation process, and the establishment of an evidence base for future action.

In order to reduce some inequitable outcomes projected under the current FiT Scenario and additionally to fully meet the environmental goals of the RET, learnings from both the Baseline and FiT Scenarios must be applied in order to derive the Alternative scenario.

Learnings:

From an environmental perspective, it is clear that a significant (>5000MWp) installation of residential PV was insufficient to achieve the RET environmental goals. Additionally, wind power is the most efficient electricity generator, and the second most effective GHG reducing technology (Although Hydro is the most efficacious from a GHG emission reduction per MWh generation standpoint, it is already maximised in all scenarios).

From an economic perspective, solar PV deployment created the most jobs among RE technologies, followed by wind power, but was also the most expensive from an LCOE and electricity price impact point of view due to the FiT. Solar PV is the cheapest technology per watt installed, however wind power's superior electricity generation potential makes it a more economically sound choice for deployment than Solar PV.

These findings represent the evidence base upon which the alternative energy scenario will be constructed - a summary of the economic and environmental impact merit order for each technology considered for deployment within the NEM to 2020 is provided at Table 4.9.

Table 4.9 Economic and Environmental Impact Merit Ordering

Environmental Factors	Economic Factors
GHG Reducing Ability (tCO_{2-e} abated/MWh – higher is better)	**LCOE ($/MWh – lower is better)**
1. Hydropower 2. Wind 3. Bio-Fuel 4. Solar PV	1. Solar PV 2. Wind 3. Hydropower 4. Bio-Fuel
Resource Management (%RE in system)	**Electricity Price Impact (Δ Electricity Price – lower is better)**
Scenario specific.	1. Solar PV 2. Wind 3. Hydropower 4. Bio-Fuel
RE technology system efficiency (MWh/MWp – higher is better)	**Jobs Created (jobs/MWp – higher is better)**
1. Wind 2. Bio-fuel 3. Hydropower 4. Solar PV	1. Solar PV 2. Wind 3. Bio-fuel 4. Hydro
	Market Impacts (reduction in RE deployment cost)
	Scenario specific.

Applying the learnings described above, under a scenario which adheres to the constraints described in Section 4.3.3, a generation and GHG forecast to 2020 is derived as shown in Table 4.10 and resultant changes in fossil fuel and RE generation sources are summarised in Figure 4.7 and Figure 4.8.

Table 4.10 Alternative Energy Policy Scenario generation and GHG forecast

Year	NEM Generation (TWh)	Black Coal	Brown Coal	Gas	Liquid Fuels	Bio-Fuel	Hydro	Wind	Solar	Gt CO_{2-e}	tCO_{2-e}/ MWh
2008	207.90	118.80	55.50	17.50	0.20	0.20	12.90	3.75	0.04	181.12	0.87
2009	206.00	115.96	53.97	18.50	0.21	1.00	12.90	4.32	0.14	177.22	0.86
2010	203.70	112.69	52.54	19.60	0.20	1.50	12.90	4.63	0.63	173.13	0.85
2011	199.00	107.28	50.16	20.60	0.20	2.00	12.90	5.13	1.72	165.96	0.83
2012	199.00	104.93	49.34	21.60	0.20	2.30	12.90	5.62	3.10	163.42	0.82
2013	194.00	99.61	45.80	22.70	0.19	2.40	12.90	7.15	4.23	154.91	0.80
2014	191.80	95.33	43.69	25.30	0.19	2.50	12.90	7.67	5.19	149.80	0.78
2015	189.60	92.62	40.90	27.00	0.19	2.60	12.90	9.17	5.19	144.75	0.76
2016	188.65	90.35	37.83	29.30	0.19	2.70	12.90	11.17	5.19	140.01	0.74
2017	187.71	88.14	33.79	31.50	0.19	2.80	12.90	14.17	5.19	134.08	0.71
2018	186.77	85.87	29.47	33.80	0.19	2.90	12.90	17.42	5.19	127.80	0.68
2019	185.84	83.54	24.87	36.20	0.19	3.00	12.90	20.92	5.19	121.16	0.65
2020	184.91	81.17	19.83	38.50	0.18	3.20	12.90	24.90	5.19	113.89	0.62

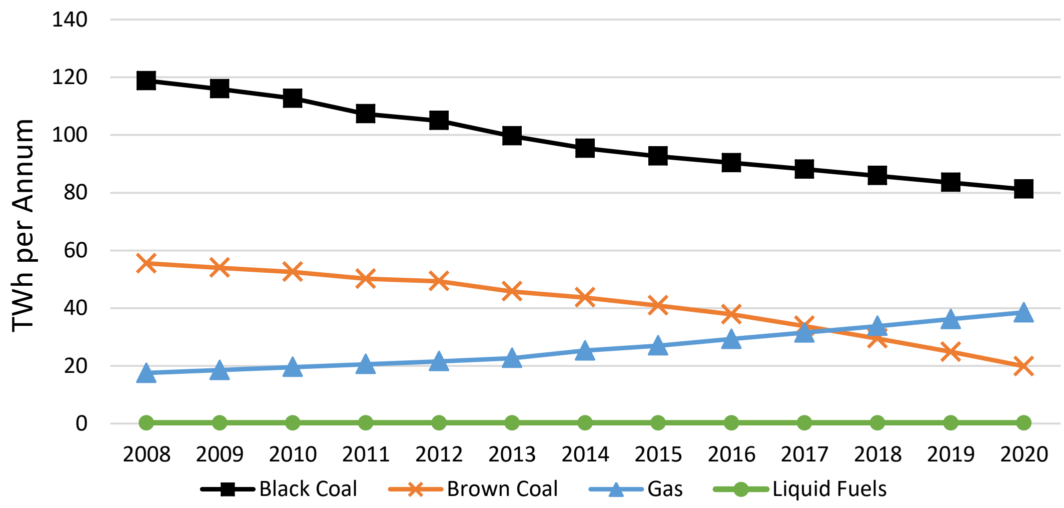

Figure 4.7 Alternative Scenario Fossil Fuel Generation Levels 2008-2020

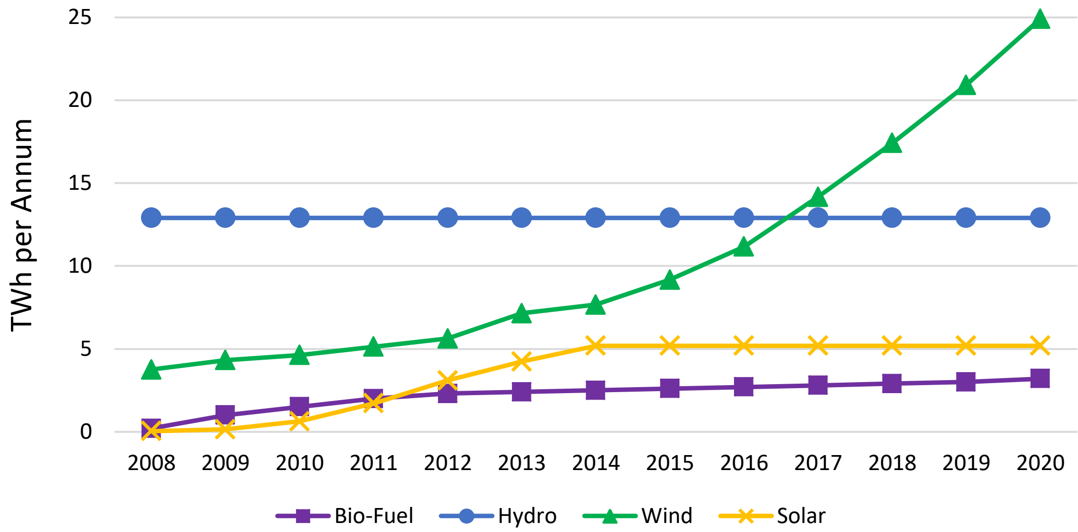

Figure 4.8 Alternative Scenario RE Generation Levels 2008-2020

Generation and GHG emission outcomes to 2014 are identical to the FiT scenario, as optimisation of the energy system takes place from 2015 onwards. The most obvious difference to the system is the cessation of installation of predominantly residential PV. As wind power is the most effective from both an electricity generation and cost of installation standpoint, it is installed centrally at the large scale in order to meet both the RE installation and large scale RE generation targets. The installation rate is increased significantly each year to 2020 in order to achieve the RET goals whilst recognising the time required for an industry transition from residential solar to large-scale wind deployment.

4.4.4 Environmental Outcomes of Alternative Energy Policy Scenario

As demonstrated in Figure 4.8, the alternative energy policy scenario favours wind power from 2015, and Solar PV installation at the residential level is ceased from the beginning of 2015. By switching to a centralised, wind based RE generation regime, both the RE target and large scale RE targets can be met.

Additionally, due to intensive wind installation in predominantly brown coal states, GHG emissions are reduced by approximately 67.2Gt, reducing NEM GHG emissions intensity by some 29.3 per cent. A summary of alternative energy scenario environmental outcomes is at Table 4.11.

Table 4.11 Summary of Alternative Scenario Environmental Outcomes

Factor	2020 Outcomes
GHG Emissions	Gross GHG Emission Reduction (%)
	37.10
	NEM Generation GHG Intensity Reduction (%)
	29.30
RE Deployment	RE Generation in NEM (%)
	24.98 (Exceeding target)
	Large Scale RE in NEM (GWh)
	41,000 (100% of target)
RE Technology System Efficiency	GHG intensity of RE (tCO_{2-e}/MWh)
	0.013
	Capacity Factor of RE (%)
	25.86

4.4.5 Economic Outcomes of Alternative Energy Policy Scenario

As with the baseline and FiT scenarios, the alternative scenario LCOE and job numbers are defined according to the makeup of 2020 generation sources and RE job multipliers, described in Table 4.12 and Table 4.13.

The 2020 LCOE for the alternative scenario is $96.36, approximately 3.1% lower than under the FiT scenario.

Table 4.12 Alternative Scenario 2020 LCOE

Fuel Source	TWh Generated	LCOE$/MWh
Black Coal	81.17	$95
Brown Coal	19.82	$100
Gas	38.50	$82
Liquid Fuel	0.18	$160
Bio-Fuel	3.20	$63
Hydro	12.90	$83
Wind	24.90	$92
Solar PV	5.19	$265
Total	**184.91**	**$96.36**

The alternative scenario discontinues PV installations and any new FiT payments from the beginning of 2015, reducing the overall FiT payments in 2020 to $496.4 million, reducing the burden on non-FiT households to approximately $64.47 per annum. By removing the FiT, electricity prices are maintained at 2014 levels before reducing due to the change in generation mix from 2015 to 2020.

Due to a massive growth in the wind industry in order to meet RET goals, 5,885 new direct RE jobs are created in 2020, approximately 2.3 times that of the baseline scenario and approximately 1.6 times that of the FiT scenario.

Table 4.13 Alternative Scenario 2020 RE Jobs

RE Type	MWp Installed in 2020	Jobs/MWp	Total Jobs
Bio-Fuel	84	2.1	177
Hydro	-	-	1,586[12]
Wind	1531	2.7	4133
Solar PV	0	10.8	0
Total	**1614**	**-**	**5,885**

[12] Average actual annual employment figures (ABS, 2015)

Market impacts as a result of the alternative scenario for PV and Wind were shown in Figure 4.5 and Figure 4.6 alongside the Baseline and FiT scenario results, and under the alternative scenario approximately 3555MWp of PV was installed, leading to a projected average system price of approximately $2 per watt installed in 2020. A much higher amount, some 9577MW of wind power was installed, leading to an average installed price of approximately $1.65 per watt installed by 2020.

A summary of economic outcomes for the alternative scenario in the year 2020 is detailed in Table 4.14.

Table 4.14 Summary of Alternative Scenario Economic Outcomes

Factor	**2020 Outcomes**
Cost of Generation	LCOE ($/MWh)
	96.36
Electricity Price	Impact ($)
	64.47 per non-FiT NEM household[13]
GDP Impact	Direct RE Jobs
	5,885
	Growth from 2008 (%)
	136
Market Impact	Solar PV ($/Wp)
	2
	Wind ($/Wp)
	1.65

With regards to policy efficacy, the achievement of the two RET goals of total RE installed and large scale RE generation for all three scenarios in the target year of 2020 are compared in Figure 4.9.

[13] Using ABS household projection figures, revised to account for NEM and non-FiT household numbers.

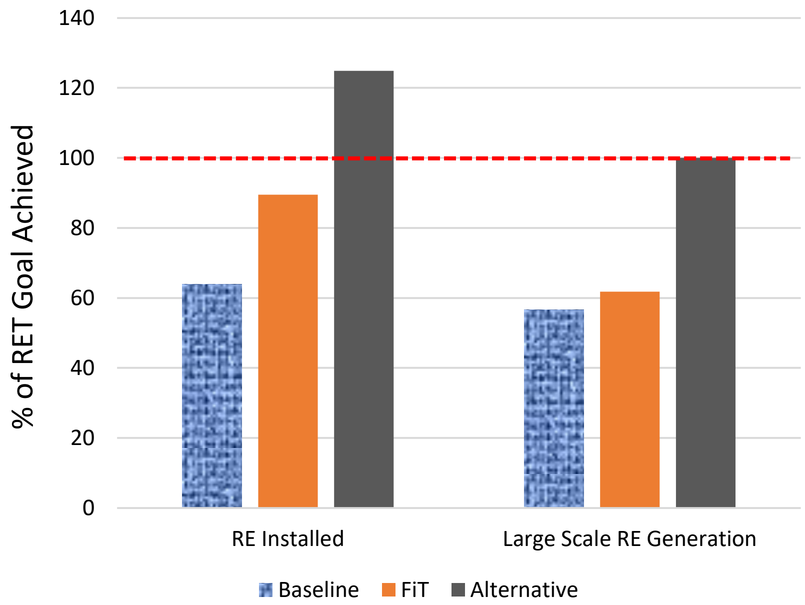

Figure 4.9 Scenario RET Goal Efficacy Comparison

4.5 Comparative Equity Assessment

In order to derive a complementary equity assessment for each scenario to the target year of 2020, an evaluation of the distribution of environmental and economic impacts is undertaken across the five levels of Australian household income (defined in Table 4.15). These income levels are not described as quintiles, but are the actual percentage of households in each income 'bracket'. In Australia, very low, low and average income households make up 71.25% of all households, the remaining 28.75% of households are high and very high income households, with very high income households accounting for 6.11%.

Table 4.15 Levels and Share of Australian Household Income (ABS, 2014)

Income level	Household income	% of households
Very Low	\$0~\$399 / week	13.31
Low	\$400~\$999 / week	28.62
Average	\$1000~\$1999 / week	29.32
High	\$2000~\$3499 / week	22.64
Very High	\$3500~\$5000+ / week	6.11

Each of the three scenarios assessed describes a vastly different energy future for Australia in the year 2020, achieving environmental and economic goals at differing levels. The achievement, and means of achievement impacts upon societal equity as each household is impacted differently according to their level of participation and subsequent allocation of subsidies, the amount and distribution of GHG reductions as well as policy driven electricity price and employment impacts (the energy policy equity impacts specific to Australia, as identified in section 4.2.1).

In order to understand the relative equity level and policy burden imparted by each scenario, the distribution of these economic and environmental costs and benefits is determined, and their impact weighted according to the comparative size of each of the impacts assessed, across the three energy scenarios, for the five income levels. Table 4.16 outlines the precedents and assumptions used for these distributions and their weighting.

Table 4.16 Australian Equity, Distribution and Weighting Factors

Equity Factors		Distribution Factors	Weighting Factors
1	Participation	Australian participation precedents (Higgins et al, 2014, Bruce et al, 2009)	% of non-subsidized households
2	GHG Reduction	Assumed to be equal	Gt of GHG reduced
3	Employment	Australian review job allocation and salaries (Payscale, 2015)	Number of direct RE Jobs in 2020
4	Subsidy Allocation	Participation rate multiplied by % of households per income level	Subsidy (FiT) payment amount
5	Elec. price impact	Elec. price % increase due to subsidization (or LCOE increase) per income level	Actual $ increase per annual average electricity bill

A matrix of the distribution factors, based on precedents and calculations as outlined in Table 4.16 is initially populated for each scenario from 2008-2020. These distribution factors are then normalised according to the ratio of the absolute values of the weighting factors (to a maximum value of 1), simultaneously across all three scenarios in order to derive the relative equity for each income level. This concurrent comparative analysis identifies the relative cost and benefit distribution bias and relative equity simultaneously for each of the three scenarios based on the difference in distribution of economic and environmental impacts between the highest and lowest income levels.

The equity and policy burden assessment takes an equally weighted assessment of the five equity factors across the five income levels, and based on these values plots a centroid for each scenario from 2008-2020, in order to enable an objective comparison of equity level and policy burden outcomes over time.

Salient formulae for determining these values are outlined below.

Firstly, to determine the equity value (EV) for each income level:

$$EV_{(i,j)} = DV_{(i,j)} \times \frac{WV_{(i,j)}}{MaxWV_{(i,j)}} \qquad \text{(eq. 4.1)}$$

where EV is the equity value, DV and WV are the distribution and weighting values respectively, i (="very low", "low", "average", "high", "very high") is the income level, j (=1,2,3,4,5) is the equity factor, as described in Table 4.16. Using the five derived equity values for each income level, relative equity can be established thus:

$$Relative\ Equity_{(i)} = \frac{EV(i,j)}{n_j} \qquad \text{(eq. 4.2)}$$

where n_j is the number of equity factors.

The distribution bias of equity factors can then be determined by calculating the difference between the highest and lowest income level's relative equity for each equity factor assessed.

A visual representation of the comparative equity tool is shown at Figure 4.10, demonstrating the consideration of the five equity factors (①), their weighting, distribution (②) and the visualisation of relative equity and policy burden as centroids (③).

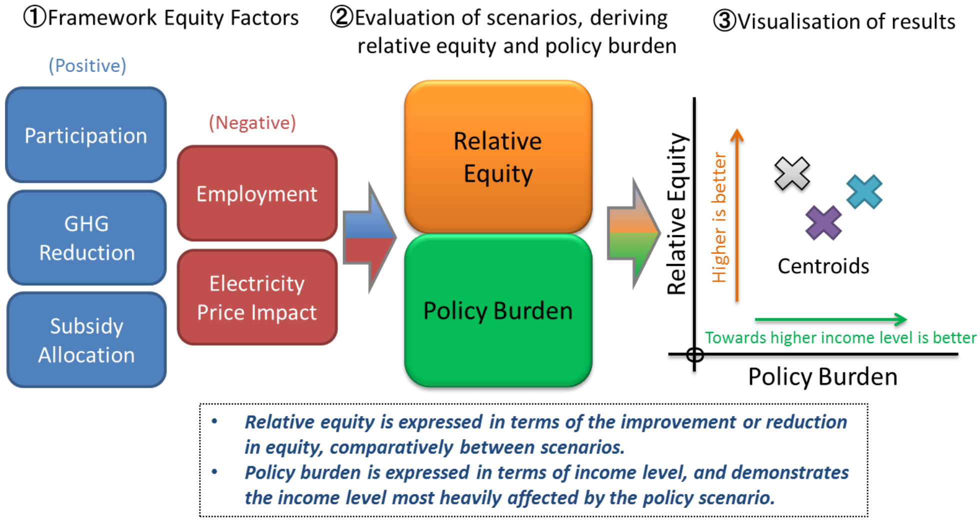

Figure 4.10 Visual Representation of the Comparative Equity Tool

4.5.1 Results of the Comparative Equity Analysis

Firstly, per scenario relative equity results (with centroids shown for each) for the year 2020 are displayed in Figure 4.11 for each of the five income levels.

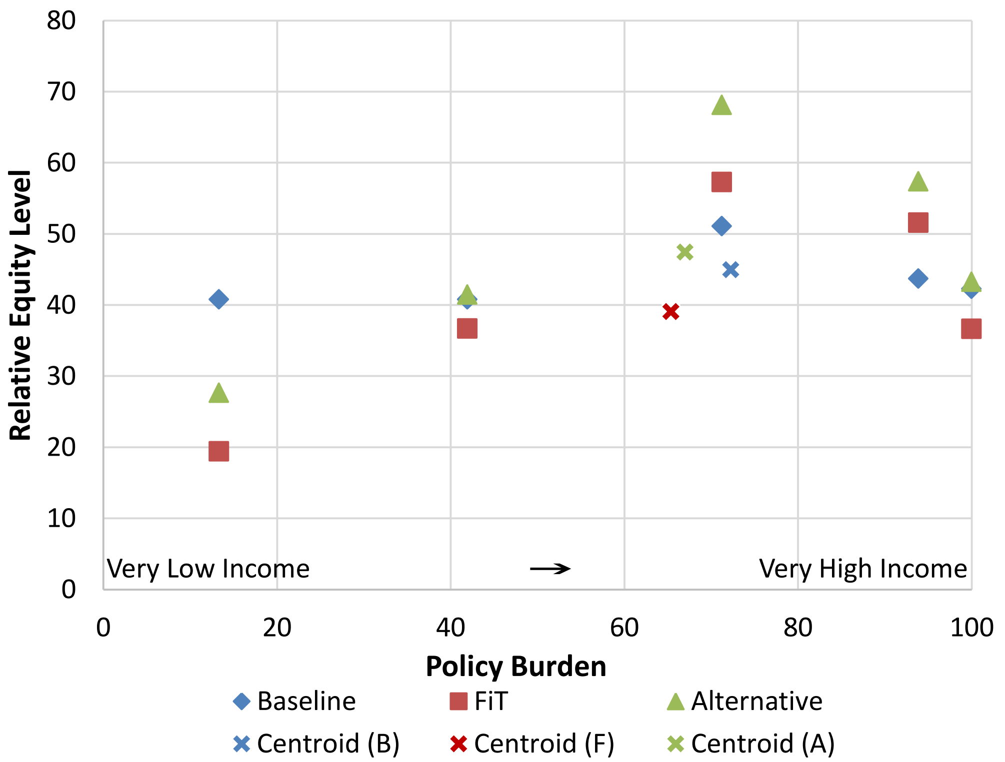

Figure 4.11 Per Scenario Relative Equity Levels and Policy Burden in 2020

In 2020, the Baseline scenarios relative equity level is fairly even across the five income levels, demonstrated by a very small difference between the lowest, average and highest income levels, indicating relatively balanced societal equity. The FiT scenario has the lowest relative equity for the very low income group. Additionally, the FiT scenario difference between lowest and highest income levels is the greatest overall.

Comparatively, the alternative scenario has a higher overall relative equity level for all income groups, and a smaller difference between the lowest and highest income levels. These differences affect the overall relative equity which is represented by the relative equity centroid, shown as a color-coded 'X' for each scenario. The higher the centroid is on the Y-axis, the greater the overall relative equity for each scenario. The further to the left the centroid is on the X-axis, the greater the burden on lower income households.

Secondly, the distribution bias resultant from each scenario in the target year of 2020 is shown in Figure 4.12, for each of the five equity factors.

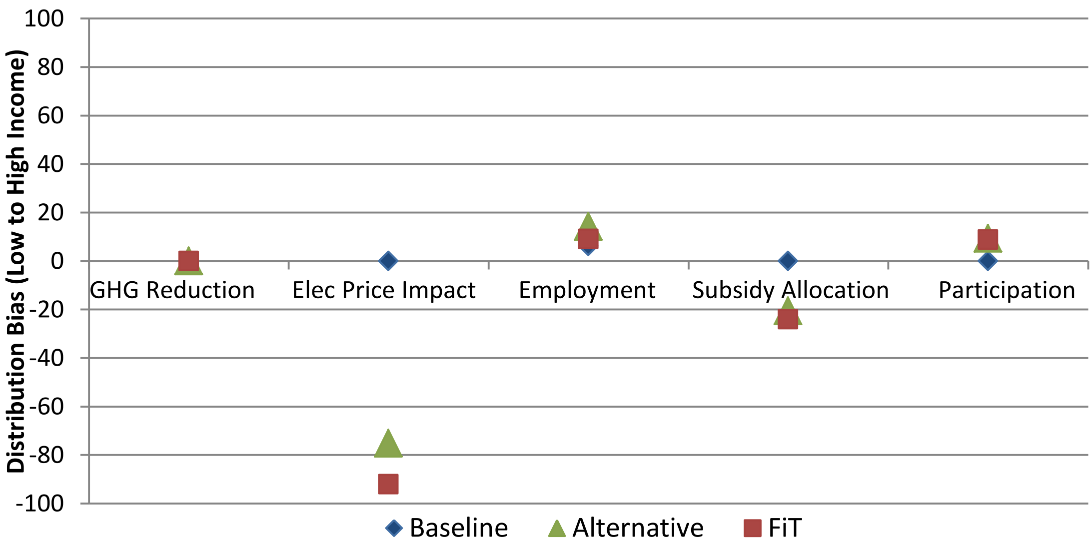

Figure 4.12 Per Scenario Equity Factor Distribution Bias in 2020

In this research, greenhouse gas reductions are assumed to be equal across all households, and therefore for each scenario there is no distribution bias. With regard to electricity price impacts, the baseline scenario introduces no subsidised electricity generation and therefore no bias is experienced. In the case of the FiT scenario, the increase in electricity bills due to FiT payments impacts lower income households significantly. This is lessened under the alternative scenario. Employment outcomes favour higher income households in each scenario, due to the nature of jobs created.

With regard to subsidy allocations, under the baseline scenario, no allocations are made, and therefore no bias is experienced, however under the FiT scenario, lower income households are seen to be cross-subsidising higher households. As with the electricity price impacts, this situation is somewhat remedied under the alternative scenario. With regard to participation, the baseline scenario sees even participation for all users due to a centralised electricity system. With the introduction of the FiT, lower income households are less able to participate exacerbating the bias in favour of higher income households. Due to the increase of centralised RE installation and a cessation of residential PV installations from 2015, this bias is reduced slightly under the alternative scenario.

Finally, in order to observe how the level of equity and the impost of policy burden as a result of the policy settings in each energy scenario changes over time, the equity level and policy burden centroids (shown and discussed for the target year of 2020 in Figure 4.11) from 2008-2020 are plotted. Figure 4.13 demonstrates how equity and policy burden shift over time in each scenario.

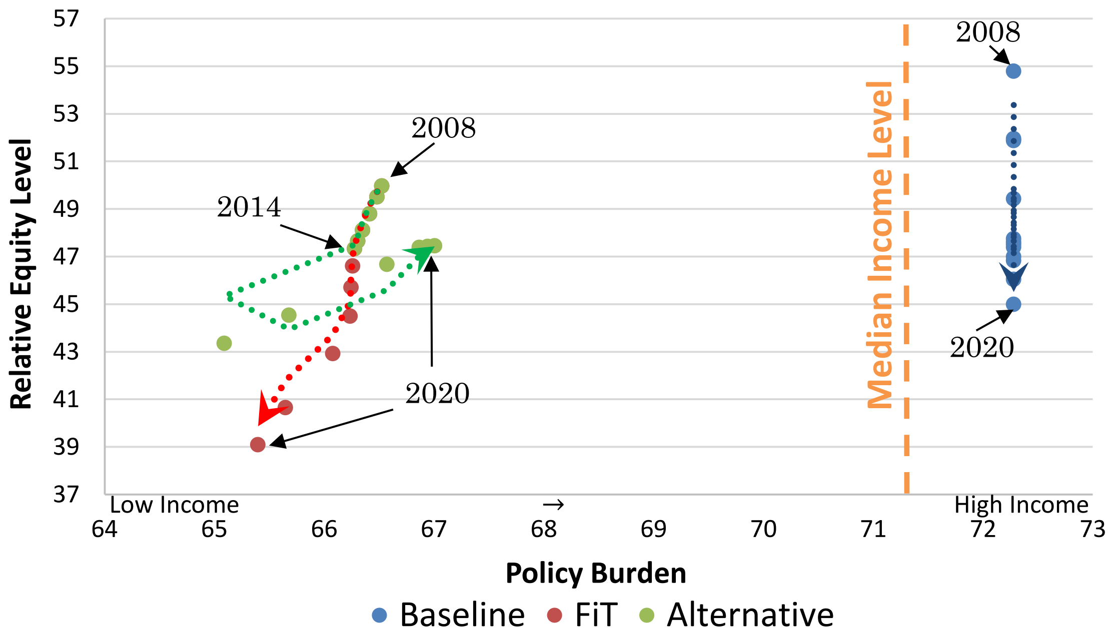

Figure 4.13 Scenario Specific Relative Equity and Policy Burden 2008-2020

As was the case with Figure 4.11, in Figure 4.13 equity improvement is shown by a shift upwards on the Y axis and the X axis shows the shifting of the policy burden of policy costs, where a shift to the right over time is desirable. The FiT and alternative scenarios are identical from 2008-2014 and do not separate until the year 2015, the FiT scenario gradually reduces in relative equity and the burden of policy costs shift toward low income households. The alternative scenario is increasing its level of relative equity over time when compared to the other scenarios and the burden of policy costs is shifting towards the median income level. The baseline scenario's burden of policy costs is borne by average to high income households, however over time, due to little economic or environmental policy achievement when compared to other scenarios, relative equity reduces.

4.6 Discussion

This research has focused on the incorporation of a qualitative assessment of equity within policy evaluation and the contribution of this chapter toward policy initiatives and energy policy making is threefold:

Firstly, a realistic evaluation of a policies ultimate success with regard to environmental and economic goals can be made, in addition to gaining an understanding of the potential distributive equity impacts that such a policy approach may engender.

Secondly, through a consideration of both efficacy (the ability of a policy to meet desired goals) and equity impacts, the policy maker can proactively evaluate potential policy pitfalls, and realign policy parameters in order to better meet both efficacy and equity goals.

Thirdly, the evaluation framework proposed allows the policy maker to identify trade-offs inherent in RE policy; i.e. the efficacy cost of giving precedence to societal equity or efficacy, and the identification of a merit order of technologies for each environmental and economic criteria, (summarised in Table 4.9) discussed in detail below.

Through this research, the negative impacts of the FiT were identified as unequal participation leading to cross subsidisation; low income households' paying a premium to offset higher income households' FiT payments, and issues at the administrative level, such as the recuperation method of FiT payments by electricity companies, further exacerbating electricity price increases and affordability issues for lower income households. The proposed alternative energy scenario seeks to redress these issues as a priority by incorporating key learnings from both the FiT and baseline scenarios. One of the key learnings described in the alternative scenario is the increased use of wind power, installed centrally, as opposed to continued installation of subsidised rooftop PV. The benefits of wind power were clarified as; superior GHG reduction, as the majority of the Australian wind resource is in brown coal states. Additionally, centralised installation of wind power increases participation rates and reduces the electricity price burden on lower-income households, as no FiT is payable and, by 2020 wind power's LCOE is lower than that of both black and brown coal, and significantly lower than that of residential PV.

Building upon learnings evident in the Baseline and FiT scenarios, the alternative energy scenario was able to be developed in order to meet both the RE deployment and large scale RE generation targets, and subsequently able to offset the greatest amount of GHG. This was due to pragmatic installation of centralised wind generation which offers the greatest electricity generation and GHG reduction per MW installed in Australia. Additionally, the evidence based alternative energy scenario generated the greatest number of direct RE jobs by 2020, and was successful in moderately reducing the FiT impact and LCOE whilst meeting all RET targets. The baseline scenario had the lowest LCOE and nil FiT impact, but was also the most environmentally ineffective, and did little to stimulate RE jobs or reduce RE technology market prices. Whilst the FiT scenario offers the greatest reduction in installed solar PV prices, it also engenders a significant electricity bill increase due to the FiT, and has the highest scenario LCOE.

Through an assessment of environmental and economic impacts of energy policy scenarios, and the application of this assessment to an understanding of the resultant equity impacts on society, the policy maker can revise policy parameters, specifically the tools in place to achieve policy goals and implement a new policy in order to meet these goals in a more effective and equitable manner, demonstrated in this research under the auspices of the evidence based alternative energy scenario.

Although the level of importance of the equity factors within the proposed efficacy and equity assessment tool may vary according to national preferences or goals (in the case of Australia, outlined in section 4.2.2), the tool proposed can be adapted according to these preferences or weightings. For this to occur in a proactive manner there is a necessity for a revision of the policy making process, called the policy cycle in Australia (Althaus et al, 2012), in order that evaluation of the sustainability of policy performance is undertaken proactively (prior to implementation), rather than retroactively, as is currently the case.

This research has demonstrated that in Australia the improvement of equity has not been indicative of a decrease in efficacy, as clearly evidenced by the alternative energy scenario which meets environmental and economic goals to a higher level than the FiT scenario whilst offering a modest improvement in equity – practically demonstrating the value of equity incorporation through an evidence based policy development process, in terms of improved energy policy sustainability outcomes and the achievement of environmental and economic goals.

4.7 Conclusions

The performance of policy with regards to sustainability is a combination of environmental, economic and social contributions. Of the social contributions, equity to date has not typically been included in policy performance assessments. However, this chapter demonstrates that essential factors of equity within a jurisdiction can be identified through an assessment of policy evaluation outcomes (as described in section 4.2.1) and then quantified, through a distribution of the economic and environmental factors which impact upon them, weighted and distributed across societal income levels (detailed in Section 4.5). By contrasting differing policy scenarios' efficacy and resultant equity impacts, holistic policy sustainability can be demonstrated in an easy to understand manner, and provide a basis for the improvement of policy development processes.

Australia is a prime candidate for such an improvement, as household income levels show, equity impacts which negatively affect average or lower income levels are indeed impacting on almost three quarters of Australian society. Other OECD nations with high levels of income inequality (expressed as a GINI coefficient), and who share a similar governance structure to Australia which may benefit from the use of this framework and assessment tool include, but are not limited to: The United Kingdom, Canada, New Zealand and Japan (OECD, 2016b).

The approach outlined in this chapter can be readily applied in other jurisdictions, most likely those identified as having high levels of income inequality within the OECD, and more broadly, through the collection and analysis of jurisdiction specific equity issue and preference information, energy policy tools, goals and energy system data and their application to the framework at Figure 4.1 and methodology outlined in sections 4.3 and 4.5. Needless to say, some assumptions will need to be modified to reflect jurisdictional characteristics. However, reflecting and building on the ideal that there is no single technical fix for energy injustice (Bickerstaff et al, 2013), but, through a holistic social, policy, economic and environmental approach as undertaken in this research, the problems of energy injustice and societal inequity as a result of energy policy implementation may begin to be remedied. Indeed the sustainability of energy policy can be improved, not only in terms of the environment and the economy but also from a social perspective.

5. Energy Policy and Social Equity Hearing in Australia: Equity Factor Finding and Application to the Comparative Equity Assessment Tool

5.1 Introduction

In order to utilise the comparative equity analysis tool as described in chapter 4, with the aim of improving the energy policy development process, and to demonstrate its practical application, a weighting of jurisdiction-specific equity and efficacy factors needs to be undertaken. This weighting takes the form of an online hearing utilising purposive stakeholder sampling of policy makers and professionals (including academics and consultants) in an energy policy related role within the jurisdiction, who have first-hand experience with not only energy policy development, but who also interface directly with households to reconcile policy issues arising from the implementation of different energy policies over time (Palys, 2008). Although there are many methodologies which could be used to elicit the information gained through this hearing (including interviews, conducting an AHP workshp etc.), an online hearing was chosen in order to access a broad range of stakeholders within energy policy across all states of Australia. Respondents were recruited via electronic means including direct email to individuals and energy policy departments and research groups, professional social networking sites (LinkedIn, ResearchGate etc.) and word of mouth from within these channels.

The hearing is designed to clarify four aspects; firstly, it aims to elicit the energy policy makers' own views towards social equity through an unguided provision of keywords descriptive of social equity. Secondly the hearing assesses whether or not the five energy policy related equity factors of participation, electricity price impacts, subsidy allocation, employment and environmental improvement are representative of the equity factors reported by stakeholders and those responsible for influencing energy policy. Thirdly, an importance weighting is asked of each of the equity factors (including the initially proposed five factors, and any additional factors provided) on an eight point Likert Scale (Likert, 1932) asking respondents to rate impacts from 1 – not at all important to 8 – extremely important, with ratings from 1-4 indicating the opinion that the equity factor is not important (not at all, not very, somewhat and unimportant) while ratings from 5-8 indicate level of importance (not very, somewhat, very and extremely). A broad range was also chosen in attempt to differentiate the perceived level of equity factor importance. The final part of the hearing investigates the level of importance attributed to the achievement of policy goals, the improvement of social equity, or both.

5.2 Energy Policy Equity Hearing Methodology

The survey is divided into two pages. The first page gathers the basic respondent data of gender, age, location and length of experience and an unguided identification of social equity, based on up to five keywords. The second page of the survey provides guidance as to the findings of Government and third-party analysis of renewable energy policy in Australia (as identified in chapter 4), and the resultant social equity factors which are impacted. Respondents are asked to consider these findings and identify any additional societal equity factors which they believe are impacted by energy policy implementation. The pre-identified and any additional societal equity factors are then rated according to their level of importance in the opinion of the respondent. Finally, the respondent's opinion on the key role of energy policy is elicited. The hearing language and questions posed are detailed in Appendix A.

5.3 Hearing Outcomes

The hearing was conducted over a two month period from early March to early May 2016 and attracted a total of 77 responses, of which 69 were complete (approximately 90 percent).

5.3.1 Demographics

Figure 5.1 to Figure 5.3 outline the demographics of the hearing respondents.

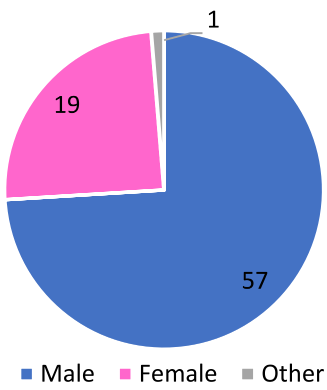

Figure 5.1 Gender Balance (n=77)

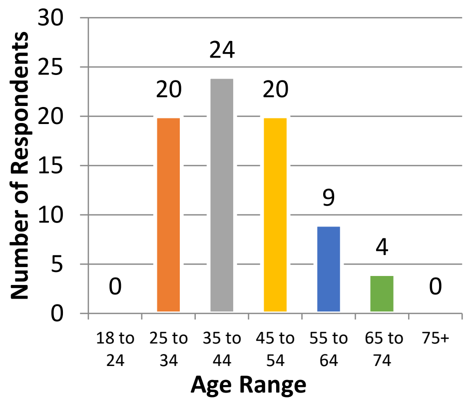

Figure 5.2 Age Distribution (n=77)

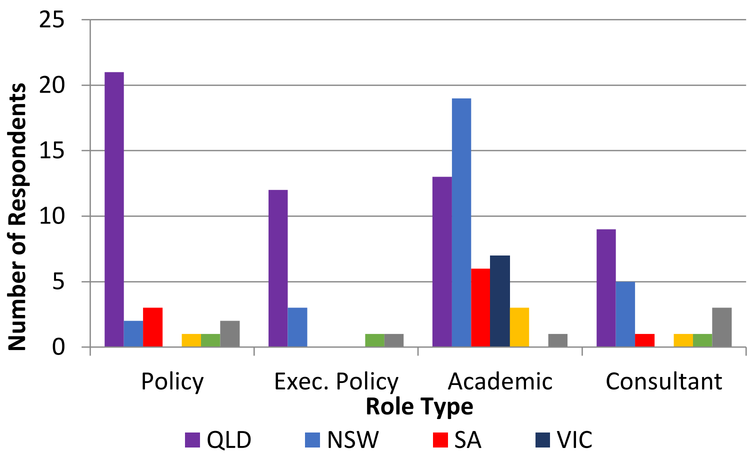

Figure 5.3 Location of Policy Related Role (Multiple Responses Allowed, n=77)

76 % of respondents were male, 24% female, aged between 25 and 74 years of age. Respondents were polled from all states of Australia except for Tasmania, and worked in policy (approximately half of which had executive responsibilities), consulting (policy and energy industry based), research (energy and social policy), and other roles including industry organisation officials and ex-government ministers. The average reported length of service in a policy related role was 11.53 years.

5.3.2 Social Equity Keywords

Respondents were asked to demonstrate their personal understanding of the term 'Social Equity' through the provision of free text in five keyword boxes. Table 5.1 summarises the ten most popular keyword responses received, combining multiple similar words to the root word (i.e. fairness, fair go and fair are all summarised as 'fair').

Table 5.1 Respondent Social Equity Keywords (n=72, Multiple Responses Allowed)

Keyword	Count
Fair	43
Equal/Equitable	41
Access	26
Just	23
Opportunity	21
Distribute	9
Resource	9
Social	9
Discriminate	8
Services	8

Respondents understood the concept of social equity predominantly as a concept which reflects fair, equal and just properties. Access and opportunity were also seen as very important tenets in respondent's conceptual understanding of social equity which exceeded the core concepts of fairness and equality, and included to a lesser degree the tenets of sustainability and some of its component parts, along with ideals such as participation, inclusion and the recognition of disadvantage.

5.4 Social Equity Impact Assessment

The hearing is specific to Australia in its assessment of social equity impacts, and five impacts are proposed based on an investigation of government and third party analysis of Australian energy policies; employment, environmental improvement, impacts on electricity prices, subsidy allocation and participation. Respondents were asked if they agreed with the five proposed equity impacts and considered them to be sufficiently comprehensive in order to evaluate social equity impacts. If they agreed, no additional factors were suggested, however if the five proposed factors were considered insufficient in order to assess social equity impacts, up to three additional factors could be proposed.

Of the 69 respondents to this question, 36 respondents (52.2%) considered the proposed factors sufficient in order to assess social equity impacts of energy policy. 33 respondents (47.8%) proposed one additional factor, 18 respondents (26.1%) proposed two additional factors and 8 respondents (11.6%) proposed three additional factors.

Of the 33 respondent's proposed additional factors, access and participation was the most common response, including participant asymmetry, genuine engagement, and participation in the electricity system. Five respondents (15.2% of those providing additional factors) identified this factor as important when evaluating social equity impacts of energy policy.

The second most popular responses were the impacts on the fossil fuel industry, specifically the loss of jobs due to retirement of generation assets, and intergenerational equity, with four responses each (12.1%).

Three respondents (9.1%) identified the distribution of health impacts and compensation, or capacity to pay as important additional social equity factors.

Other factors which were proposed by two respondents each included education, energy quality and availability, subsidies, lobbying, regional and technology choice impacts and recognition.

Figure 5.4 summarises the level of support for each additionally proposed social equity factor.

Further, section 5.6 will outline how these identified social equity factors will be incorporated into the Energy Policy Sustainability Framework initially described in chapter 4, in order to test the robustness of the tool and improve its applicability to Australian energy policy.

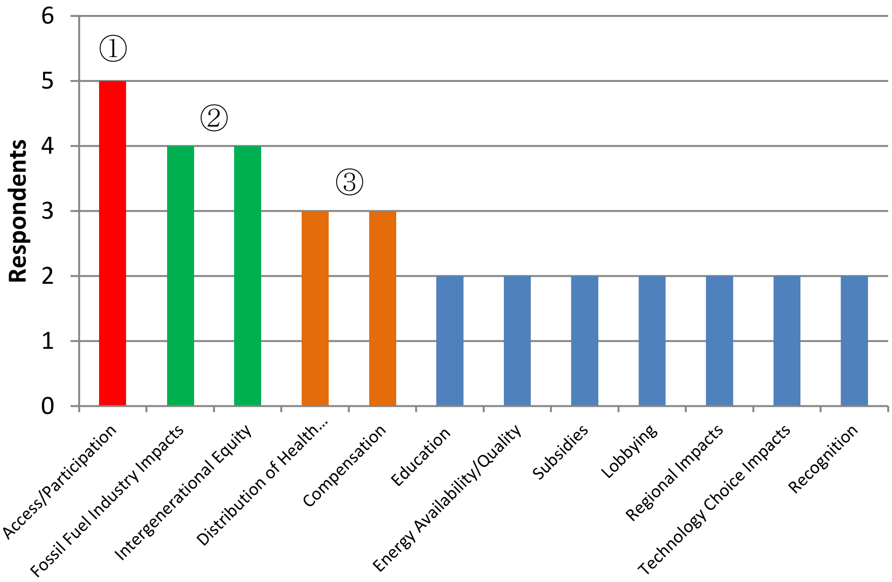

Figure 5.4 Social Equity Factors Identified by Respondents (n=33, multiple responses allowed)

5.5 Social Equity Impact Weighting and Policy Purpose Preference

Respondents were asked to comparatively weigh the importance of the five social equity impact factors on a Likert scale with a range from 1 (not important at all) to 8 (extremely important), as described in Section 5.1. The results of this weighting are presented in Figure 5.5.

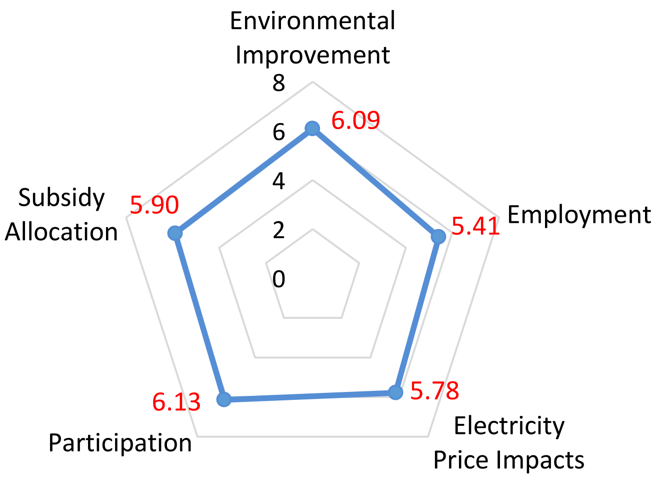

Figure 5.5 Social Equity Factor Importance Weighting (n=67)

Participation (6.13) was considered most important to respondents of the hearing, and was also identified (including under the auspices of access) as a key additional factor to be considered in the factor identification phase as shown in Figure 5.4. Environmental improvement (6.09) was identified as the second most important equity factor in energy policy, followed by subsidy allocation (5.90), electricity price impacts (5.78) and finally, employment (5.41).

None of the proposed factors was considered unimportant (a score of 4 or below) and the variation between the factors was less than one point on the eight point Likert scale, suggesting that professionals associated with Australian energy policy consider each of these factors as important in determining social equity impacts.

The importance level and standard deviation for each social equity impact is shown in Figure 5.6 and the wide standard deviation result suggests that accurate differentiation between factors level of importance has not been made clear. A larger sample of respondents may improve this result, and more direct investigation approaches such as an AHP participatory workshop or interviewing of respondents may yield a clearer order of preference for the 5 equity factors.

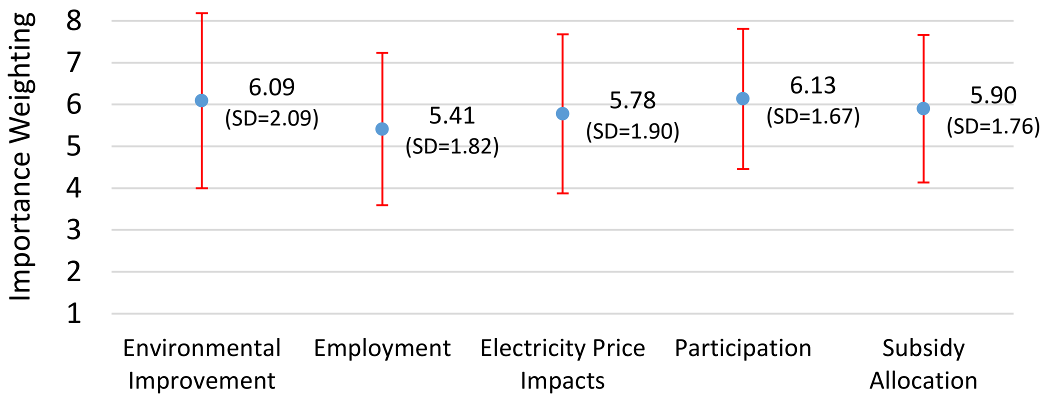

Figure 5.6 Equity Factor Importance and Standard Deviations

The final question posed in the hearing was to determine policy associated professional's opinion as to their preferred key role of energy policy: To achieve policy goals, to create policy outcomes which improve societal equity, or both.

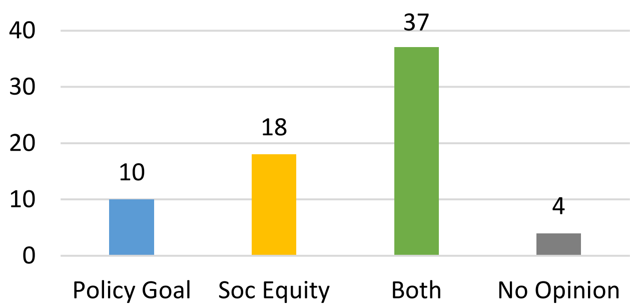

Figure 5.7 Key Role of Energy Policy Preference (n=69)

As shown in Figure 5.7 the majority (53.6%) of respondents preferred that energy policy should both achieve policy goals whilst improving societal equity outcomes. Of the remainder, 26.1% preferred that improving societal equity should be the key role of energy policy, while 14.5% preferred that policy goals be achieved as a priority. 5.8% of respondents had no opinion, with comments provided from these respondents suggesting that it is dependent on the nature of policy goals, and that these goals could include the improvement of social equity.

5.6 Incorporation Approach for Newly Proposed Factors

Based on the level of importance attributed to each of the social equity factors and the most prominent of the newly proposed factors relevant to energy policy which are not already incorporated, the Energy Policy Sustainability Evaluation Framework can be modified, allowing for testing of its robustness.

Considering the most prominent responses to additional societal equity impacts which should be considered within energy policy (as summarised in Figure 5.4), the factors of health impacts and impacts on the fossil fuel industry are incorporated.

The most prominent response of access and participation is already contained within the tool (and considered the most important by hearing respondents), however one of the second most prominent responses, 'the impacts on the fossil fuel industry' – specifically the loss of jobs due to retirement of generation assets is not considered by the framework, and could be implemented by a revision of the existing employment factor, modified to consider the new jobs created in the RE industry, less those jobs lost in the fossil fuel industry.

Intergenerational equity was also the second most prominently suggested social equity factor which should be considered by the framework, however, as the framework only considers a single policy scenario, it is intra-generational equity specific, leaving intergenerational equity out of scope. The framework does however show the shifting level of societal equity and burden of policy implementation on society (in the case of Australia) from 2008-2020, and with additional or projected energy system information (based on future policy goals and aspirations) could be further extended.

The two, third most prominently suggested social equity factors were compensation or ability to pay and the distribution of health impacts. Compensation and the ability to pay are already addressed within the framework within the subsidy allocation and participation factors; however, the concept of the distribution of health impacts is not addressed. Health impacts will be introduced as a discrete factor within the framework – investigated and detailed in section 5.7.

In addition to the factors discussed above, several new social equity factors were proposed, however consensus was not sufficient (two or less similar concepts suggested for each potential factor) for these to be considered for inclusion in the framework at this stage.

5.7 Applying New Factors to the Framework

The two new factors to be applied to the Energy Policy Sustainability Framework are impacts on the fossil fuel industry and the distribution of health impacts, described in detail below.

Impacts on the fossil fuel industry will specifically consider the number of jobs lost due to the retirement of fossil fuel based generation as a result of RE deployment. These jobs will be subtracted from new RE jobs created and incorporated under the 'employment' factor for each energy policy scenario year.

The distribution of health impacts factor will consider the negative health impacts as a result of pollutants emitted by the energy generation system. This factor will be incorporated as an additional factor in the framework, labelled 'health', considering the number and distribution of health impacts resultant from environmental conditions surrounding fossil fuel based electricity generation plants. The methodology for the application of the additional factors to the framework is outlined below.

5.7.1 Impacts on the Fossil Fuel Industry

Prior to input from energy policy stakeholders in Australia, the Energy Policy Sustainability Evaluation Framework only considered employment from the point of view of the number of new jobs created each year, due to a transition from fossil fuel to RE based electricity generation. Stakeholder engagement suggested that the loss of jobs in the fossil fuel industry should also be considered as a part of the employment social equity factor. In order to incorporate the loss of jobs in the fossil fuel based generation industry, the retirement of coal generation assets (distributed across black and brown coal) equivalent to the reduced amount of annual coal based generation will be subtracted from the jobs created from additional RE generation over time. The number and type of jobs lost are derived from selected power station and generator annual reports and databases (Macquarie Generation, 2007; Global Energy Observatory, 2016; Origin Energy, 2015) these are assumed to be the same for all fossil fuel power stations, approximately 23.2 direct FTE jobs per TWh generated. The distribution of full time jobs and approximate remuneration (Payscale, 2016) is outlined in Table 5.2.

Table 5.2 Fossil Fuel Generation Jobs, Distribution and Remuneration

Type of Job	**% of Jobs**	**Median Wage**
Executive & senior management	5.9%	$248,942[14]
Engineering officers	13.4%	$82,850
Professional officers	6.4%	$56,098
Administration officers	12.8%	$46,622
Operators	20%	$92,500
Mobile coal plant operators	1.5%	$62,641
Tradespersons (electrical)	4.9%	$75,505
Tradespersons (mechanical)	11.3%	$67,492
Tradespersons (metal fabrication)	1.5%	$70,039
Power workers	14.9%	$97,800
Apprentices (electrical & mechanical)	6.7%	$25,012

In each scenario, electricity generation in the NEM due to gas fired power plants increases over time, it is assumed that this increase will absorb some of the jobs lost from the coal fired power generation plants. Under the three scenarios outlined in chapter 4, the total number of job losses from 2008-2020 are shown in Table 5.3.

[14] Including cash bonuses

Table 5.3 Scenario Specific Jobs Lost in the Fossil Fuel Industry

Year	Baseline	FiT	Alternative
2008	0	0	0
2009	70	78	78
2010	74	84	84
2011	130	158	158
2012	16	50	50
2013	128	180	180
2014	63	88	88
2015	63	75	88
2016	34	44	71
2017	33	41	94
2018	34	39	100
2019	34	36	105
2020	36	38	119
Total	**713**	**910**	**1213**

5.7.2 Distribution of Health Impacts

In order to determine the distribution of health impacts, fossil fuel power stations which emit particulate matter (PM_{10}) associated with health risks (including respiratory and cardiovascular morbidity, WHO, 2013) are investigated based on their location, and the number and socio-economic status of households within the surrounding local government area (LGA) of the power station (including all LGA'S within a 20km radius).

The Australian Government provided National Pollutant Inventory (NPI, Department of Sustainability, Environment, Water, Population and Communities, 2012) is relied upon to provide estimates of PM_{10} emissions in each case, whilst Australian Socio-economic Indexes for Areas (SEIFA, ABS, 2006) are used to identify the socioeconomic status of impacted households in the affected LGAs surrounding the generation facility.

Figure 5.8 shows the location of all operating coal and gas fired power plants within the NEM states of Australia.

Figure 5.8 Location of Fossil Fuel Power Stations within the NEM

5.7.2.1 Estimating PM_{10} Emissions

In order to estimate the amount of PM_{10} emitted and the number of households affected, the following assumptions and formulae are used to determine the amount of PM_{10} emitted.

For coal fired power plants, black coal PM_{10} emissions are approximately .34 kg/tonne, based on the NPI provided formula of:

$$PM_{10}\text{ Emissions} = A \times 1000 \times F \times \left(1 - \frac{ER}{100}\right) \times FP \qquad \text{(eq. 5.1)}$$

where A = weight fraction of ash in the coal (using the NPI assumed value of 0.2), F = flyash fraction of total ash (using the NPI assumed value of 0.9), ER = emission reduction efficiency (assuming fabric filters gives a default value of 99.8%), and FP = PM_{10} fraction of emitted particles on a mass basis (assuming fabric filters giving a default value of 0.92).

Brown coal emissions use the same formula, however, as the ash content is widely variable based on the location of the coal, an approximation of 1.7×A is recommended in the NPI to derive fabric filter PM_{10} emissions for brown coal. In Victoria brown coal PM_{10} emissions are approximately .02 kg/tonne and in South Australia, approximately .35 kg/tonne (upper range ash content value used). In order to determine the amount of PM_{10} emissions from generation, higher heating values (also provided in the NPI, upper range values used, MJ converted to MWh) are used as shown in Table 5.4 for each state.

Table 5.4 Higher Heating Values for Coal Combustion (MJ converted to MWh)

State	NSW	QLD	SA	VIC
MWh/tonne	7.297	7.611	3.944	2.833

Based on NEM generation reports (AER, 2014) the average capacity factor for coal fired plants is established as 59.4%.

Finally, in order to derive the approximate PM_{10} emissions per coal fired power station per annum in kg/MWh, the following formula, bringing together all relevant factors is used:

$$PM_{10}\text{ Emissions} = \frac{CAP_{(Plant)} \times 8760 \times CF_{(Coal)}}{HHV_{(Fuel)}} \times E_{(PM_{10})} \qquad \text{(eq. 5.2)}$$

where CAP is the nameplate capacity of the power station, CF is the average coal fired NEM capacity factor, HHV is the higher heating value for the fuel type and E are PM_{10} emissions in kg/tonne.

For gas fired power stations, PM10 emissions are approximately 0.01kg/MWh (converted from NPI values, initially expressed in kg/PJ). The average capacity factor of gas turbines in the NEM is approximately 26% (AER, 2014). In order to derive the approximate PM_{10} emissions per gas fired power station per annum in kg/MWh, the following formula is used:

$$PM_{10}\text{ Emissions} = CAP_{(Plant)} \times 8760 \times CF_{(Gas)} \times E_{(\mathrm{PM}_{10})} \qquad \text{(eq. 5.3)}$$

where CAP is the nameplate capacity of the power station, CF is the average NEM gas fired capacity factor, and E is the PM_{10} emissions in kg/MW.

5.7.2.2 Scale and Distribution of Impacts

Using the LGA indices of relative social disadvantage deciles, the average socio-economic status of households is determined for each affected LGA surrounding coal and gas fired power stations.

Contrasting the socio-economic status of each LGA with the Australian household income levels as established in Table 4.15, the LGA social disadvantage deciles are allocated to approximate the distribution of income levels, shown in Table 5.5.

Table 5.5 LGA Social Disadvantage Deciles & Australian Income Levels

Income Level	Very Low		Low		Average			High		Very High
Decile	1	2	3	4	5	6	7	8	9	10

Table 5.6 and Table 5.7 show the details of the coal and gas fired power stations operating within the NEM, their nameplate capacity, location and PM_{10} emissions per annum, calculated using the methodologies outlined in section 5.7.2.1.

A summary of affected social disadvantage deciles, corresponding income level and amount of PM_{10} emissions per capita in each is shown at Table 5.8 (Complete details of affected LGA's, population and SEIFA specifics are available in Appendices B and C).

Within the NEM, Emissions are concentrated most heavily in very low, low and average income areas, causing an uneven distribution of health impacts across society. The health impact is treated differently to GHG reduction, as health impacts are localised in the area of PM_{10} dispersal, whereas climate change impacts experienced due to GHG emissions are experienced more broadly across society, over time.

Table 5.6 Coal Fired Power Station Capacity, Location and Emissions

Name of Power Plant	MWe	Location	PM_{10} (tonne p.a.)
Bayswater	2640	NSW	640.1
Liddell	2000	NSW	484.9
Eraring	2840	NSW	688.6
Redbank	151	NSW	36.6
Mount Piper	1400	NSW	339.4
Vales Point B	1320	NSW	320.0
Wallerawang-C	1000	NSW	242.5
Callide B	700	QLD	162.7
Callide C	900	QLD	209.2
Millmerran	880	QLD	204.6
Kogan Creek	750	QLD	174.3
Tarong	1400	QLD	325.4
Tarong North	443	QLD	103.0
Gladstone	1680	QLD	390.5
Stanwell	1460	QLD	339.4
Collinsville	190	QLD	44.2
Northern	544	SA	251.2
Thomas Playford B	240	SA	110.8
Loy Yang A	2210	VIC	81.2
Loy Yang B	955	VIC	35.1
Hazelwood	1600	VIC	58.8
Yallourn West	1480	VIC	54.4
Anglesea	150	VIC	5.5
Energy Brix (Morwell)	170	VIC	6.2

Table 5.7 Gas Fired Power Station Capacity, Location and Emissions

Name of Power Plant	MWe	Location	PM_{10} (tonne p.a.)
Colongra OCGT	667	NSW	15.2
Uranquinty OCGT	640	NSW	14.6
Tallawarra CCGT	435	NSW	9.9
Smithfield CHP CCGT	160	NSW	3.6
Braemar I OCGT	450	QLD	10.2
Swanbank E CCGT	385	QLD	8.8
Barcaldine CCGT	53	QLD	1.2
Condamine CCGT	140	QLD	3.2
Roma OCGT	74	QLD	1.7
Mica Creek CCGT	304.7	QLD	6.9
Oakey OCGT	332	QLD	7.6
Mackay OCGT	34	QLD	0.8
Phosphate Hill	42	QLD	1.0
Bulwer Island Cogen CCGT	33	QLD	0.8
Xstrata X41	30	QLD	0.7
Yabulu (Townsville) CCGT	242	QLD	5.5
Mount Stuart	414	QLD	9.4
Diamantina CCGT	242	QLD	5.5
Pelican Point CCGT	487	SA	11.1
Torrens Island Thermal	1280	SA	29.2
Quarantine OCGT	216	SA	4.9
Ladbroke Grove OCGT	80	SA	1.8
Dry Creek OCGT	156	SA	3.6
Mintaro OCGT	90	SA	2.0
Snuggery OCGT	63	SA	1.4
Osborne CHP CCGT	180	SA	4.1
AGL Hallett OCGT	203	SA	4.6
Tamar Valley CCGT	390	TAS	8.9
Newport D Gas	510	VIC	11.6
Jeeralang OCGT	468	VIC	10.7
Bairnsdale OCGT	94	VIC	2.1
Somerton OCGT	150	VIC	3.4
Laverton North	320	VIC	7.3
Valley Power OCGT	300	VIC	6.8
Mortlake OCGT	550	VIC	12.5

Table 5.8 Social Disadvantage, Income Level and Emissions per Capita

Social Disadvantage Decile	Income Level	PM_{10} (tonnes p.a.)	Affected Population	PM_{10} (tonne/capita)
1	Very Low	808.3	632,332	0.0013
2				
3	Low	1122.4	2,337,475	.00048
4				
5	Average	2792.8	3,632,199	.00077
6				
7				
8	High	811.8	4,029,150	.0002
9				
10	Very High	5.9	653,885	.000009

5.7.3 Comparative Equity Analysis Including New Factors

The Australian equity distribution and weighting factors initially described in Table 4.16 are modified to incorporate the newly identified energy policy equity impacts as shown in Table 5.9 (modifications to the initial five factor tool are underlined).

Table 5.9 Revised Australian Equity Distribution and Weighting Factors

Equity Factor	Distribution Factors	Weighting Factors
Participation	Australian participation precedents (Higgins et al, 2014, Bruce et al, 2009)	% of non-subsidized households
GHG Reduction	Assumed to be equal	Gt of GHG reduced
Employment	Australian review RE **and fossil fuel** job allocation and salaries (Payscale, 2015)	Number of direct RE Jobs in 2020 **less jobs lost in the fossil fuel industry.**
Subsidy Allocation	Participation rate multiplied by % of households per income level	Subsidy (FiT) payment amount
Elec. price impact	Elec. price % increase due to subsidization (or LCOE increase) per income level	Actual $ increase per annual average electricity bill
Health	**PM_{10} pollution distribution per capita in each income level**	**TWh of fossil fuel based generation in the energy mix**

Incorporating the newly identified factors, relative equity and policy burden centroids for each of the three policy scenarios from 2008-2020 (initially assessed in chapter 4) can be derived, as shown in Figure 5.9 for the FiT and alternative Scenario, and Figure 5.10 for the baseline Scenario.

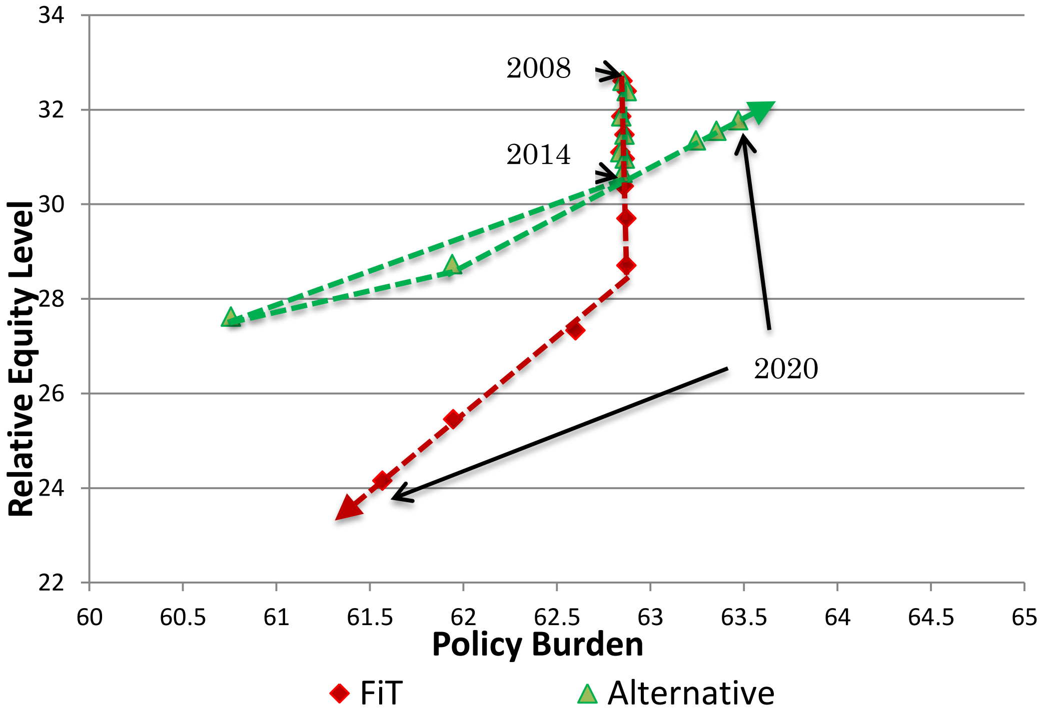

Figure 5.9 Fit and Alternative Scenario Relative Equity and Policy Burden 2008-2020

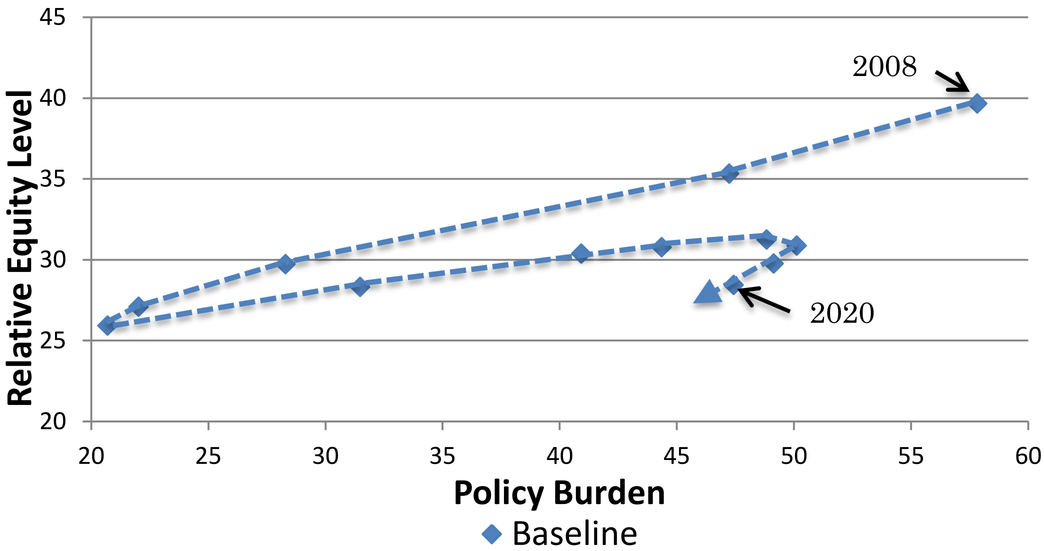

Figure 5.10 Baseline Scenario Relative Equity and Policy Burden 2008-2020

Compared to the initial results shown at Figure 4.13, incorporating two negative factors, firstly the loss of jobs in the fossil fuel industry to the employment factor, and the incorporation of health impact distribution considerable reduces overall relative equity in all scenarios, as expected.

The baseline scenario suffers the most from the inclusion of the two additional factors, as health impacts are most markedly felt due to the consistently high level of fossil fuel based electricity under this scenario. The relative equity and burden vectors of the FiT and Alternative Scenario are similar to the initial results, however the level of relative equity is reduced, and the lower income levels are more heavily burdened, due mainly to the health impacts of fossil fuel generation laying most heavily very low, low and average income households.

The revised, Australian energy policy specific comparative equity assessment tool, incorporating the two new factors as identified by the energy policy hearing will be subjected to sensitivity analysis for the target year of 2020 in chapter 6.

6. Proposed Framework Revision and Testing

6.1 Introduction

Based on the Energy Policy Sustainability Evaluation Framework introduced in chapter 4, investigation was undertaken based on government and third party analysis of equity impacts resultant from energy policy implementation in Australia. This analysis led to the extraction of five quantitative equity factors, namely employment, electricity price impacts, participation, subsidy allocation and environmental improvement (GHG reduction). An initial comparative equity analysis was undertaken over the three energy policy scenarios in Australia (baseline, FiT and alternative (see section 4.3). This analysis showed the alternative (evidence based) scenario as having the highest level of relative equity in the target year of 2020, however the baseline scenario distributed the burden of policy implementation impacts in the most preferable manner. The FiT scenario showed the lowest level of comparative relative equity and the worst distribution of burdens. Following the introduction of two additional factors of employment impacts on the fossil fuel industry and health impacts, elicited through the Energy Policy and Social Equity Hearing in Australia, the comparative analysis results change markedly for the baseline scenario, relegating it to the least desirable levels of equity and burden distribution. The target year centroids for each of the three scenarios for the initial five factor framework, and the revised six factor framework (fossil fuel industry impacts are combined into the existing employment factor) are shown at Figure 6.1.

For the FiT and alternative scenarios, the introduction of two negative factors, the loss of jobs in the fossil fuel industry and the health impacts of fossil fuel generation within the NEM cause a reduction in relative equity level, and also shift the burden of energy policies more heavily onto lower income level households, however when compared to the Baseline scenario, this reduction is relatively mild. This is because under the both the FiT and Alternative scenarios, significant amounts of RE are deployed, creating job opportunities and reducing GHG within the NEM, however under the baseline scenario, no mitigating factor is offered against the small loss of jobs in the fossil fuel industry and the most significant level of fossil fuel generation to the target year of 2020.

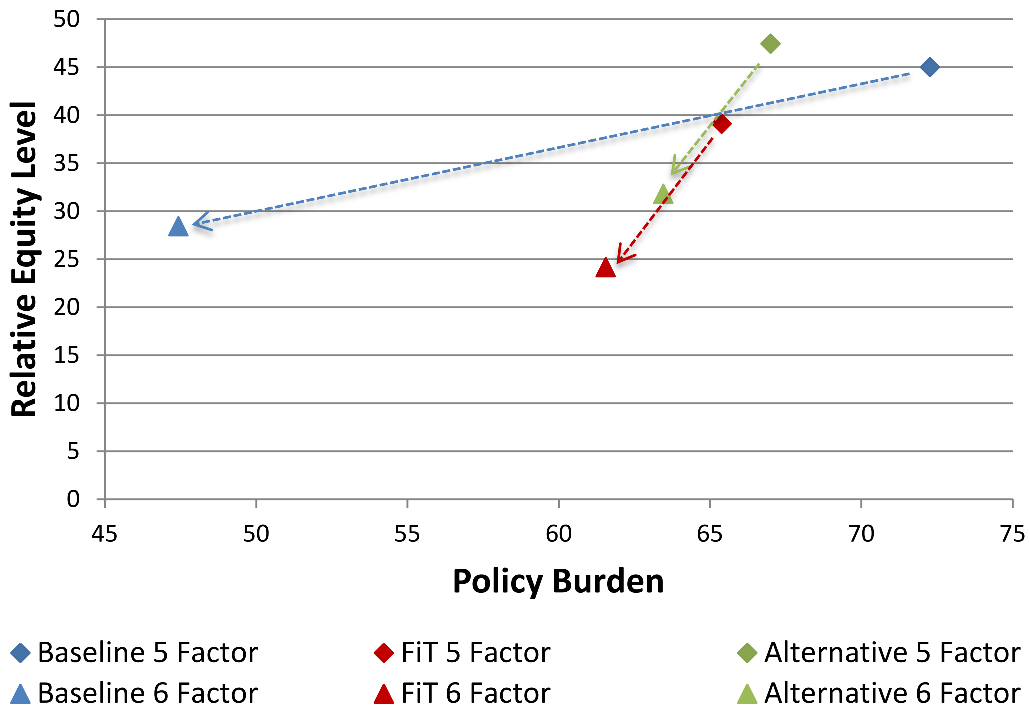

Figure 6.1 Initial & Revised Framework Relative Equity & Policy Burden in 2020

Of the two new factors, the health impact has the greatest effect on equity reduction due to the large bias of pollutants towards lower income households (see section 6.3.1 for details). Further to this comparison of a change from a five factor to a six factor equity evaluation process in order to be more representative of Australian energy policy and equity preferences, sensitivity analysis is conducted on the level of impact each factor imparts on the relative equity and social burden outcomes.

6.2 Methodology

With the revision of the Energy Policy Sustainability Evaluation Framework to include a sixth factor, and the revision of the employment factor, the framework now consists of additional negative factors, and the relative importance of each factor is also changed from 1/5 to 1/6 of the total.

Figure 6.2 illustrates the nature of each of the factors prior to sensitivity analysis. Positive factors are blue, negative are red, and employment which consists of positive and negative factors is shaded purple.

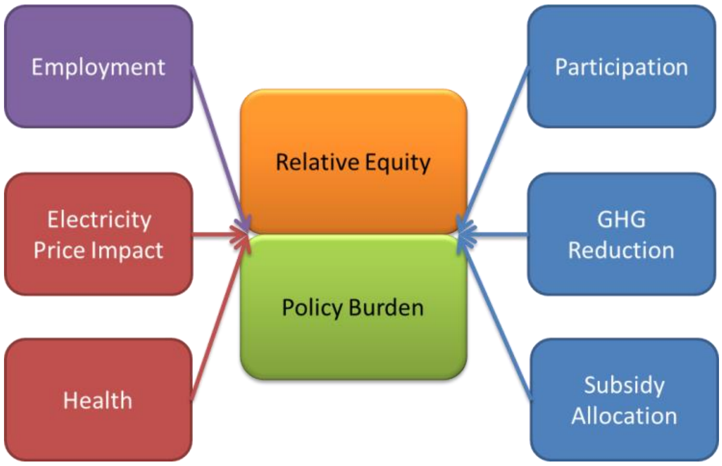

Figure 6.2 Revised Energy Policy Sustainability Evaluation Framework Factors

In order to perform sensitivity analysis, the weighting of each the framework factors will be modified in order to observe the behaviour of the framework under various conditions. Additionally, specific allocation of jobs, a progressive electricity billing regime, the efficiency of the fossil fuel component of the energy system, conditions which influence hydro-electricity generation and electricity price impact factors will be adjusted to assess their impact on the frameworks equity evaluation outcomes.

6.2.1 Equity Factor Weighting Sensitivity Analysis

For the target year of 2020, each of the six factors overall weighting will be modified by ±10, 20 and 50 and 100% with a subsequent assessment of the resultant impact on 1) the level of relative equity and 2) the shift in policy burden. The equity and policy burden centroids will be recalculated for each scenario based on the applied weightings.

6.2.2 Conditional Sensitivity Analysis

The second series of sensitivity analyses will employ conditional effects on the energy system which may impact more than one equity factor including a ±10, 20, 50 and 100% change in the emissions (greenhouse and PM_{10}) of coal fired power stations considering technological improvements and other exogenous factors affecting performance. Additionally, hydroelectric generation within the NEM, considering drought and high rainfall impacts will be assessed in the same range.

Two social policies will also be tested including purposive job allocation based on the populations within each income level, as well as testing a progressive electricity billing regime for households based on a percentage of the household income as well as a combination of these two policies. Additionally, a sensitivity analysis is undertaken whereby the cost of electricity derived from each NEM source is the same across scenarios, irrespective of the amount of electricity derived from each source, in order to assess equity and burden impacts in the absence of significant scenario electricity price differences to 2020.

6.3 Results

As previously shown in Figure 6.1, the Energy Policy Sustainability Evaluation Framework's equity evaluation which incorporates six factors is expressed as a centroid consisting of an X-axis value which represents the policy burden imparted by a policy approach (i.e. which income levels of society are bearing the burden due to the implementation of a specific policy approach), and a Y-axis value which represents relative equity, considered comparatively across scenarios, for both factors, a higher result is considered better. The initial centroid values (prior to sensitivity analysis) for each scenario are shown at Table 6.1.

Table 6.1 Initial Relative Equity and Policy burden Centroids

Scenario	Baseline		FiT		Alternative	
Centroid Values (x,y)	Burden	Equity	Burden	Equity	Burden	Equity
	47.441	28.422	61.567	24.157	63.47	31.779

The minimum and maximum values theoretically possible for policy burden range from 0 to 100. Under the six value relative equity analysis incorporating two negative factors and one factor which includes both positive and negative aspects, the minimum and maximum theoretically possible value range for equity is 0 to 50 (prior to sensitivity adjustments).

6.3.1 Equity Factor Weighting Sensitivity Results

Table 6.2 to Table 6.7 outline the sensitivity analysis results for each of the social equity impact factors. Figure 6.3 to Figure 6.8, displayed below each impact factor sensitivity analysis results table shows the relative equity and social burden centroid movement and trend as a result of sensitivity analysis adjustments. Appendix D contains detailed charts of sensitivity analysis results for each factor.

Table 6.2 Participation Sensitivity Analysis Results

Scenario	Baseline		FiT		Alternative	
Initial Centroid	Burden	Equity	Burden	Equity	Burden	Equity
	47.441	28.422	61.567	24.157	63.47	31.779
Participation +10% Centroid	47.441	30.168 (+6.1%)	61.674 (+0.2%)	25.002 (+3.5%)	63.609 (+0.2%)	32.579 (+2.5%)
Participation -10% Centroid	47.441	26.587 (-6.5%)	61.463 (-0.2%)	23.285 (-3.6%)	63.336 (-0.2%)	30.953 (-2.6%)
Participation +20% Centroid	47.441	31.831 (+12%)	61.783 (+0.4%)	25.822 (+6.9%)	63.75 (+0.4%)	33.356 (+5.0%)
Participation -20% Centroid	47.441	24.655 (-13.3%)	61.361 (-0.3%)	22.384 (-7.3%)	63.204 (-0.4%)	30.102 (-5.3%)
Participation +50% Centroid	47.441	36.376 (+28%)	62.217 (+1.1%)	28.139 (+16.5%)	64.198 (+1.1%)	35.556 (+11.9%)
Participation -50% Centroid	47.441	18.197 (-36%)	61.07 (-0.8%)	19.495 (-19.3%)	62.829 (-1.0%)	27.373 (-13.9%)
Participation +100% Centroid	47.441	42.738 (+50.3%)	62.762 (+1.9%)	31.593 (+30.8%)	65.032 (+2.5%)	38.851 (+22.3%)
Participation -100% Centroid	47.441	4.563 (-83.9%)	60.626 (-1.5%)	13.94 (-42.3%)	62.26 (-1.9%)	22.14 (-30.3%)

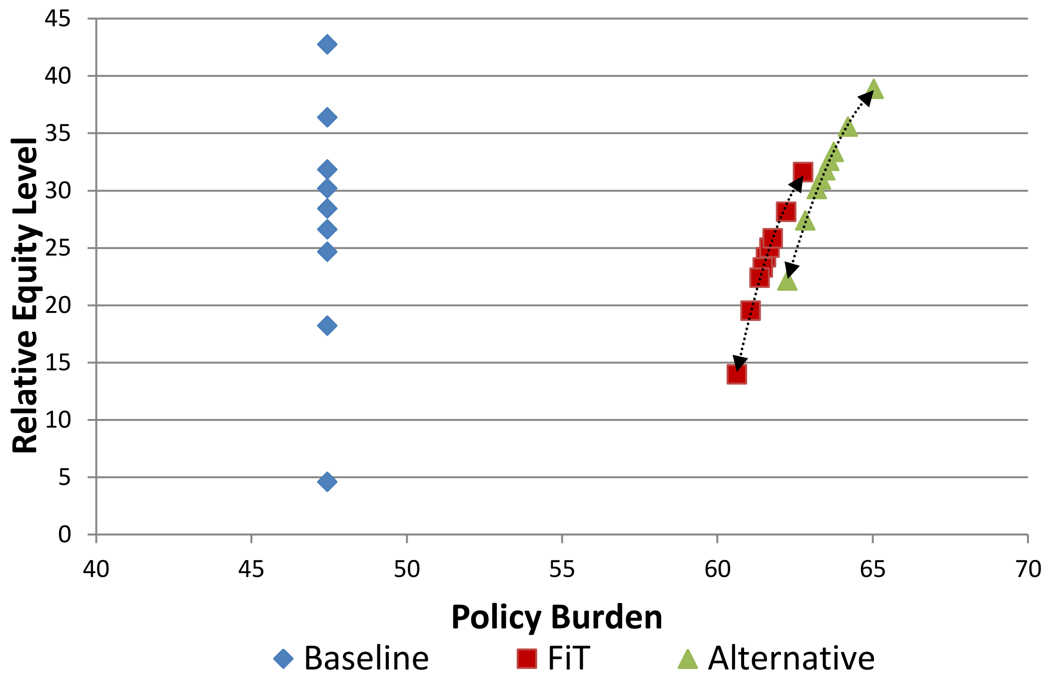

Figure 6.3 Participation Sensitivity Analysis Centroids

Table 6.3 GHG Reduction Sensitivity Analysis Results

Scenario	Baseline		FiT		Alternative	
Initial Centroid	Burden	Equity	Burden	Equity	Burden	Equity
	47.441	28.422	61.567	24.157	63.47	31.779
GHG Reduction +10% Centroid	47.441	29.269 (+3%)	61.567	24.979 (+3.4%)	63.47	32.897 (+3.5%)
GHG Reduction -10% Centroid	47.441	27.533 (-3.1%)	61.567	23.307 (-3.5%)	63.47	30.623 (-3.6%)
GHG Reduction +20% Centroid	47.441	30.075 (+5.8%)	61.567	25.775 (+6.7%)	63.47	33.98 (+6.9%)
GHG Reduction -20% Centroid	47.441	26.596 (-6.4%)	61.567	22.428 (-7.2%)	63.47	29.426 (-7.4%)
GHG Reduction +50% Centroid	47.441	32.278 (+13.6%)	61.567	28.015 (+16%)	63.47	37.027 (+16.5%)
GHG Reduction -50% Centroid	47.441	23.465 (-17.4%)	61.567	19.598 (-18.9%)	63.47	25.577 (-19.5%)
GHG Reduction +100% Centroid	47.441	35.363 (+24.4%)	61.567	31.322 (+29.7%)	63.47	41.525 (+30.7%)
GHG Reduction -100% Centroid	47.441	16.854 (-40.7%)	61.567	14.126 (-41.5%)	63.47	18.135 (-42.9%)

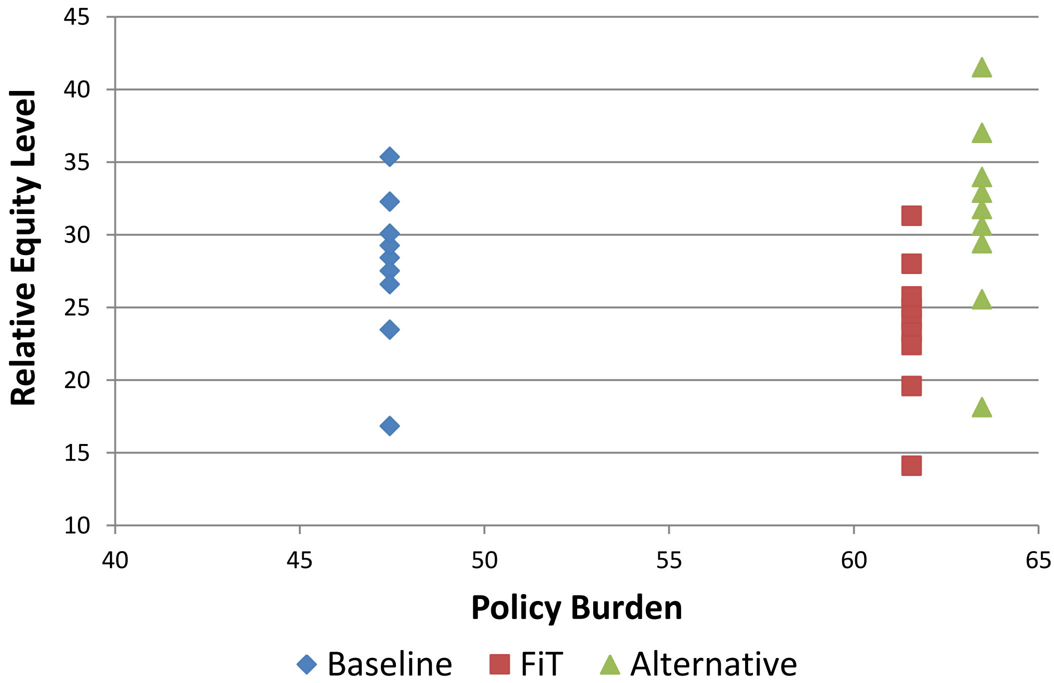

Figure 6.4 GHG Reduction Sensitivity Analysis Centroids

Table 6.4 Employment Sensitivity Analysis Results

Scenario	Baseline		FiT		Alternative	
Initial Centroid	Burden	Equity	Burden	Equity	Burden	Equity
	47.441	28.422	61.567	24.157	63.47	31.779
Employment +10% Centroid	49.604 (+4.6%)	28.467 (<+0.1%)	61.823 (+0.4%)	24.147 (<-0.1%)	63.798 (+0.5%)	31.871 (+0.3%)
Employment -10% Centroid	44.825 (-5.5%)	28.301 (-0.4%)	61.298 (-0.4%)	24.169 (<+0.1%)	63.118 (-0.6%)	31.686 (-0.3%)
Employment +20% Centroid	51.424 (+8.4%)	28.456 (+0.2%)	62.068 (+0.8%)	24.139 (-0.1%)	64.102 (+1%)	31.963 (+0.6%)
Employment -20% Centroid	41.598 (-11.6%)	28.07 (-1.2%)	61.015 (-0.9%)	24.183 (+0.1%)	62.736 (-1.2%)	31.592 (-0.6%)
Employment +50% Centroid	55.479 (+16.9%)	28.228 (-0.7%)	62.738 (+1.9%)	24.124 (-0.1%)	64.9 (+2.3%)	32.232 (+1.4%)
Employment -50% Centroid	24.962 (-47.4%)	26.019 (-8.5%)	60.073 (-2.4%)	24.242 (+0.4%)	61.382 (-3.3%)	31.314 (-1.5%)
Employment +100% Centroid	59.608 (+25.6%)	27.569 (-3%)	63.681 (+3.4%)	24.122 (-0.1%)	65.94 (+3.9%)	32.654 (+2.8%)
Employment -100% Centroid	0[15]	0[15]	58.1 (-5.6%)	24.419 (+1.1%)	58.042 (-8.6%)	30.906 (-2.7%)

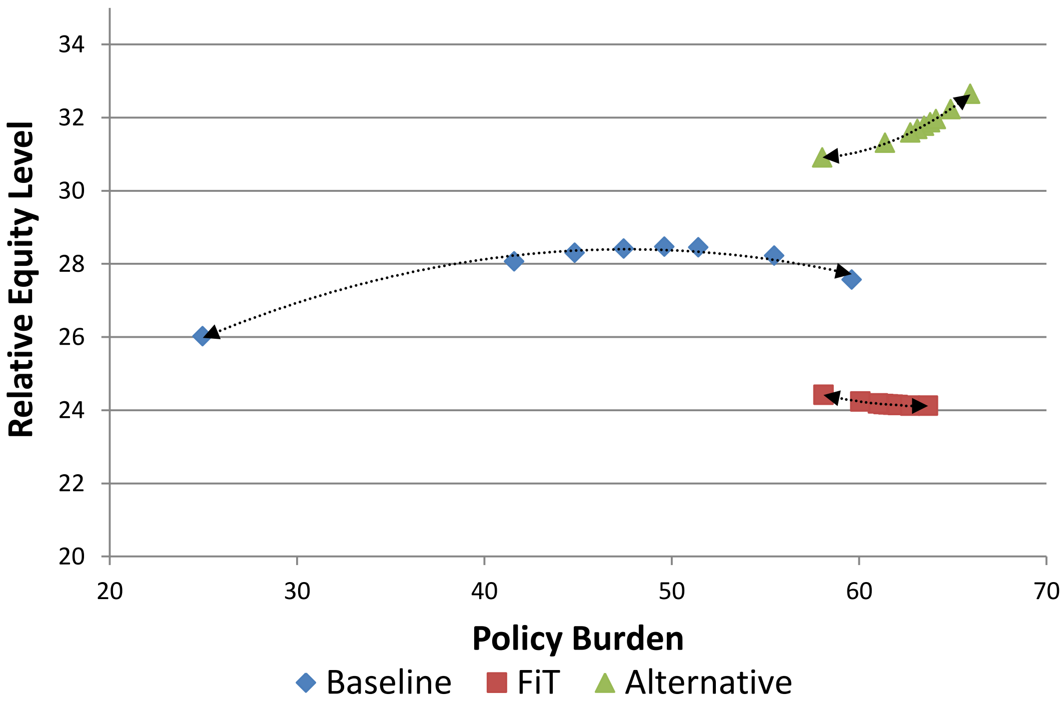

Figure 6.5 Employment Sensitivity Analysis Centroids

[15] Not plotted, centroid outside graph area.

Table 6.5 Subsidy Allocation Sensitivity Analysis Results

Scenario	Baseline		FiT		Alternative	
	Burden	Equity	Burden	Equity	Burden	Equity
Initial Centroid	47.441	28.422	61.567	24.157	63.47	31.779
Subsidy Allocation +10% Centroid	Not included in Baseline Scenario		61.754 (+0.3%)	24.863 (+2.9%)	63.533 (+0.1%)	32.161 (+1.2%)
Subsidy Allocation -10% Centroid			61.354 (-0.3%)	23.418 (-3.1%)	63.4 (-0.1%)	31.382 (-1.2%)
Subsidy Allocation +20% Centroid			61.92 (+0.6%)	25.538 (+5.7%)	63.59 (+0.2%)	32.529 (+2.4%)
Subsidy Allocation -20% Centroid			61.109 (-0.7%)	22.641 (-6.3%)	63.321 (-0.2%)	30.97 (-2.5%)
Subsidy Allocation +50% Centroid			62.321 (+1.2%)	27.408 (+13.5%)	63.729 (+0.4%)	33.558 (+5.6%)
Subsidy Allocation -50% Centroid			60.092 (-2.4%)	20.031 (-17.1%)	63.009 (-0.7%)	29.624 (-6.8%)
Subsidy Allocation +100% Centroid			62.778 (+2.0%)	30.102 (+24.6%)	63.895 (+0.7%)	35.065 (+10.3%)
Subsidy Allocation -100% Centroid			55.914 (-9.2%)	13.903 (-42.4%)	61.956 (-2.4%)	26.871 (-15.4%)

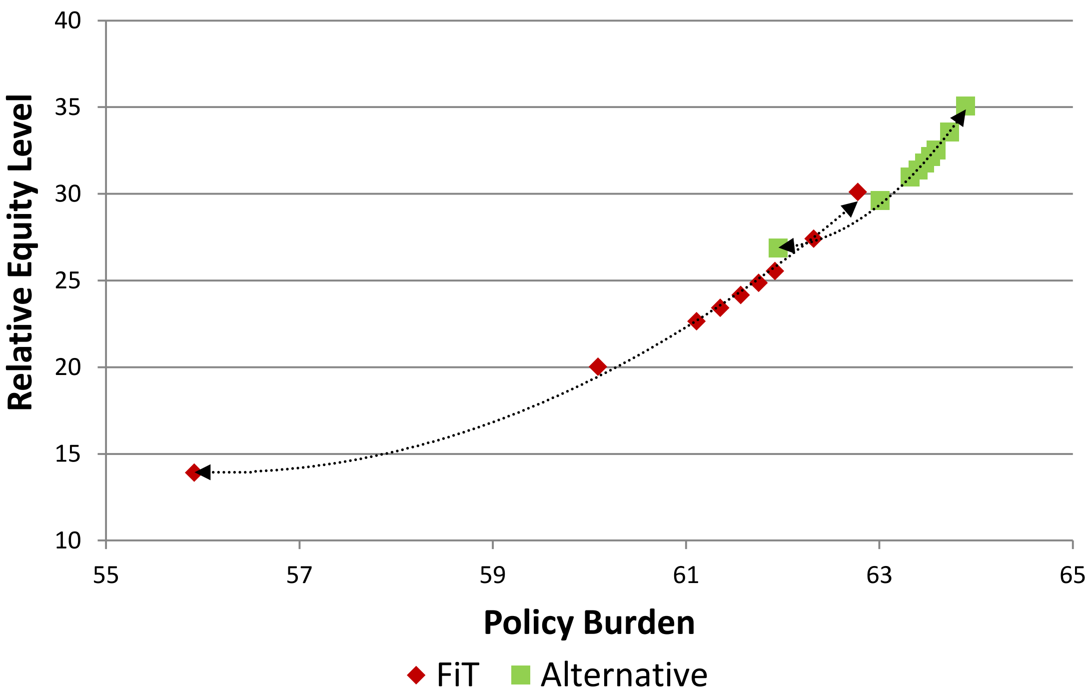

Figure 6.6 Subsidy Allocation Sensitivity Analysis Centroids

Table 6.6 Electricity Price Impact Sensitivity Analysis Results

Scenario	Baseline		FiT		Alternative	
	Burden	Equity	Burden	Equity	Burden	Equity
Initial Centroid	47.441	28.422	61.567	24.157	63.47	31.779
Elec. Price Impact +10% Centroid	Not included in Baseline Scenario		61.381 (-0.3%)	23.042 (-4.6%)	63.282 (-0.3%)	30.681 (-3.5%)
Elec. Price Impact -10% Centroid			61.762 (+0.3%)	25.308 (+4.8%)	63.666 (+0.3%)	32.912 (+3.6%)
Elec. Price Impact +20% Centroid			61.202 (-0.6%)	21.959 (-9.1%)	63.1 (-0.6%)	29.617 (-6.8%)
Elec. Price Impact -20% Centroid			61.965 (+0.6%)	26.495 (+9.7%)	63.869 (+0.6%)	34.081 (+7.2%)
Elec. Price Impact +50% Centroid			60.71 (-1.3%)	18.9 (-21.8%)	62.592 (-1.4%)	26.609 (-16.3%)
Elec. Price Impact -50% Centroid			62.637 (+1.7%)	30.295 (+25.4%)	64.526 (+1.7%)	37.828 (+19%)
Elec. Price Impact +100% Centroid			60.008 (-2.5%)	14.351 (-40.6%)	61.849 (-2.6%)	22.142 (-30.3%)
Elec. Price Impact -100% Centroid			64.012 (+3.9%)	37.544 (+55.4%)	65.817 (+3.7%)	45 (+41.6%)

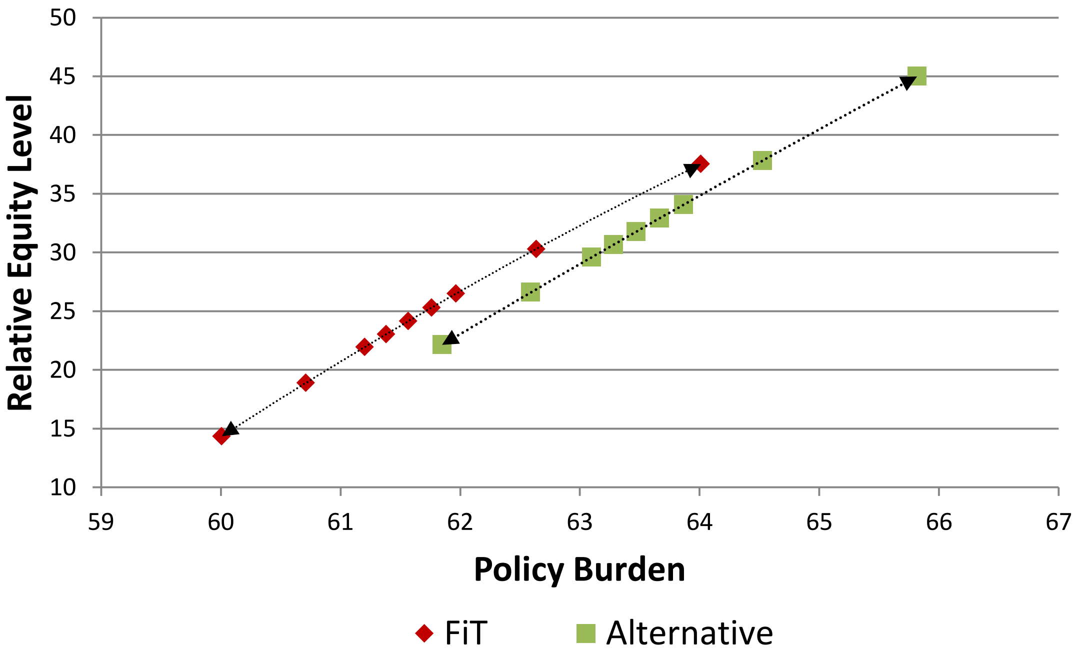

Figure 6.7 Electricity Price Sensitivity Analysis Centroids

Table 6.7 Health Sensitivity Analysis Results

Scenario	Baseline		FiT		Alternative	
	Burden	Equity	Burden	Equity	Burden	Equity
Initial Centroid	47.441	28.422	61.567	24.157	63.47	31.779
Health +10% Centroid	45.085 (-5%)	25.719 (-9.5%)	61.19 (-0.6%)	22.902 (-5.2%)	63.12 (-0.6%)	30.481 (-4.1%)
Health -10% Centroid	49.822 (+5%)	31.191 (+9.7%)	61.944 (+0.6%)	25.447 (+5.3%)	63.821 (+0.6%)	33.114 (+4.2%)
Health +20% Centroid	42.754 (-9.9%)	23.076 (-18.8%)	60.814 (-1.2%)	21.679 (-10.3%)	62.771 (-1.1%)	29.218 (-8.1%)
Health -20% Centroid	52.229 (+10.1%)	34.028 (+19.7%)	62.322 (+1.2%)	26.774 (+10.8%)	64.172 (+1.1%)	34.489 (+8.5%)
Health +50% Centroid	35.908 (-24.3%)	15.484 (-45.5%)	59.689 (-3.1%)	18.195 (-24.7%)	61.725 (-2.7%)	25.627 (-19.4%)
Health -50% Centroid	59.608 (+25.6%)	42.996 (+51.3%)	63.46 (+3.1%)	30.993 (+28.3%)	65.229 (+2.8%)	38.871 (+22.3%)
Health +100% Centroid	24.962 (-47.4%)	3.801 (-86.6%)	57.827 (-6.1%)	12.922 (-46.5%)	59.992 (-5.5%)	20.216 (-36.4%)
Health -100% Centroid	72.465 (+52.7%)	59.818 (+110.4%)	65.369 (+6.2%)	38.963 (+61.3%)	67.002 (+5.6%)	47.183 (+48.5%)

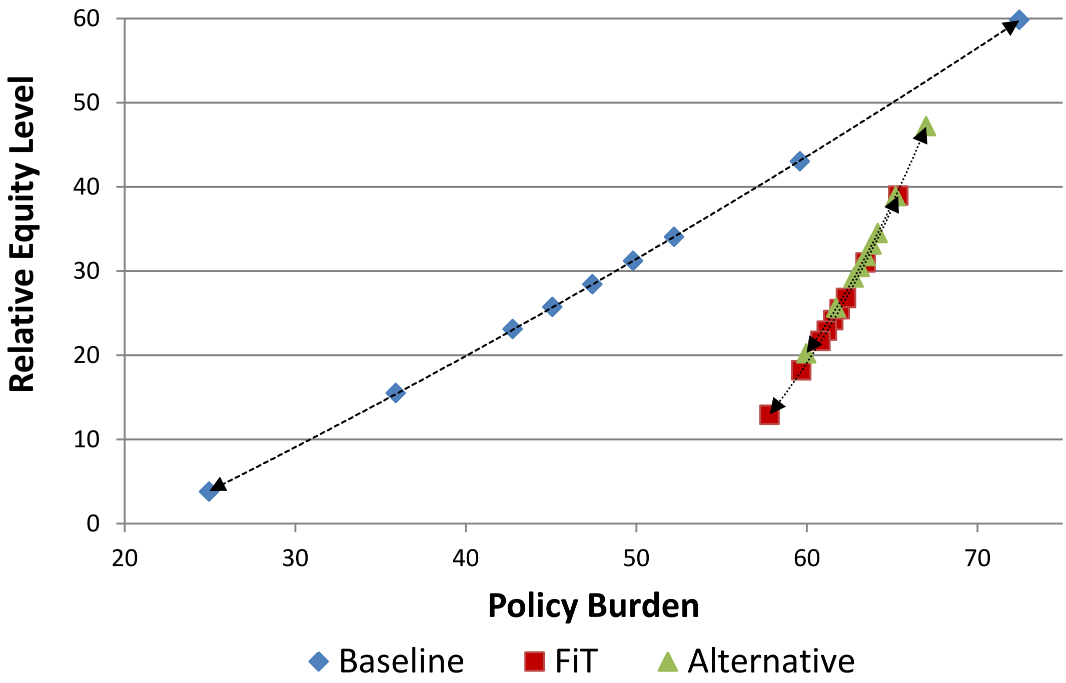

Figure 6.8 Health Sensitivity Analysis Centroids

6.3.2 Conditional Sensitivity Analysis Results

Coal Fired Generation Emissions: For coal fired generation emissions (GHG and PM_{10}), NEM specific emissions intensities (as specified in section 4.3) are used to determine the impacts on GHG levels and PM_{10} emission related health impacts are also considered in order to test the frameworks sensitivity to changes in emissions from coal fired power stations. Table 6.8 outlines the results with Figure 6.9 showing the movement of centroids for each of the three scenarios tested.

Table 6.8 Coal Fired Emissions Sensitivity Analysis Results

Scenario	Baseline		FiT		Alternative	
	Burden	Equity	Burden	Equity	Burden	Equity
Initial Centroid	47.441	28.422	61.567	24.157	63.47	31.779
Emissions +10% Centroid	47.441	24.587 (-13.5%)	61.567	22.207 (-8.1%)	63.47	30.754 (-3.2%)
Emissions -10% Centroid	47.441	31.99 (+12.6%)	61.567	25.929 (+7.3%)	63.47	32.875 (+3.4%)
Emissions +20% Centroid	47.441	20.154 (-29.1%)	61.567	19.931 (-17.5%)	63.47	29.793 (-6.2%)
Emissions -20% Centroid	47.441	35.466 (+24.8%)	61.567	27.613 (+14.3%)	63.47	34.049 (+7.1%)
Emissions +50% Centroid	47.441	-8.121 (-128.5%)	61.567	5.403 (-77.6%)	63.47	27.239 (-14.3%)
Emissions -50% Centroid	47.441	46.644 (+64.1%)	61.567	32.628 (+35.1%)	63.47	38.135 (+20%)
Emissions +100% Centroid	47.441	-37.753 (-232.8%)	61.567	-19.022 (-178.7%)	63.47	-1.166 (-103.7%)
Emissions -100% Centroid	47.441	75.282 (+164.9%)	61.567	42.614 (+176.4%)	63.47	47.616 (+49.8%)

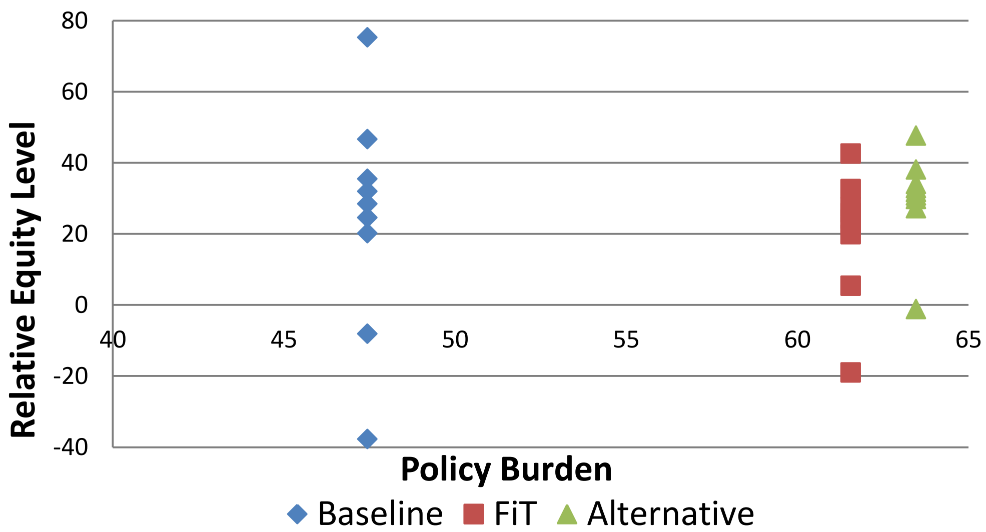

Figure 6.9 Coal Fired Emissions Sensitivity Analysis Centroids

Hydro Generation: For hydroelectricity, drought and high rainfall conditions markedly impact on the amount of generation, consequently influencing both GHG emissions and RE and fossil fuel jobs within the NEM. Table 6.9 outlines the results of the sensitivity analysis based on the change in employment distribution and greenhouse emissions and Figure 6.10 shows the movement and trend of centroids for each of the three scenarios, considering the impacts of increased and decreased hydroelectric generation in the target year of 2020.

Table 6.9 Hydro Generation Sensitivity Analysis Results

Scenario	Baseline		FiT		Alternative	
Initial Centroid	Burden	Equity	Burden	Equity	Burden	Equity
	47.441	28.422	61.567	24.157	63.47	31.779
Hydro Generation +10% Centroid	48.742 (+2.7%)	28.838 (+1.4%)	61.639 (+0.1%)	24.415 (+1.1%)	63.502 (<+0.1%)	31.88 (+0.3%)
Hydro Generation -10% Centroid	46.059 (-2.9%)	27.621 (-2.8%)	61.52 (<-0.1%)	24.066 (-0.4%)	63.464 (<-0.1%)	31.758 (<-0.1%)
Hydro Generation +20% Centroid	49.801 (+5%)	29.375 (+3.4%)	61.694 (+0.2%)	24.58 (+1.8%)	63.52 (<+0.1%)	31.937 (+0.5%)
Hydro Generation -20% Centroid	44.327 (-6.6%)	26.921 (-5.3%)	61.455 (-0.2%)	23.82 (-1.4%)	63.443 (<-0.1%)	31.693 (-0.3%)
Hydro Generation +50% Centroid	52.246 (+10.1%)	30.783 (+8.3%)	61.84 (+0.4%)	25.04 (+3.7%)	63.569 (+0.2%)	32.094 (+1%)
Hydro Generation -50% Centroid	36.282 (-23.5%)	24.211 (-14.8%)	61.233 (-0.5%)	23.28 (-3.6%)	63.372 (-0.2%)	31.481 (-0.9%)
Hydro Generation +100% Centroid	54.858 (+15.6%)	32.659 (+14.9%)	62.041 (+0.7%)	25.707 (+6.4%)	63.636 (+0.3%)	32.32 (+1.7%)
Hydro Generation -100% Centroid	-23.823[16] (-150.2%)	10.95 (-61.5%)	60.741 (-1.3%)	22.084 (-8.6%)	63.221 (-0.4%)	31.048 (-2.3%)

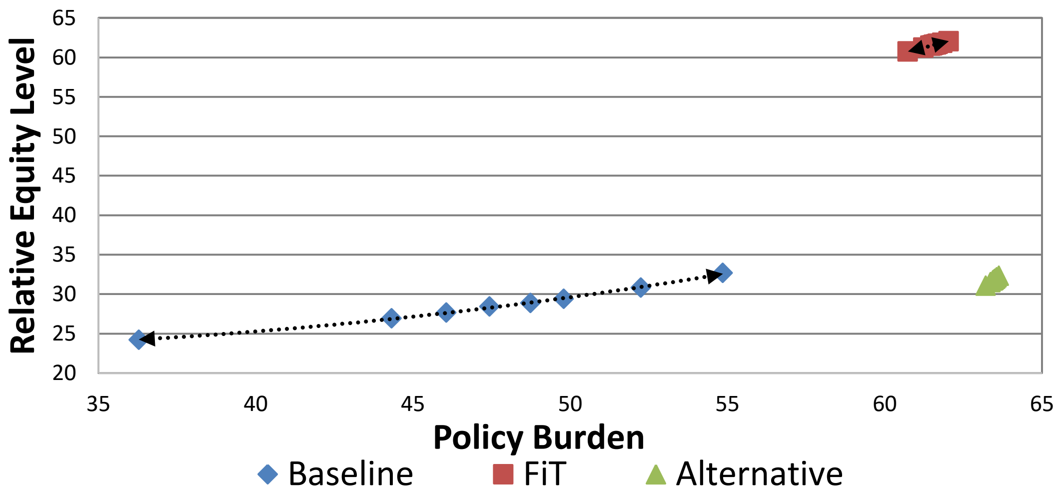

Figure 6.10 Hydro Generation Sensitivity Analysis Results

[16] Not plotted, centroid outside graph area

Progressive Job Allocation and Billing Policies: With regard to a job allocation policy in the target year, RE and fossil fuel based jobs are distributed according to the population in each of the five income levels as defined in section 4.5. Similar to the job allocation sensitivity analysis approach, progressive billing sensitivity analysis is carried out by spreading the impacts of increases in electricity bills based on household means, whereby the lowest income houses pay the least, and the highest income houses pay the most, according to the ratio of their household income. Table 6.10 and Figure 6.11 demonstrate the impact of these two social policy approaches and a combined approach.

Table 6.10 Job Allocation and Progressive Billing Sensitivity Analysis Results

Scenario	Baseline		FiT		Alternative	
Initial Centroid	Burden	Equity	Burden	Equity	Burden	Equity
	47.441	28.422	61.567	24.157	63.47	31.779
Job allocation by % of population per income level	48.334 (+1.9%)	33.575 (+18.1%)	59.463 (-3.4%)	27.252 (+12.8%)	60.024 (-5.4%)	36.429 (+14.6%)
Progressive electricity billing regime by household income	Not included in Baseline Scenario		64.081 (+4.1%)	22.892 (-5.2%)	65.497 (+3.2%)	30.372 (-4.4%)
Job allocation and Progressive billing			61.633 (+0.1%)	26.442 (+9.5%)	61.64 (-2.9%)	35.647 (+12.2%)

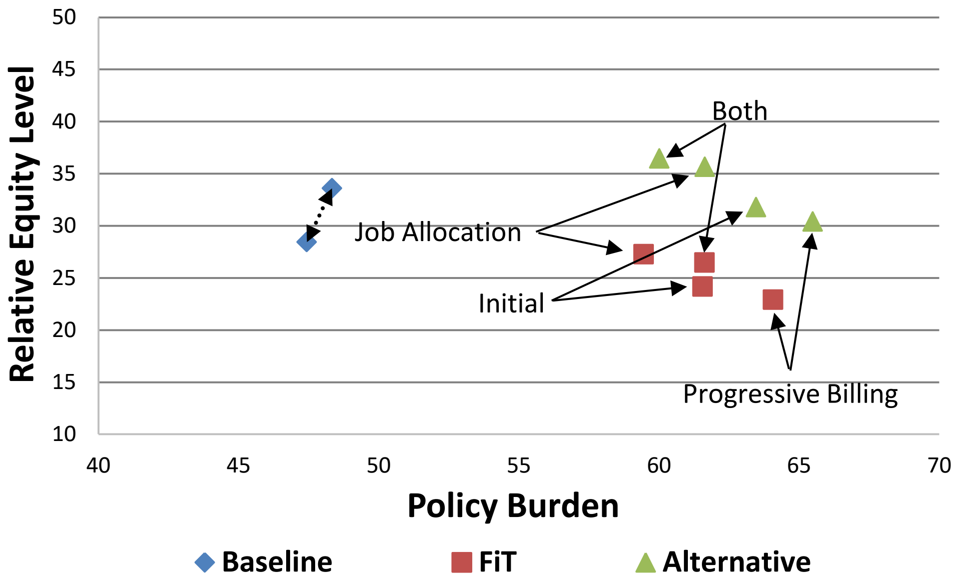

Figure 6.11 Job Allocation & Progressive Billing Sensitivity Analysis Results

Electricity Generation Cost: In order to observe the quanta of the significant impact of electricity prices on both the level of relative equity and policy burden allocation in the original analysis, the three energy policy scenarios are re-assessed using a constant price for each source of electricity (LCOE values established in Section 4.4.2 (Table 4.6), according to the amount of each generation source from 2008-2020 within the NEM. The result of this assessment is shown in Figure 6. and Figure 6., with the changes experienced in the alternative and baseline scenarios expressed alongside the original results.

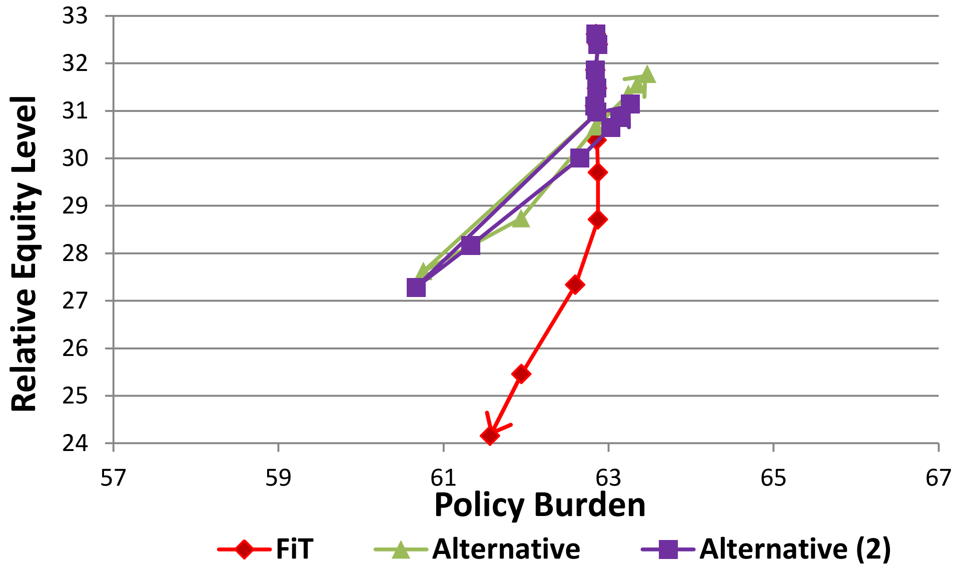

Figure 6.12 Alternative Scenario Electricity Price Sensitivity Analysis Results

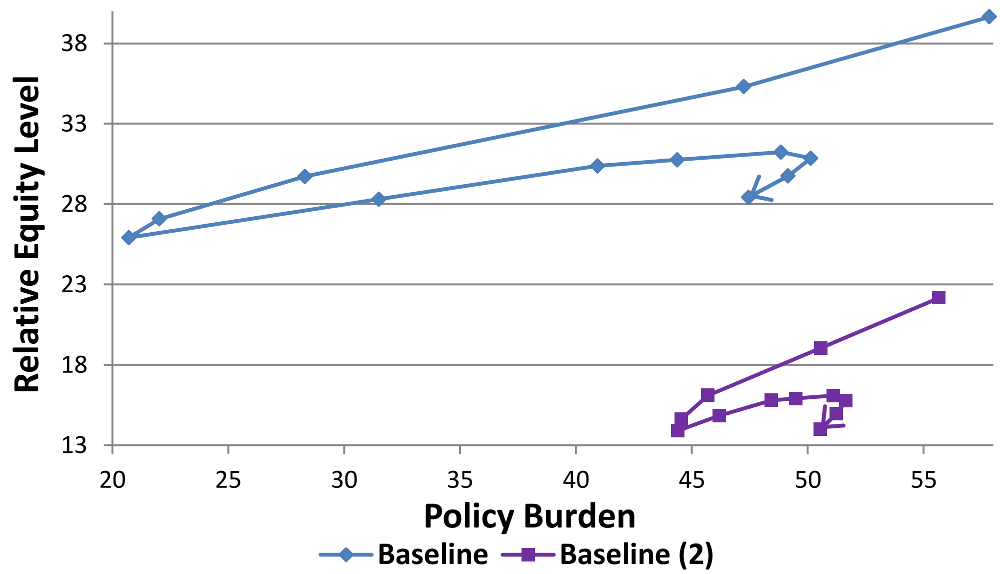

Figure 6.13 Baseline Scenario Electricity Price Sensitivity Analysis Results

6.4 Discussion

Two series of sensitivity analysis were undertaken in this chapter in order to test the sensitivity and robustness of the Energy Policy Sustainability Evaluation Framework's comparative equity analysis tool when subjected to both equity factor weighting and conditional changes.

The equity factor weighting results across the six equity factors demonstrated the robustness of the tool, as positive and negative factor weighting results showed the expected change (expressed as positive or negative slopes in Appendix D), and a generally consistent level of impact through both positive and negative weighting changes. In all cases the baseline scenario was the most sensitive due to only four factors being considered in the calculation of equity and burden levels.

Participation sensitivity analysis showed that an increase in participation across income levels improved equity levels in all cases, while a decrease in participation led to a larger overall decrease in equity levels. In the baseline case, the policy burden level is not impacted, as full participation is experienced in this case (i.e. all households participate through a centralised electricity system), and in the FiT and alternative scenarios the level of burden is only mildly affected (within ±2.5%) when compared to the significant change in equity levels (+22.8%~50.3% and -30.3%~83.9%).

For GHG reduction where the benefits are assumed to be equal across society, the level of policy burden is not impacted by weighting sensitivity changes in all cases, and the level of equity change is consistent across all scenarios (+3%~30.7% and -3.6%~-42.9%) with the largest change attributable to the removal of GHG reduction impacts from the framework (the -100% sensitivity analysis setting). The sensitivity analysis results highlight how the tool will react to an increase or decrease in the ability of energy policy scenarios to reduce GHG emissions and the expected impact on equity levels in each case.

With regard to employment, due to the nature of jobs being gained due to RE deployment (mostly in average and higher income brackets) and the nature of jobs being lost in the fossil fuel industry (a majority in average income, followed by low income and a small amount in very high income brackets) an increase in the employment weighting meant a consistent, mild shift (between ±0.4%~8.6% in FiT and alternative scenarios) of policy burden towards higher income levels (a desirable outcome), and vice-versa. However, the level of equity was only mildly affected in the FiT and alternative scenarios, varying by ±0.1%~2.8%. The baseline case was affected to a greater degree than the other scenarios with regard to employment weighting, with policy burden shifting by ±4.6%~47.4%, however the equity levels were less affected, similar to what was experienced in the other scenarios (±0.1%~8.5%). The removal of employment from the baseline scenario (the -100% sensitivity analysis setting) led to a centroid plotted outside of the graph.

Sensitivity analysis of subsidy allocation affects only FiT and alternative scenarios, as no subsidy allocation occurs under the baseline scenario. The FiT scenario, which has the largest amount of subsidies generated and therefore distributed (due to the FiT) is most sensitive to weighting changes in terms of both equity level and policy burden (±2.9%~42.4% and ±0.3%~9.2% respectively). In comparison, under the alternative scenario which removes Solar PV household deployment from 2015 onwards the sensitivity to weighting changes is much lower, in a range of ±1.2%~15.4% for equity levels and ±0.1%~2.4% for policy burden.

For electricity impact weighting analysis the baseline scenario is excluded as no change is experienced under the assumptions of the framework. Both the FiT and alternative scenarios experience similar levels of change in policy burden due to changes in weighting, ranging in a tight band from ±0.3%~3.9%. In the case of equity level, the FiT scenario affects electricity price impacts the most, reflected in the sensitivity analysis results (±4.6%~55.4%). The alternative scenario reduces the level of the FiTs impact on electricity prices and this is reflected in the reduced equity level change in the weighted sensitivity analysis results (±3.5%~41.6%).

Health impacts is the final weighting sensitivity impact analysed, and in the case of the baseline scenario the impact of changes in weighting was significant on equity level and policy burden results (±9.5%~110.4% and ±5.0~52.7% respectively) due to the maximum fossil fuel emissions when compared to the other scenarios, and no mitigating factors such as additional RE deployment or additional jobs. In contrast, in the case of the FiT and alternative scenarios where substantial numbers of additional jobs are created and fossil fuel based generation (and associated pollutant emissions) are reduced, the weighting changes of health impacts had only a minor influence on policy burden, ranging from just ±0.6%~6.2%. The impact on equity levels was more pronounced due to the pollutant fossil fuel emissions affecting lower income households to a higher level (±5.2%~61.3% under the FiT scenario and ±4.1%~48.5% for the alternative scenario).

The -100% weighting sensitivity, literally meaning the removal of a whole factor from the framework had the highest level of impact overall, materially changing the nature of the evaluation tool from a six to a five factor evaluation. In the case of the baseline scenario, whereby electricity price impacts and subsidy allocations do not emerge and are therefore not measured, the evaluation is based on a total of four equity factors, and the reduction of these to a total of three has (not unexpectedly) the most significant impact on the results of the comparative equity evaluation. Indeed, in the case of the elimination of employment (-100%) under the baseline scenario, the centroid is impacted beyond the measure of the tool. Although the comparative equity evaluation tool has shown a high level of robustness with regard to equity factor weighting, the results for all scenarios suggest that a higher number of equity factors improves the overall stability of the tool, as the centroid movement results of the FiT and alternative scenarios, both containing six equity factors, are more contained than the movement of the four factor Baseline scenario centroids. The highest change experienced in all cases due to the -100% equity factor weighting adds further credence to the idea that a higher number of equity factors increases overall tool stability.

With regard to conditional sensitivity analysis, based on realistic, possible future scenarios impacted predominantly by exogenous factors (rainfall, drought, technological advances and policy intervention) such as coal fired generation based emissions which influence more than one equity factor at a time, a reduction in emissions caused a significant increase in overall equity levels, affecting scenarios in the order: baseline>FiT>alternative reflective of their respective levels of fossil fuel generation contribution to the NEM (baseline:±12.6%~232.8%, FiT:±7.3%~178.7%, alternative:±3.2%~103.7%). However as the ratio of the distribution of GHG and PM_{10} emission reductions (and increases) remain the same, the burden of policy costs did not change under any of the scenarios.

A change in the contribution of hydroelectric generation to the NEM alters both the GHG emissions and job allocations, based on a change in overall RE and fossil fuel generation levels and jobs gained and lost as a result. A change in hydro generation changes both relative equity (baseline:±1.4%~61.5%, FiT:±0.3%~2.3%, alternative:±0.4%~8.6%) and the distribution of policy burden (baseline:±2.7%~150.2%, FiT:±0.1%~0.4%, alternative:±0.1%~1.3%), with the FiT and alternative scenarios varying within a very tight band of values, while the four factor baseline scenario is most significantly affected.

Additionally, in the case of sensitivity analysis applied completely externally from the energy system, i.e. through the enactment of the social policies including a progressive electricity billing regime and deliberate job allocation, overall equity was improved with deliberate job allocation, however the level of burden on lower income levels was increased, whilst progressive billing had the opposite effect. As might be expected, a combination of these two policies gave a mixed result, with relative equity fairing slightly better than policy burden due to the combination of factors.

The final sensitivity analysis undertaken considered electricity generation source prices to be the same for each technology, modified only by the amount of electricity generated from each source. This analysis did not affect FiT scenario outcomes, as the FiT scenario has the highest priced electricity in either case. The alternative scenario's level of equity was reduced slightly in response to the reduction in electricity cost difference to the FiT scenario. The baseline scenario was most heavily impacted as the additional, negative equity factor of electricity price impacts was considered in this scenario for the first time. This had the effect of reducing overall equity levels, as would be expected, however it also reduced the range of policy burden shift over time due to an additional negative impact acroos all household income levels.

6.5 Conclusions

A battery of sensitivity analyses was applied to the Energy Policy Sustainability Evaluation Framework's comparative equity analysis tool. The tool proved robust, performing as expected in the vast majority of cases, however some key learnings were brought to the fore. Firstly, the baseline scenario, which only incorporates four factors, is not as robust as the FiT or alternative scenarios which incorporate six factors, developed through an investigation of Australian energy policy outcomes, reviews and equity preferences, along with an energy policy and social equity hearing of Australian policy professionals. This finding suggests that a policy scenario evaluation tool that considers a wide range of energy policy relevant equity impacts deemed important within the jurisdiction being investigated leads to a more robust, reliable tool. Reinforcing this ideal is the fact that in all sensitivity analysis cases, the -100% setting had the highest impact on equity and policy burden levels, as it is synonymous with removing an equity factor from the framework completely.

Sensitivity analysis of the baseline scenario under a -100% employment weighting and -100% hydroelectric generation scenario led to a centroid which was not within the graph area (relative equity or policy burden coordinates less than zero). Both of these cases are representative of a three factor framework at the extreme limits of sensitivity analysis. In all other equity factor weighting and energy system based tests, the tool performed within expected parameters, extolling its value as a complementary tool in the energy policy evaluation and development process.

7. Thesis Conclusions and Future Work

7.1 Conclusions

This thesis investigated energy policy making in order to evaluate sustainability outcomes holistically and quantitatively, considering the three aspects of the environment, economy and social equity.

Through the development of a framework to quantitatively measure energy policy effectiveness and equity, the aim of the thesis is to enable the development of evidence based energy policy which can meet policy targets whilst maintaining or improving societal equity.

The conclusions of the thesis are as follows:

1. **A policy development weakness was exposed as the misalignment of policy tools and sustainability goals.**

Through a QCA evaluation of eight OECD nations' energy policy development processes, tools and goals, a weakness in the policy development process was identified. The key weakness exposed was the misalignment of current economic tools in place, and national sustainability goals. Because social goals are not advanced through the use of the current suite of policy tools, the final evaluation stage of the policy process is the first time that these issues are brought to the fore and remedial action is implemented.

2. **A revised policy cycle was derived, incorporating a pre-implementation sustainability evaluation process.**

In order to ameliorate the weakness identified in (1), the incorporation of a 'pre-evaluation phase' which includes sustainability evaluation prior to implementation of energy policies is proposed. The codification of the energy policy cycle, and a pre-implementation comparison of policy approaches' sustainability impacts will enhance the energy policy making process, leading to superior energy policy sustainability outcomes.

3. **An energy policy evaluation and improvement framework which integrates social equity into energy policy evaluation quantitatively was developed and tested.**

To date, the concept of social equity has been dealt with in a predominantly qualitative manner, however, this thesis provides an equity quantification methodology which is jurisdiction agnostic, based on the extraction of national equity priorities, and their quantification in terms of the distribution of benefits and burdens on socioeconomic layers within a society. The proposed methodology enables the incorporation of social equity quantitatively into energy policy sustainability evaluations, in a manner which is compatible with and complementary to economic and environmental assessments. Australia is used as a test case to demonstrate the value of the proposed framework in assessing and developing new, more effective and sustainable policy approaches.

4. **Quantified social equity was demonstrated to be an integral component of holistic energy policy sustainability evaluation and development.**

Through the identification of a common OECD energy policy making approach and the identification of the misalignment of policy goals and policy tools from a sustainability point of view, a revised policy cycle was derived in order to mitigate this issue. In practical terms, a framework which considers social equity in addition to the traditionally considered economic and environmental factors was developed which can both assess and improve energy policy approaches. The frameworks development and application identified the importance of social equity in defining policy which can improve social outcomes whilst meeting economic and environmental goals.

7.2 Future Work

Future research could further improve this thesis' outcomes and newly proposed energy policy cycle and evaluation framework by addressing the remaining energy justice tenet of procedural justice and through the formalization of a fair, unrestricted stakeholder engagement process within the energy policy cycle to further improve national energy policy making processes and sustainability outcomes by engaging society in the policy making process.

A first step in this process might be the investigation of public sustainability preferences incorporating social, economic and environmental factors in order to determine an appropriate societal balance, and to provide a clear mandate for governments working towards the development of energy policy goals.

The development of truly sustainable energy policy should begin with an understanding of societal preferences rather than the chasing of policy goals by government at any cost. The incorporation of societal preferences and a representative cohort of society in the consultation phase of policy development in a bottom-up manner could provide an additional evidence base towards the development of nationally sustainable energy policy.

Further, the application of the framework devised in this thesis has only been tested in terms of energy policy. Additional applications may also be possible in the sphere of social and environmental policy development, where the equitable distribution of costs and benefits across society is a desirable outcome.

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Appendices

Appendix A. Australian Energy Policy and Social Equity Hearing Language

Hearing Introduction

As a person with experience relevant to energy policy making in Australia, your input on the priority allocated to equity impacts resultant from policy implementation is very valuable. In your policy related role (past or present) you would be aware of the important economic and environmental impacts that energy policy can make. Also, you may be aware of key stakeholders opinions about the societal impacts that energy policies can introduce. I am interested in your opinions with regard to social equity. Specifically, I would like to hear your feedback on

1) Whether or not you agree with the 5 equity policy impacts that have been identified through my research; and,

2) How you would prioritize these impacts in order of importance (and any other impacts you are aware of).

Hearing Guiding Texts and Questions

1. What is your gender?
    a. Female
    b. Male
    c. Other / Prefer not to answer
2. What is your age?
    a. 18 to 24
    b. 25 to 34
    c. 35 to 44
    d. 45 to 54
    e. 55 to 64
    f. 65 to 74
    g. 75 or older
    h. Other / Prefer not to answer

3. How many years have (did) you worked in a role related to policy?

- Free text entry response

4. What is/was your policy related occupation, and in which region?
    a. Policy officer
    b. Policy officer with executive responsibilities
    c. Academic
    d. Consultant
    e. Other (please specify)

- This question is asked across the 7 Australian regions (SA, WA, NT, QLD, NSW & ACT, VIC, TAS) and outside Australia.

5. Using up to 5 keywords, please describe what "Social Equity" means to you

- Free text entry response

<Page Break>

Australian Governments and independent third party research institutes have assessed present and past renewable energy (RE) policies in Australia, specifically the feed-in tariff (FiT) and renewable energy certificate (REC) tools used in Australia to encourage RE deployment. Their analysis have covered environmental and economic impacts of these policies, and have also looked at some of the social (equity) impacts resultant from these policies and their implementation.

The most prominent equity issue identified was the increase in electricity prices due to subsidization, as generous FiT and REC policies introduced encouraged greater than expected amounts of renewable energy into the grid.

Also, for any group of consumers to enjoy a benefit such as electricity prices below the cost of their consumption, the remainder of consumers must pay for this benefit.

It has been noted that those who can least afford to participate in subsidization schemes are likely subsidizing users who receive a benefit, identifying both an inequitable level of participation and allocation of subsidies.

Further, it has been identified that the type and method of implementation of subsidies can have a marked effect on the technologies deployed, and therefore the environmental efficacy (ability to generate renewable energy and reduce greenhouse gases) and the sharing of this public benefit of renewable energy deployment.

Another factor which has been noted as having an influence upon societal equity in Australia is employment, both in the number and type of jobs provided but also through the provision of stable employment through ever-changing incentive schemes.

In summary, Government and third party reports have identified these 5 issues as having the greatest effect on societal equity, specifically in the widening of the gap between rich and poor. Indeed as a result of these findings, Government Ministers (those ultimately responsible for policy implementation outcomes) have issued statements or directives in order to modify renewable energy technology support mechanisms (such as Renewable Energy Certificates and Feed in Tariff policies); in order to reduce electricity price increases to reduce the burden on low income households, to ensure that employment outcomes are sustained, to more equitably distribute subsidies through increased participation from households with lower means, and ultimately to improve environmental outcomes for all households.

6. My research has identified the following 5 key social equity impacts arising from energy policy implementation:

1) Environmental Improvement (reducing greenhouse gases);
2) Employment (the number and allocation of jobs);
3) Electricity Price Impacts (The impact of introducing renewable energy on energy prices);
4) Participation (the ability for households to participate in renewable energy deployment); and,
5) Subsidy allocation (The distribution of subsidies across income levels).

In your experience, do you feel that these 5 factors are comprehensive enough, or, can you think of any additional social equity factors that can be impacted by renewable energy policy implementation? If so, please enter them below.

- Free text entry response (up to 3 additional factors)

7. On a scale from 1 (not at all important) to 8 (extremely important), please rate the 5 (or more if you identified additional factors) equity factors in order of importance.
    a. Environmental Improvement
    b. Employment
    c. Electricity Price Impacts
    d. Participation
    e. Subsidy Allocation
    f. Additional Factor 1
    g. Additional Factor 2
    h. Additional Factor 3

8. Should the key role of energy policy be to achieve policy goals or to create policy outcomes which improve societal equity?
    a. Achieving policy goals is the most important
    b. Improving social equity is the most important
    c. Both are equally important
    d. I do not have an opinion on this issue
    e. Other (please specify)

Appendix B. Coal Fired Power Station PM_{10} and SEIFA Details

Name of Power Plant	MWe	Location	LGA(s)	Population(s)	SEIFA Decile(s)	PM_{10} (t/p.a)
Bayswater	2640	NSW	Muswellbrook	15234	5	640.1
Liddell	2000	NSW	Muswellbrook	15234	5	484.9
Eraring	2840	NSW	Newcastle, Lake Macquarie, Gosford	141753, 183140, 158157	6, 7, 8	688.6
Redbank	151	NSW	Singleton	21938	8	36.6
Mount Piper	1400	NSW	Lithgow	19759	3	339.4
Vales Point B	1320	NSW	Wyong, Lake Macquarie, Gosford	139801, 183140, 158157	5, 7, 8	320.0
Wallerawang-C	1000	NSW	Lithgow	19759	3	242.5
Callide B	700	QLD	Banana	13358	7	162.7
Callide C	900	QLD	Banana	13358	7	209.2
Millmerran	880	QLD	Millmerran*	3098	4	204.6
Kogan Creek	750	QLD	Chinchilla*	5940	6	174.3
Tarong	1400	QLD	Nanango	9014	2	325.4
Tarong North	443	QLD	Nanango	9014	2	103.0
Gladstone	1680	QLD	Gladstone	29084	8	390.5
Stanwell	1460	QLD	Rockhampton	58747	5	339.4
Collinsville	190	QLD	Bowen*	12378	3	44.2
Northern	544	SA	Port Augusta	13876	2	251.2
Thomas Playford B	240	SA	Port Augusta	13876	2	110.8
Loy Yang A	2210	VIC	Latrobe	69329	4	81.2
Loy Yang B	955	VIC	Latrobe	69329	4	35.1
Hazelwood	1600	VIC	Latrobe	69329	4	58.8
Yallourn West	1480	VIC	Latrobe	69329	4	54.4
Anglesea	150	VIC	Surf Coast, Greater Geelong	21769, 197475	10, 7	5.5
Energy Brix (Morwell)	170	VIC	Latrobe	69329	4	6.2

Appendix C. Gas Fired Power Station PM_{10} and SEIFA Details

Name of Power Plant	MWe	Location	LGA(s)	Population(s)	SEIFA Decile(s)	PM_{10} (t/p.a.)
Colongra OCGT	667	NSW	Wyong, Lake Macquarie, Gosford	139801, 183140, 158157	5, 7, 8	15.2
Uranquinty OCGT	640	NSW	Wagga Wagga	57015	7	14.6
Tallawarra CCGT	435	NSW	Wollongong, Shellharbour, Kiama	184213, 60336, 18985	6, 5, 10	9.9
Smithfield CHP CCGT	160	NSW	Auburn, Bankstown, Burwood, Canada Bay, Canterbury, Fairfield, Holroyd, Strathfield, Parramatta	64961, 170488, 30927, 65745, 129963, 179893, 89766, 31982, 148323	2,4,8,10,3,2,5,9,7	3.6
Braemar I OCGT	450	QLD	Dalby*	9779	6	10.2
Swanbank E CCGT	385	QLD	Brisbane, Ipswich	956131, 140183	9,5	8.8
Barcaldine CCGT	53	QLD	Barcaldine	1617	5	1.2
Condamine CCGT	140	QLD	Murilla*	2687	4	3.2
Roma OCGT	74	QLD	Roma*	6507	5	1.7
Mica Creek CCGT	304.7	QLD	Mt Isa	19663	6	6.9
Oakey OCGT	332	QLD	Toowoomba	90200	7	7.6
Mackay OCGT	34	QLD	Mackay	84890	8	0.8
Phosphate Hill	42	QLD	Boulia Shire	420	2	1.0
Bulwer Island Cogen CCGT	33	QLD	Redland, Brisbane	127628, 956131	9,9	0.8
Xstrata X41	30	QLD	Mt Isa	19663	6	0.7
Yabulu (Townsville) CCGT	242	QLD	Townsville	95463	8	5.5
Mount Stuart	414	QLD	Townsville	95463	8	9.4
Diamantina CCGT	242	QLD	Mt Isa	19663	6	5.5
Pelican Point CCGT	487	SA	Port Adelaide Enfield, Salisbury, Charles Sturt, Adelaide, Prospect, Walkerville, West Torrens	102929, 118421, 1000531, 16660, 19294, 6371, 52157	2,3,5, 9, 9, 5, 6	11.1
Torrens Island Thermal	1280	SA	Port Adelaide, Salisbury, Charles Sturt, Adelaide, Prospect, Walkerville, West Torrens	102929, 118421, 1000531, 16660, 19294, 6371, 52157	2,3,5, 9, 9, 5, 6	29.2
Quarantine OCGT	216	SA	Port Adelaide, Salisbury, Charles Sturt, Adelaide, Prospect, Walkerville, West Torrens	102929, 118421, 1000531, 16660, 19294, 6371, 52157	2,3,5, 9, 9, 5, 6	4.9
Ladbroke Grove OCGT	80	SA	Wattle Range	11889	4	1.8

Dry Creek OCGT	156	SA	Port Adelaide, Salisbury, Charles Sturt, Adelaide, Prospect, Walkerville, West Torrens, Burnside, Unley, Norwood & St Peters	102929, 118421, 1000531, 16660, 19294, 6371, 52157, 41956, 35999, 33732	2,3,5, 9, 9, 5, 6, 10, 10, 9	3.6
Mintaro OCGT	90	SA	Clare and Gilbert Valleys	8144	7	2.0
Snuggery OCGT	63	SA	Wattle Range	11889	4	1.4
Osborne CHP CCGT	180	SA	Port Adelaide, Salisbury, Charles Sturt, Adelaide, Prospect, Walkerville, West Torrens	102929, 118421, 1000531, 16660, 19294, 6371, 52157	2,3,5, 9, 9, 5, 6	4.1
AGL Hallett OCGT	203	SA	Goyder	4184	4	4.6
Tamar Valley CCGT	390	TAS	George Town	6526	2	8.9
Newport D Gas	510	VIC	Brimbank, Hobsons Bay, Maribyrnong, Melbourne, Melton, Moonee Valley, Moreland, Port Phillip, Wyndham	168218, 81462, 63142, 71380, 78910, 107090 135763, 85097, 112696	3,7,4,10,8 ,8,6,10,9	11.6
Jeeralang OCGT	468	VIC	Latrobe	69329	4	10.7
Bairnsdale OCGT	94	VIC	East Gippsland	40036	5	2.1
Somerton OCGT	150	VIC	Brimbank, Hobsons Bay, Maribyrnong, Melbourne, Melton, Moonee Valley, Moreland, Port Phillip, Wyndham	168218, 81462, 63142, 71380, 78910, 107090 135763, 85097, 112696	3,7,4,10,8 ,8,6,10,9	3.4
Laverton North	320	VIC	Brimbank, Hobsons Bay, Maribyrnong, Melbourne, Melton, Moonee Valley, Moreland, Port Phillip, Wyndham	168218, 81462, 63142, 71380, 78910, 107090 135763, 85097, 112696	3,7,4,10,8 ,8,6,10,9	7.3
Valley Power OCGT	300	VIC	Latrobe	69329	4	6.8
Mortlake OCGT	550	VIC	Moyne	15452	8	12.5

Appendix D. Detailed Sensitivity Analysis Figures

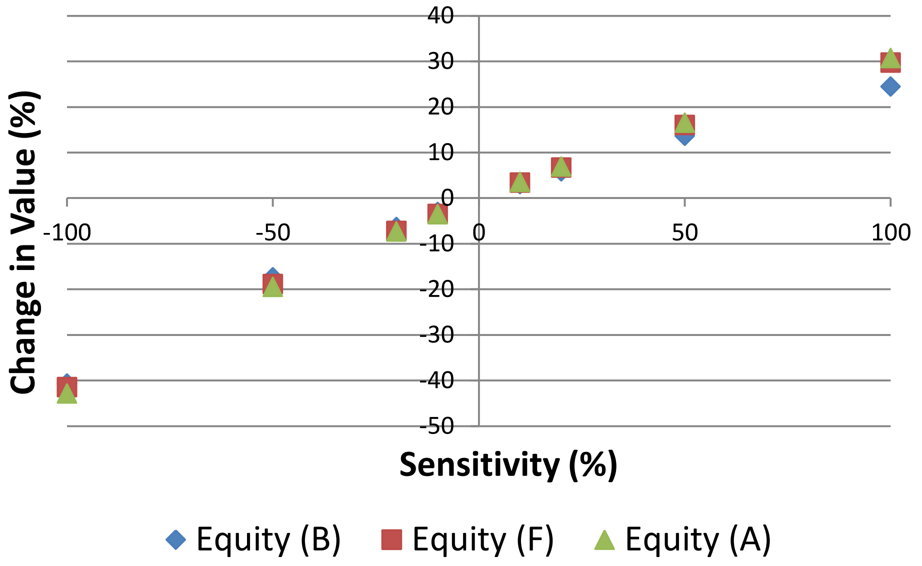

Figure D-1 GHG Reduction Equity Level Sensitivity Analysis Result

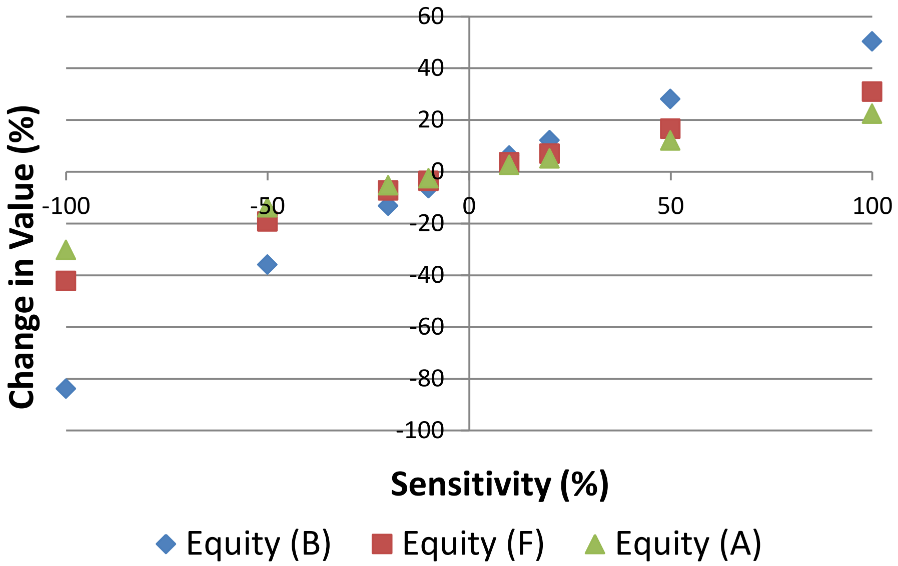

Figure D-2 Participation Equity Level Sensitivity Analysis Result

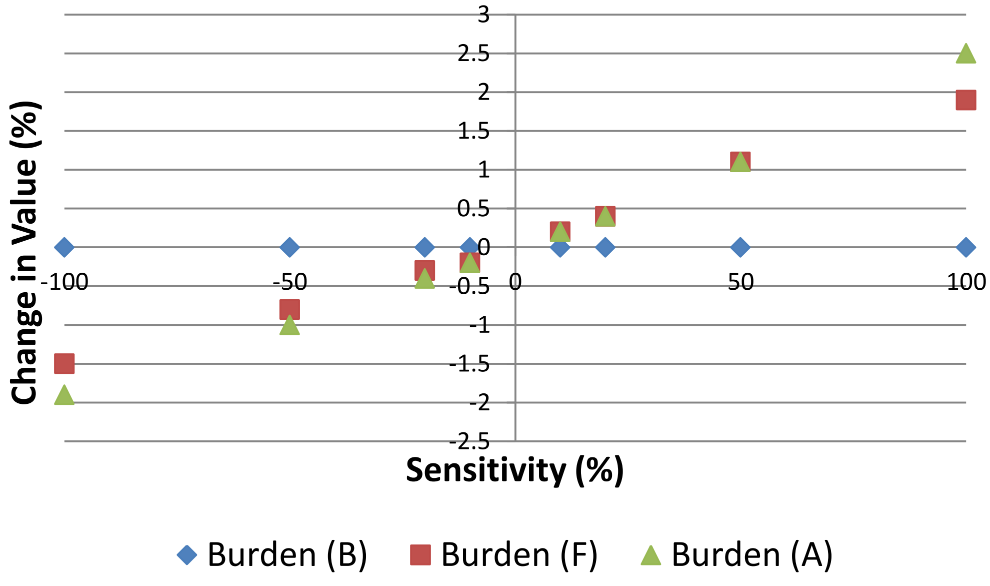

Figure D-3 Participation Burden Sensitivity Analysis Result

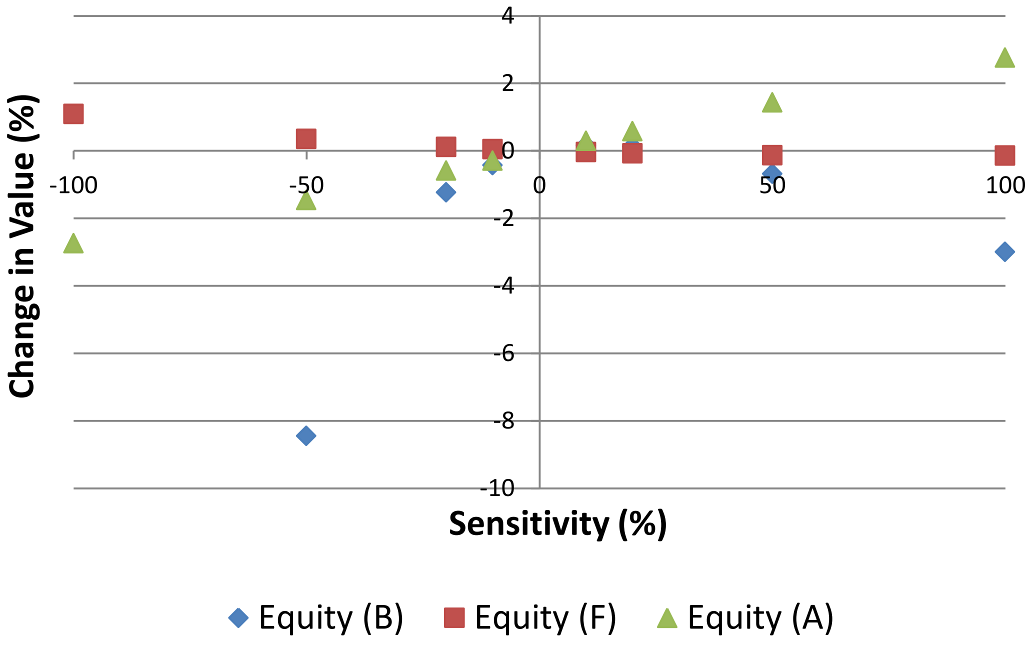

Figure D-4 Employment Equity Level Sensitivity Analysis Result

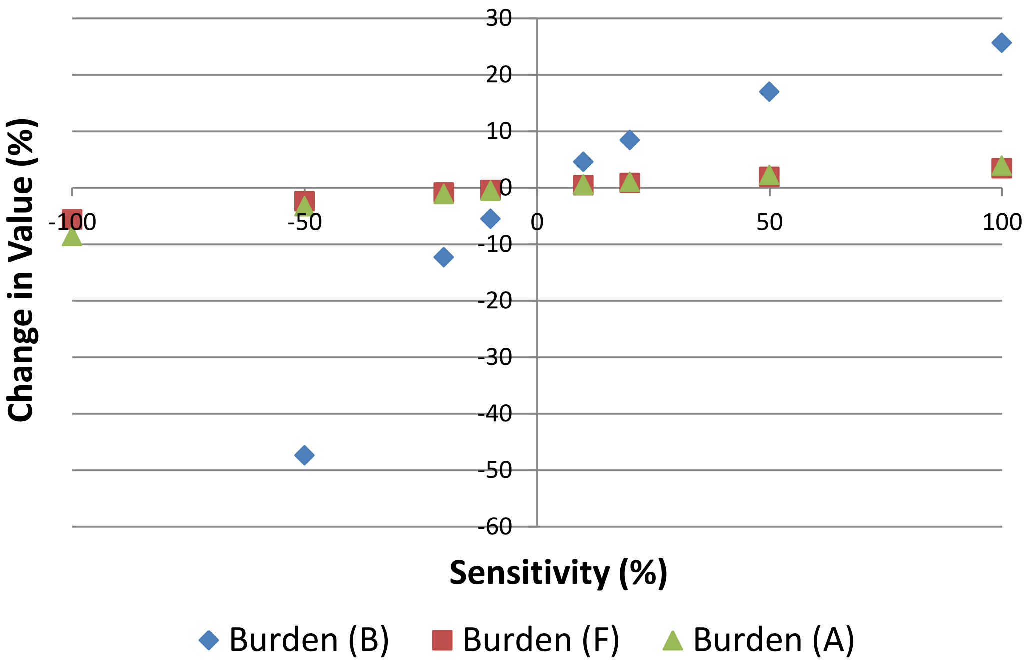

Figure D-5 Employment Burden Sensitivity Analysis Result

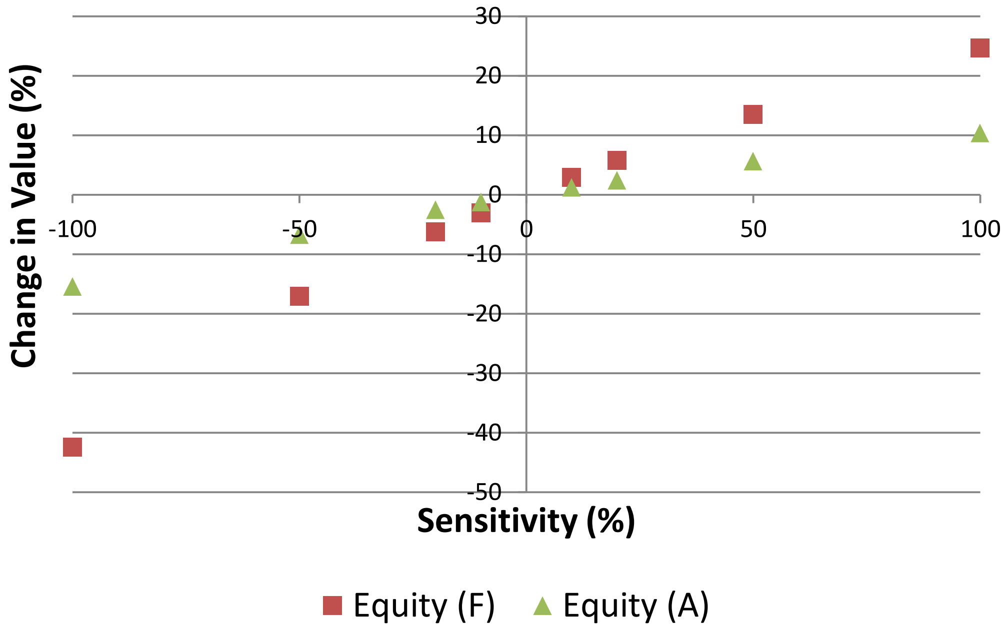

Figure D-6 Subsidy Allocation Equity Level Sensitivity Analysis Result

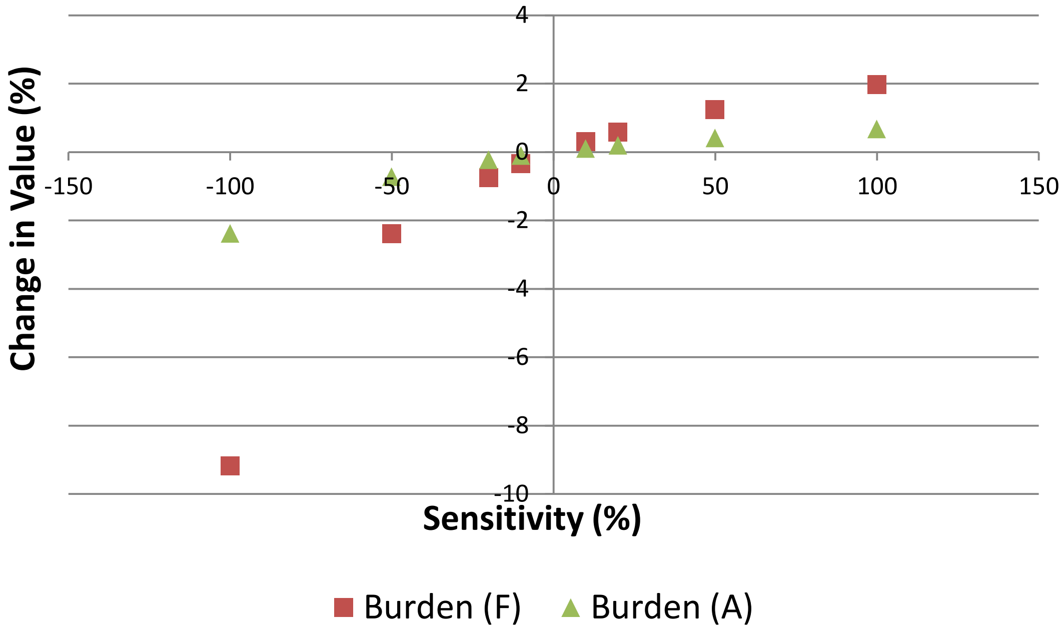

Figure D-7 Subsidy Allocation Burden Sensitivity Analysis Result

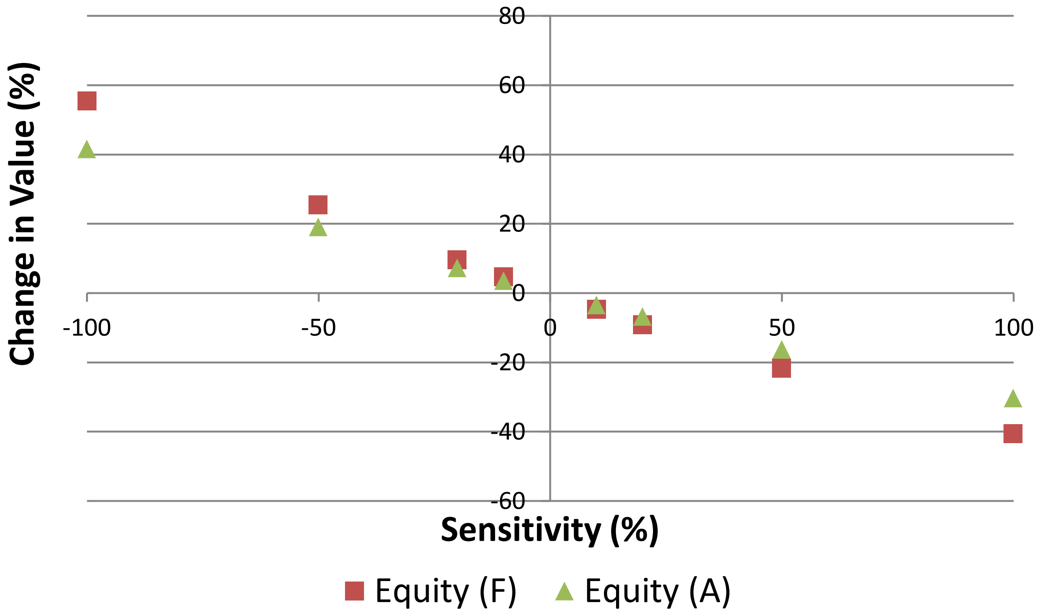

Figure D-8 Electricity Price Impact Sensitivity Analysis Result

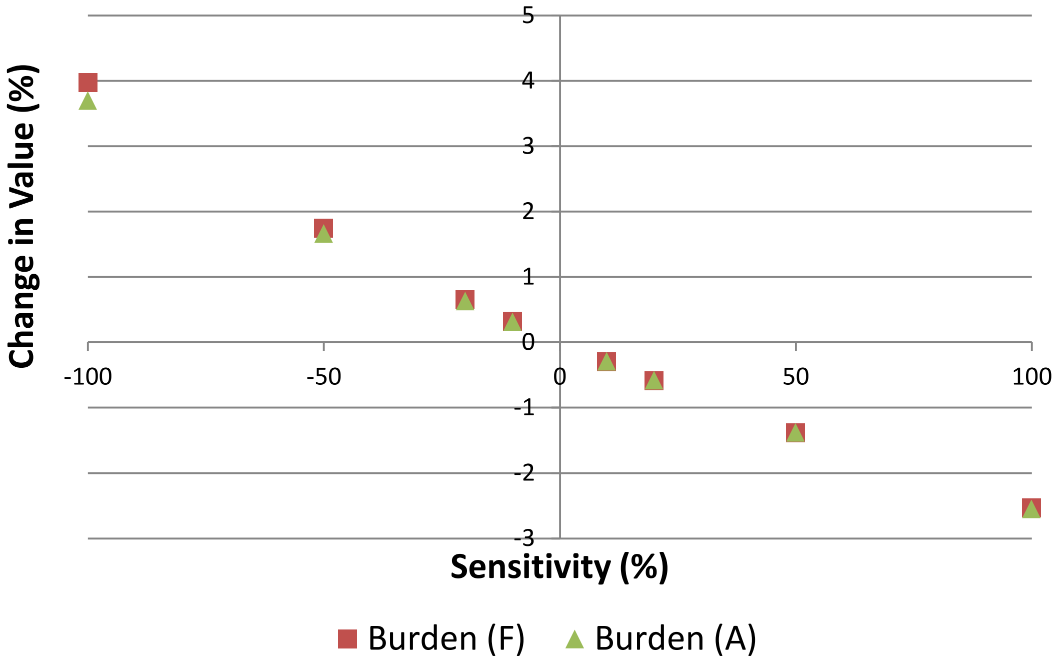

Figure D-9 Electricity Price Impact Burden Sensitivity Analysis Result

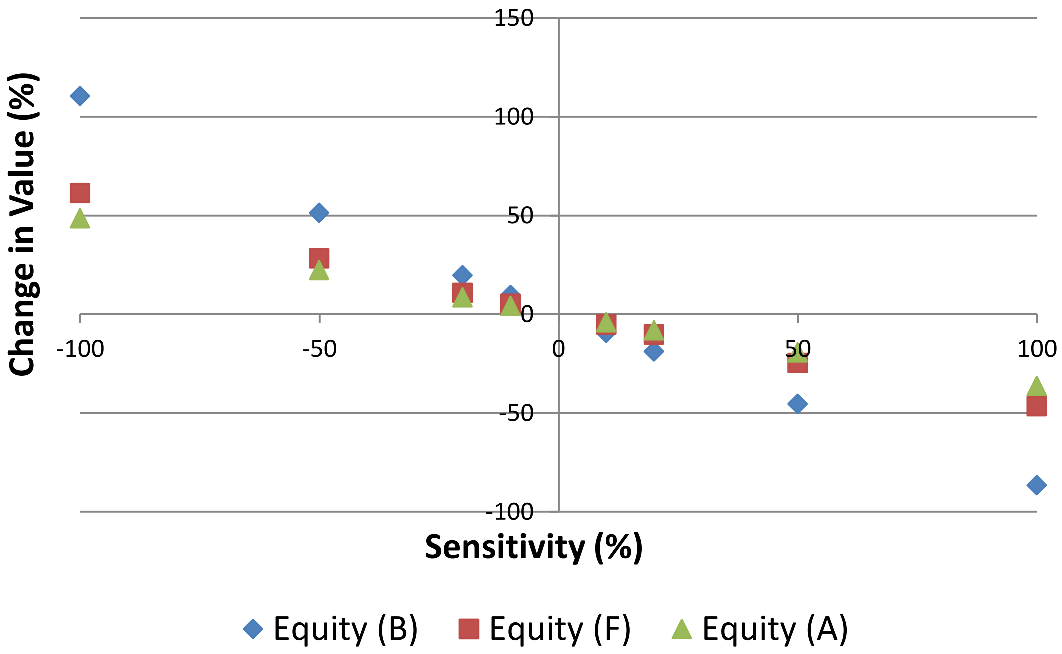

Figure D-10 Health Equity Level Sensitivity Analysis Result

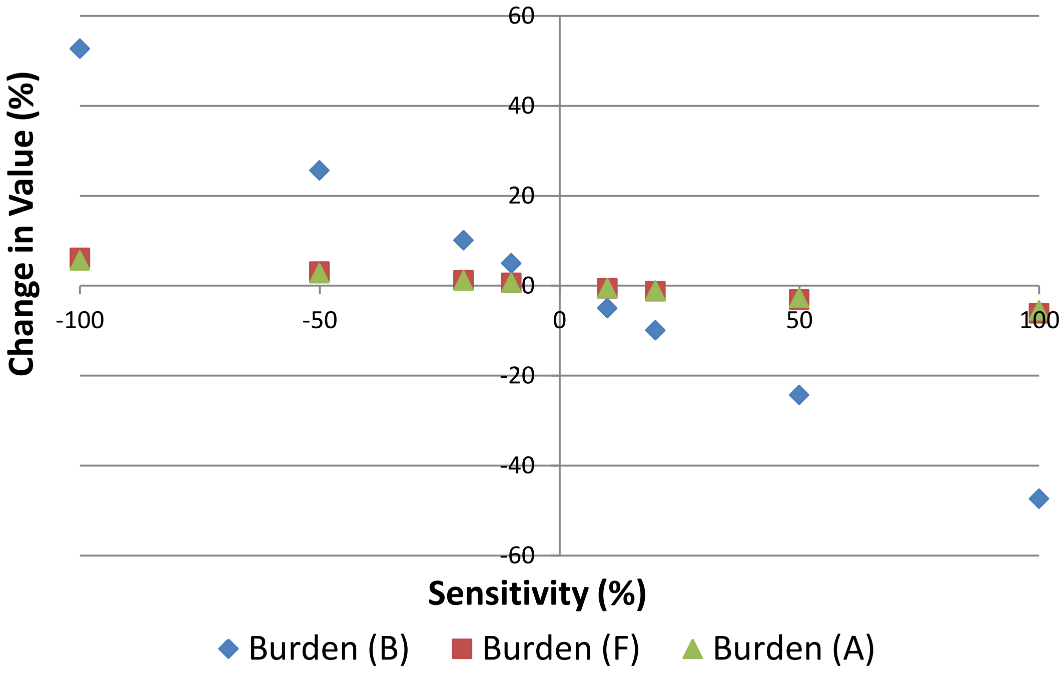

Figure D-11 Health Burden Sensitivity Analysis Result

Peer Reviewed Publications

Publications in PhD

Chapter 2

- Chapman, A. McLellan, B. Tezuka, T. 2016. Strengthening the Energy Policy Making Process and Sustainability Outcomes in the OECD through Policy Design. Administrative Sciences 6(3), pages 1-16 (Article 9).

Chapter 3

- Chapman, A. McLellan, B. Tezuka, T. 2016. Residential Solar PV Policy: An analysis of impacts, successes and failures in the Australian case. Renewable Energy 86, pages 1265-1279.

Chapter 4

- Chapman, A. McLellan, B. Tezuka, T. 2016. Evaluation Framework for Energy Policy Making Incorporating Equity: Applications in Australia. Energy Research and Social Science 21, pages 54-69.

- Chapman, A. Tezuka, T. McLellan, B. 2016. Renewable Energy Policy Efficacy and Sustainability: The role of equity in improving energy policy outcomes. Book Chapter: Sustainability Through Innovation in Product Life Cycle Design, Editors: Mitsutaka Matsumoto, Keijiro Masui, Shinichi Fukushige, Shinsuke Kondoh. Springer, Singapore.

Other Publications

- McLellan, B. Chapman, A. Aoki, K. 2016. Geography, urbanization and lock-in – considerations for sustainable transitions to decentralized energy systems. Journal of Cleaner Production 128, pages 77-96.