“An economic/financial, environmental/health and political analysis of the impact of replacing coal-fuelled power stations with renewable technology in Australia”.
I declare that all work submitted for assessment in this subject is my own work and does not involve plagiarism or teamwork.

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Abstract

The question to be examined in this dissertation involves the analysis of the economic/financial, environmental/health and political impact of replacing Australia’s coal fuelled power stations with renewable technology mix. The quantitative analysis was conducted using RETScreen software package and raised some fascinating results.

The RETScreen extensive quantitative analysis of the financial and economic impact of renewable energy for Australia has been conducted in this report. It shows the Net Present Value (NPV) for solar thermal was $26,061,592,811; a positive amount indicating a good investment proposition; and a reasonable Levelised Cost of Electricity (LCOE) of $3,683.37 p.a. Solar thermal also offered a relatively high Internal Rate of Return (IRR) of 12.1%, as well as a short Simple Payback Period (SPP) of 7.4 years. The NPV for solar photovoltaic was $43,686,592,811 making it an economically viable proposition; and a LCOE of $6,174.37 p.a. Solar PV also offered a high IRR of 20.7%, as well as a short SPP of 4.7 years. The NPV for wind was $122,850,329,916, making it a highly economically viable proposition, and a LCOE of $8,681.42. Wind also offered a high IRR of 50.1% and an extremely short SPP of 2.0 years [19]. The macroeconomic impact of the replacement of coal-fuelled power stations with renewable technology has also been calculated in this report. The switch from coal fuelled power stations to renewables would result in; 318,563 additional jobs for Australia, and increase of $24,591,152,220 annually to GDP or an increase of 1.206%.

The environmental/health aspects of the switch to renewables have been ascertained in this report. In the extraction of the coal, there is the inherent land degradation for open cut mines and the land subsidence issues for underground mines. The spontaneous combustion of coal occurs with alarming regularity in Australia with the interaction of oxygen in the air and the pulverised coal powder. The contamination of the water supply is also an issue of major concern in the extraction process. Then the issues of carbon dioxide (and other GHG’s) released into the atmosphere when the coal is combusted in the power plant solar thermal and solar PV will each save 12,252,065 tCO2 per annum, and wind will save 24,504,129 tCO2 annually; a total of 49,008,259 tCO2 annually. Other gases released from burning coal include sulphur...
dioxide, mercury and other particulates. These are known to cause respiratory health problems as well as acid rain and could be the direct result of human death and increase this mortality by up to 4% [46].

The current political standing and Renewable Energy Target (RET) have been assessed in this report. As at 23/02/2016, the most current renewable energy target (RET) for Australia is from the Department of the Environment (DET) media release from 23 June 2015. It states that the new target for large scale generation of “33,000GWh in 2020 will double the amount of large scale renewable energy being delivered...compared to current levels” [48]. This means the current level of large scale renewable energy in the mix of 13.47% [49] will almost double to 23.5% of the total energy supply. However, some exemptions in the RET legislation have resulted in a redistribution of wealth from retail consumers of electricity to the manufacturing export sector.

The findings of this report is that an energy mix of 50% wind, 25% solar thermal and 25% solar photovoltaic would suit Australia’s climate and economic standing. The replacement of coal fuelled power stations with 100% renewable is in the best interests for the Australian people in an economic/financial, environmental/health, and political aspects. While the rest of the planet is embracing the renewable energy renaissance, Australia has the resources and opportunity to move forward but seems to lack only motivation; the onus is on the people to demand change via their elected politicians.
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1. Introduction

The quest for alternative energy sources for a species for an exponential thirst for energy [7] has become a global imperative. The inherent environmental consequences of anthropogenic activities in the burning of fossil fuels have been a driving force in this quest. For Australia, this entails addressing a major contributor to greenhouse gas emissions (GHG); the fossil fuelled power stations. This report will assess the viability of replacing the current coal-fuelled power stations in Australia with an equivalent GW capacity in renewable technology. The proposed mix of renewables for Australia is based on its natural resources as well as the experiences of other countries. As such, a mix of 25% solar thermal, 25% solar photovoltaic and 50% wind will be assessed in this report. The method of the financial/economic aspect of the assessment will include such financial tools as NPV, IRR SPP and LCOE to provide a fiscal analysis on the viability of such a proposal. The environmental aspect of the report will determine land degradation, water contamination and air pollution as a result of coal-fuelled power stations. The political aspect of this report will determine the political climate in Australia and assess the willingness for change. This willingness for change will also be the focus for the sociological aspect of the report. The quantitative analysis of the financial ramifications proposed in this report is of high significance for policy makers regarding the question of the viability of renewable energy for Australia.

This report is a quantitative analysis of the economic/financial, environmental/health and political impacts for Australia with the replacement of coal-fuelled power stations with renewable energy technologies. It will commence with a literature review from various countries around the world detailing the economic/financial, environmental/health impact. The literature review will continue with an analysis of the Australian political standing in the renewable energy sector with and analysis of the Renewable Energy Target and the domestic plans for the expansion of renewables into the energy mix.
The motivation for this report is to provide a quantitative analysis as to the financial/economic viability for the transition to renewable energy technology for Australia. It seeks to further demonstrate the environmental/health consequences of inaction. Also, this report seeks to highlight the ineffectual political stance of past and current parties regarding incentives for households and businesses to transition to renewable energy generation.

The exploration of literature of the experiences of other countries provided in this report seeks to provide a pointer towards the direction that Australia may follow. The literature review is definitive proof that a renewable transition is possible and economically/financially viable and environmentally/health prudent and politically advisable. While naysayers argue that renewables can’t be done, or is too difficult; the literature seeks to provide a multitude of quantifiable examples clearly showing not only that a renewable transition is achievable, but provides examples on how to proceed.

This report will also answer several questions pertinent to the quantitative assessment as to the viability of replacing coal-fuelled power stations with renewable energy technology as follows:

- What is the current electricity usage for Australia as measured in Watts derived from coal-fuelled power plants?
- What is the total revenue raised annually from this supply?
- What is an appropriate mix of renewable energy technologies appropriate for Australia to replace the current coal-fuelled power plants; based on natural resources and overseas models?
- Provide a financial assessment of the viability of replacing existing fossil technologies with renewables using Net Present Value (NPV), Internal Rate of Return (IRR), Levelised Cost of Electricity (LCOE) and Simple Pay-back Period (SPP).
- Provide an analysis of the findings and recommendations based on financial indicators.
- What are the consequences to Australia’s economy in replacing coal-fuelled power stations with renewable technology?
- Determine the environmental/health consequences of extracting and burning coal for electricity production in Australia
- Determine the current political Renewable Energy Target (RET) and the current political persuasions towards renewable energy.
- Analyse any current renewable energy incentives operating in Australia
2. Literature review

Literature review is based on articles from peer reviewed journals. All quantitative figures utilised in this study are sourced (where possible) from credible sources such as Government bodies. All reasonable attempts have been made throughout this report to assure the reader of the reliability and authenticity of the data presented.

2.1 Finance and economics literature review

There have been several financial analyses of the financial impact of renewable energy for various countries in recent years. Reliable financial indicators are the Net Present Value (NPV) and the Levelised Cost of Electricity (LCOE). These are some of the tools that have been used in the studies from the various countries submitted in this report.

2.1.1 European Union subsidies - Czech Republic; Simple Payback Period, Internal Rate of Return and Net Present Value.

One such study is the Marousˇek 2015 paper that used such financial tools for the analysis of the implications of the EU subsidy policy on the renewable energy industry in the Czech Republic. It analysed three separate renewable energy technologies that were under subsidy from the government and assessed the economic viability of the technologies using SPP, IRR and NPV. The SPP used in the report has shortcomings in the time value of money and thus negate to effectively determine the economic efficiency of the projects. However, the NPV in particular allowed for the assessment of the effectiveness of the subsidy policy for renewable technology projects for the Czech Republic. The report assessed three different renewable energy projects; a renewal and modernisation of an existing power plant, the construction of a small hydro project, and a hypothetical project with estimated financial indicators close to reality.
Regarding the renewal and modernisation of the existing power plant, the report found that initial calculations for the SPP was 6.4 years (however in reality it was found that this value was closer to 15-20 years, highlighting the inadequacies of the SPP methodology). Using a return of 7%, the NPV was calculated to be ~14.6, a positive value and thus an economically viable opportunity. Consequently, the IRR was determined to be 7.96%<IRR<8% and therefore another indicator of a profitable project.

The next project to be financially assessed was the small hydro project. The NPV was determined to be ~(-25), an indication of not an economically viable proposition. Furthermore, the IRR was found to be 3.84%<IRR<4%, and with the discount rate of 7% used across the study this IRR is an indication that the small hydro project is only viable with substantial government subsidies to assist in its operation.

The final project to be calculated was the hypothetical project that used economic indicators that were assumed to be close to reality. It was found that the SPP was 14.2 years and the NPV was ~(-135.4). The IRR was subsequently calculated to be 4.45%IRR<4.5%. Both the IRR and NPV are clear indicators that the hypothetical project is only viable with heavy government subsidy.

Using those three financial tools, the paper concluded that “(the) government should promote the renewable technologies only by burdening the old technologies (those with negative environmental impacts) with additional taxation” [1], [19].

2.1.2 Feed-In Tariff – Turkey; Net Present Value.
The 2012 Ertürk paper evaluated the effect of feed in tariffs (FIT) for the onshore wind industry in Turkey. It utilised the NPV financial tool for the purpose of this analysis based on a discount rate of 9.43%. The results indicated that onshore wind projects with wind speeds of 7.5m/s or higher achieve a positive NPV and thus only those projects are economically viable without any government assistance. The results also indicated that as the wind speed increased and the quality of the wind improved, the NPV showed higher values. Thus, as the quality and speed of the wind improved, so did the NPV. It was found that if the wind speed exceeded 9m/s, the NPV per unit capacity nearly achieves 40% of the capital cost per unit capacity. Whereas with wind
speeds of only ~7m/s, the NPV became negative. The paper concluded that onshore wind projects for Turkey with wind speed in excess of 7.5m/s were economically feasible and in fact highly profitable with an average NPV of $149/kW and an associated risk probability of only 10% for a negative NPV at that wind speed. It was further found in the 2012 Ertürk paper that for sites with wind speed of 7m/s that an increase of $0.002/kWh feed-in-tariff would offset the losses and make them economically viable [2], [19].

### 2.1.3 Hydroelectric in Costa Rica; Adjusted Present Value, Net Present Value and Internal Rate of Return.

The 2014 Jenkins paper discussed the viability of financing the La Esperanza Hydroelectric Project in Costa Rica using the adjusted present value (APV) method of evaluation. The paper also discussed how financial institutions use debt service coverage ratios to measure the capacity of projects to repay debt obligations. A discount rate of 15% was assumed for the purposes of the calculations.

It was found that if the La Esperanza Hydroelectric Project was completely equity financed, the NPV would be a positive $959,426 making the project economically viable. However, discounting the free cash flows by the unlevered cost of equity (15%) results in a negative NPV of (-$332,645) and an IRR of 8.42 percent. The addition of the base case and the collateral effects still results in a NPV of (-$316,874). Even a government subsidised loan reducing it to 7.03% was not enough to offset a negative NPV value for the project. Only when all the collateral effects such as tax shields, subsidy and issuance costs are taken into account for the project does the NPV become a positive $568,314. Thus the conclusion is that the project only becomes feasible when these three factors are taken into consideration when considering a financed option [3], [19].

### 2.1.4 Renewables in Taiwan; Net Present Value and Internal Rate of Return.

The 2010 Leu paper discusses the implications of renewable energy for Taiwan using NPV and IRR as financial tools, and using a rate of return of 6%. The report categorised the renewable energy resources into; solar thermal, solar photovoltaic, wind energy, geothermal energy and biomass energy; and calculated the NPV and
IRR for each category. It was found that for solar thermal; NPV=(-21,182,841.66) and IRR=0%. For solar photovoltaic; NPV=(-174,796,037.20) and IRR=0%. For wind energy; NPV=4,179,949.27 and IRR=29.3716%. For geothermal energy; NPV=1,936,565.53 and IRR=14.4274%. And finally for biomass energy; NPV=(-9,964,359.03) and IRR=0%. The report concluded that the short term objective of the government should be the development of the biomass and solar thermal energy sectors of renewable energy, where the combined output can reach 34.2 billion. The long term objectives for the government should be solar photovoltaic, wind and biomass sectors; of which the solar photovoltaic shows the greatest potential followed by wind, biomass, solar thermal, and geothermal respectively; collectively achieving 25.585 billion annually. The paper suggests price adjustments to each renewable energy sector based on an assumed achievable IRR of 15% and to improve the economic feasibility for each sector. It proposes the following adjustments; solar thermal to $4.75/kW, solar photovoltaic to $23/kW, wind to $1.65/kW, geothermal to $2/kW and biomass to $3.65/kW. The paper suggests that with these changes, the economic viability of the renewable energy sector should remain strong and the government’s target of 14.8% renewable can be achievable by 2020 [4], [19].

2.1.5 Cost of renewables in China; Net Present Value and Real Option Analysis.
The 2014 Zhang paper discusses factors such as; non-renewable energy cost, the price of carbon, the fiscal cost of renewable energy as well as government subsidies with respect to photovoltaic energy for China. It utilises real option analysis (ROA) to account for uncertainty and thus provides a more effective model than NPV for the purposes of analysis. The study found that non-renewable energy cost determines the pace of development of renewable energy technologies. It assumed a Geometric Brown Motion (GBM) of uncertainty of outcomes in the development of renewables in its analysis. A Clean Development Mechanism (CDM) adopted after the Kyoto Protocol was used to determine the probability of changes in carbon pricing for the report. A Wright learning curve was adopted for the purposes of determining the relationship between cost and accumulation of certain indices in relation to the cost of renewable energy. The current Chinese subsidy policy includes tax relief, FIT and subsidised loans for investment in renewable energy technologies.
The report found that the NPV in early 2013 was (-0.57) and this less than zero trend continued into 2015 and 2016. The ROA was also found to be less than zero for 2013 and into 2015 and 2016. These results are clear indicators that the photovoltaic industry in China is unprofitable without government intervention. The report showed that with government subsidies in place, the NPV and ROA both become positive, indicative of an economically viable proposition. The paper reported that increasing the subsidy rate increased the value for NPV and ROA. The paper concluded that without government subsidy, the photovoltaic industry in China is not economically feasible and only with subsidies in place would the industry be an attractive investment opportunity [5], [19].

2.1.6 Net Present Value in Italian renewables analysis.
The 2014 Cucchiella paper uses the NPV tool to evaluate the impact of a variation in variables such as; subsidies, sale price of electricity, investment cost, and equivalent operating hours for renewable energy technologies in the Italian context. The report categorised renewable energy into; photovoltaic, biomass, wind and hydro power. It also categorised the renewable according to the size of contribution; 10kW, 100kW, 1MW, 5MW, 10MW, and 100MW. The results are shown below.

Table 1. Net Present Value/Unit of installed power output by renewable resource and plant size. Table adapted from [6].

<table>
<thead>
<tr>
<th>Renewable</th>
<th>NPV/Power Euro/W</th>
<th>Renewable</th>
<th>NPV/Power Euro/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind 100kW</td>
<td>3.87</td>
<td>Hydro 10MW</td>
<td>1.91</td>
</tr>
<tr>
<td>Biomass 100kW</td>
<td>3.63</td>
<td>Hydro 100MW</td>
<td>1.76</td>
</tr>
<tr>
<td>Biomass 100MW</td>
<td>3.32</td>
<td>PV 1MW</td>
<td>1.56</td>
</tr>
<tr>
<td>Hydro 10kW</td>
<td>3.3</td>
<td>PV 10kW</td>
<td>1.5</td>
</tr>
<tr>
<td>Hydro 100kW</td>
<td>2.99</td>
<td>PV 100MW</td>
<td>1.3</td>
</tr>
<tr>
<td>Hydro 1MW</td>
<td>2.99</td>
<td>PV 5MW</td>
<td>1.23</td>
</tr>
<tr>
<td>Biomass 10MW</td>
<td>2.79</td>
<td>Wind 1MW</td>
<td>0.76</td>
</tr>
<tr>
<td>PV 100kW</td>
<td>2.12</td>
<td>Wind 5MW</td>
<td>0.68</td>
</tr>
<tr>
<td>Wind 10kW</td>
<td>2.1</td>
<td>Biomass 5MW</td>
<td>0.51</td>
</tr>
<tr>
<td>Biomass 10kW</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The report discovered that the current structure of Italian legislature and FIT encourages the development of photovoltaic resources (59-65%) while wind and hydro share 17-20% of FIT and biomass only 13-14%. The profitability in almost all the cases studied in the report was positive (~96.9%) with NPV negative in only three cases; 100MW wind and 5MW hydro and biomass. This was found to be resultant from the incentive mechanisms in place as well as the relative investment costs. Variations in NPV for photovoltaic systems were attributed to operating hours as this renewable energy source is most sensitive to operating hour variations. Wind and biomass were most effected by FIT schemes more than photovoltaic was. The report concluded that investments in renewables provided healthy and long term stability with high returns and low risk. The NPV results highlighted the importance of the selection of the optimum sized plant to maximise NPV values. It also demonstrated which renewable resource provided the highest NPV. The highest NPV resources were; 100kW wind, 10kW hydro, 100kW and 1MW and 100MW biomass, with values between 3.3 and 3.9 €/W. The 5MW plants and several wind plants had lower NPV of between 0.5 and 1.2 €/W [6], [19].

2.1.7 German employment in renewables.
The 2012 Lehr paper analyses the economic impact of renewable energy in Germany, focusing on the effect on the labour market to 2030. The “production, installation, operation and maintenance of wind-mills, solar modules, biomass power plants or heating systems as well as biogas and solar thermal applications have a positive short-term investment effect” [20]. Export of renewable energy technology is important for Germany with 70% of the turnover for the wind turbine industry being derived from exports [20]. The economy-energy-environment model PANTA RHEI was utilised for this report. It is an empirically evaluated model with an iterative annual procedure. After the positive and negative effects of renewable energy were evaluated in this study, and a conservative quantitative data set was adopted, it was concluded that net employment for renewable energy in Germany would reach 150,000 by 2030. The gross employment figure for the renewable energy sector was estimated to be 340,000 in 2009 and between 500,000 and 600,000 by 2030 [20].

2.1.8 Concentrating Solar Power, Photovoltaic and wind in Morocco
Mediterranean countries such as Morocco share a high density of normal irradiation (DNI) like Australia and thus focus on renewable technology such as concentrated solar power (CSP), solar photovoltaic (PV) and wind turbine technologies. The Moroccan renewable energy target of 40% renewables by 2020 was established in their 2008 National Renewable Energy and Efficiency Plan. The 2012 de Arce paper analyses the effect to GDP, added value by economic sector and employment of this initiative over a 30 year span. “In the baseline scenario I, the value-added global average annual effect on the Moroccan economy resulting from the installation of renewable energy starts at about 0.18% of GDP in 2010 and reaches 1.21% in 2040. The corresponding impact on employment would be about 36,000 new jobs in 2010 and around 269,000 at the end of the forecasting period… For the optimum scenario (scenario IV) the combined impact of RES, reducing dependence on imports and exporting a 20% surplus is equal to 1.99% (in terms of value added) and 499,000 employees” [21].

The overall impact ranges from 1.21% to 1.99% on GDP up to 2040 with an associated full time employment increase of 269,252 to 499,000 jobs for the economy. The paper concluded that the most positive effect for the economy was the installation of wind turbines and mentions the positive environmental and socio-economic outcomes also.

2.1.9 Gross Domestic Product and renewables in China

The 2011 Fang paper is an extensive analysis from 1978 to 2008 for China using multivariate OLS and SPPS software of the renewable energy consumption rate over the period. It was found that a 1% increase in renewable energy consumption resulted in; an increase to GDP of 0.120%, GDP per capita increase of 0.162%, an increase of income to rural households of 0.444%, and an increase to urban household income of 0.368% [22]. The paper found that there was a high correlation between economic welfare variables and renewable energy. It calculated the advantage to China’s economy into the future and found the following in Table 2 below:

Table 2. Impact of REC implications into the future for China [22].
As can be seen in Table 2, for 2020; 9.29–15.06% growth in real GDP, 12.55–20.33% growth in GDP per capita, 34.39–55.72% growth in per capita annual income of rural households, and 28.50–46.18% growth in per capita annual income of urban households respectively.

Also for 2030; 21.76–37.41% growth in real GDP, 29.38–50.51% growth in GDP per capita, 80.53–138.42% growth in per capita annual income of rural households, and 66.75–114.73% growth in per capita annual income of urban households respectively.

Finally for 2050; 39.76–72.31% growth in real GDP, 53.68–97.62% growth in GDP per capita, 147.13–267.56% growth in per capita annual income of rural households, and 168.25–221.76% growth in per capita annual income of urban households respectively [22].

Clearly, the paper shows the positive impacts to overall GDP and GDP per capita both for rural and urban households into the future.

### 2.1.10 Gross Domestic Product in Organization for Economic Cooperation and Development countries with renewables

The 2016 Inglesi-Lotz paper determines a quantitative the impact of renewable energy consumption to the economic conditions in a panel data framework for all the OECD countries for the period from 1990 to 2010. The paper argues that in previous studies, on average and in the long run, a 1% increase in the proportion of renewable energy...
to the total energy mix will increase a country’s GDP by 4% as seen in European models [23]. According to its quantitative data, the results saw a long run equilibrium relationship between; “real GDP or real GDP per capita, total renewable energy consumption or share of total renewable energy consumption, real gross fixed capital formation, employment and the R&D expenditures of the countries. The estimations indicate that a 1% increase of renewable energy consumption will increase GDP by 0.105% and GDP per capita by 0.100% while a 1% increase of the share of renewable energy to the energy mix of the countries will increase GDP by 0.089% and GDP per capita by 0.090%” [23].

The paper advocates the advantages of government interventionist policies in the promotion of renewable energy in the establishment of renewable energy markets in a macroeconomic context. The paper also states that its main concern is to aid policy makers in decisions relating to renewable energy in OECD countries and that those decision makers should focus on the proportion of renewable energy in the energy mix. Thus its conclusion of increased government promotion of renewable energy is quantitatively based and will result in both environmental standards as well as macroeconomic performance of the country.
2.2 Political literature review

The political literature review is an analysis of the current trend regarding renewable energy in Australia from a political standpoint. The Renewable Energy Target (RET) is of concern as it sets the future goal for the percentage of renewable technologies in the energy mix for Australia. The RET has seen numerous changes since its inception in 2001 and the current target, as well as the consequences for the wholesale and retail electricity price is discussed below from the literature.

2.2.1 Australia Renewable Energy Agency and Clean Energy Finance Corporation 2015

The 2015 Australia Renewable Energy Agency (ARENA) and Clean Energy Finance Corporation (CEFC) report details the revenue kick starts to large scale renewable energy projects. ARENA is seeking bids from major solar PV proponents of up to $30 million for AC projects of at least 5MW. The aim is to develop a further 200MW of additional large scale to nearly double the current 211MW capacity [51]. Also, the CEFC is running a congruent $250 million programme aimed at large scale solar projects. The projects targeted are for private sector with values of $15 million or more [51]. ARENA is anticipated to fund between four to ten projects with its initiative. As the cost for large scale solar PV is decreasing these government initiatives is part of their legislative reforms to increase large scale renewables in the energy mix. Examples of previous projects funded through ARENA and CEFC include the 56MW Moree Solar Farm, and the Broken Hill and Nyngan 155MW large scale PV projects [51]. These projects created 550 direct construction jobs, building
2.2 million solar panels and will generate enough electricity to power 65,000 homes [51].

The approach of the CEFC in its funding is commercial in nature; it looks for a return on its investment. To date, it has funded $1.4 billion in projects worth currently over 3.5 billion. It has over 55 direct investments and 34 co-financed projects all in low-emission and energy efficient technologies. The expectation of these projects is the abatement of 4.2 million tonnes of CO2e annually, as well as having a positive impact on the Australian economy [51]. The CEFC operates under the Clean Energy Finance Corporation Act 2012 [51].

2.2.2 Renewable Energy Target in Australia

The 2014 Cludius paper analyses the distributional effects of the RET in Australia through the price changes in wholesale and retail electricity. The 2011 legislative division of LRET and SRES also included exemptions to large industries involved in exports. It is notes in the report, that these manufacturers are large consumers of electricity, consuming a significant proportion of the domestic supply. However, little has been provided publically as to the extent of the impact of these exemptions including the costs to the consumers and the benefits to electricity providers [52]. The short term impacts of the RET is that the spot price of wholesale electricity. This is attributed to the fact that renewables have a low to zero short run marginal cost. However, a major component in the RET scheme is the transmission and distribution networks for the renewable technologies installed. The cost break-down for the National Electricity Market (NEM) is; 8% for transmission, 37% for distribution, a wholesale component including carbon costs of 37%, and a retail component of 17% that included LRET and SRES cost components [52]. While the short run whole spot price is notes, it can be seen that retail prices have increased as a result of the cost of the green certificates incorporated in the RET. The paper further notes that the energy intensive exporting manufacturers that are exempt from RET constraints are also benefiting from the lower wholesale spot price, creating a disparity in the market. Thus, the paper calls for a review of this aspect of the RET to eliminate indirect wealth transfer from the retail paying consumer to the manufacturing exporter.
The paper concludes that wholesale electricity prices have been driven downward as a result of the RET but the retail price paid by consumers has increased as a result of the green surcharges imposed by retailers. The paper argues that there is an inequitable distribution of financial costs and benefits with the manufacturing exporters benefiting from a lower wholesale spot price as well as legislative exemptions. This inequity is further compounded with electricity retailers failing to pass on the reduction in wholesale prices to retail consumers. Exemptions to some consumers of electricity invariably result in the increased costs to other consumers in the electricity market. This inherent result, the paper argues, is not necessarily a feature of the RET, but the result of the design choices when implementing the policy [51].
2.3 Environmental/health literature review

The environmental impact of mining and combusting coal in Australia should not be underestimated. Many studies have confirmed the catastrophic impact of mining and burning coal over the last decades. Australia may indeed be an island continent, but it is a citizen of the planet and in 2010 was ranked as the world’s largest coal exporter [33] as can be seen in appendix 2. As the world’s largest exporter of coal, we hold the global social responsibility to instigate a change to renewables so the environment has a chance to recover. Indeed “current climate change policies (for Australia), such as the Federal Government’s Clean Energy Futures package, will deliver global temperature increase of 4 degrees Celsius, probably more…(and) would lead to the death of 6 billion people…with horrific implications for our children and grandchildren” [34]. The simply is no excuse for Australia, the 6th highest ranked GDP per capita globally economy, [35] not to be the leader in ushering in the next energy renaissance; an era of change and discovery for the betterment of mankind.

2.3.1 Coal combustion in Czech Republic

The 2015 Jelinek paper discussed the environmental impacts of burning in coal mine and in coal tailing dumps. The analysis was conducted on soil sediments in Ostrava, a major industrial city. Burning of coal tailing dumps is considered a serious hazard but happens with alarming frequency and is a direct consequence of coal mining. The Seyitomer lignite mine in Turkey ignited and burnt for 40 years before it was extinguished; the Centralia mine in Pennsylvania USA ignited in May 1962 and continues to burn, resulting in the evacuation of most of the town [36]. Sometimes the cause of the burn is anthropogenic, and sometimes it is the spontaneous exothermic reaction of pulverised coal oxides with the surrounding oxygen in the air. Never the less, the resultant environmental consequences are clear. Coal mines expose coal oxides to the air and this can result in an uncontrolled, sometimes decades-long burning of the coal remaining on and close to the surface of the mine dump. The release of carbon dioxide, carbon monoxide, soot, dust particulates and sulphur dioxide and other GHG’s have catastrophic consequences for the environment. Australia is well versed in the phenomena; with one mine self-igniting annually [37].
2.3.2  **Australia, coal power stations and the environment.**
The 2011 Snell report has some interesting conclusions. The 2008-2009 emissions from coal-fuelled stations totalled 122.03 million tonnes of Carbon Dioxide emissions (as seen in appendix 3). This makes Australia one of the highest carbon emissions per capita in the world [38]. “Australia is a classic example of where access to cheap energy, the capacity to pollute without responsibility, and generous government subsidies to the coal and heavy emitting industries has contributed to a lack of innovation among the corporations who are major energy users” [38].

2.3.3  **IEA 2000; China**
The 2000 IEA report: Coal in the Energy Supply of China revealed a lot of the environmental consequences of coal mining in China. China uses 75% of their coal for commercial energy supply. Particulate emissions are of concern, with 3.63 million tonnes recorded in 1994. Coal combustion is also responsible for 70% of sulphur emissions. Underground mining has resulted in 400,000 hectares of subsidence. There is a total of 5,500 hectares of land being used as refuse for coal mines, with 150-200 million tonnes being added annually. Approximately 6 million cubic meters of methane are discharged from underground mines annually and the spontaneous combustion of coal consumes 100 million tonnes of coal annually. Only 15% of the water used in coal mines in China is treated before it is released into the surrounding river systems, causing catastrophic environmental consequences [44].

2.3.4  **Canadian health impacts**
The 2007 Jardine paper details the concerns of the 1,034,945 residents of Alberta, a town close to a coal-fuelled power plant, regarding risks to their health. Of concern was the “major pollutants released by coal-fired power plants are nitrogen oxides (NOx), sulphur dioxide (SO2), carbon dioxide (CO2) and mercury” [45]. These pollutants result in “ground-level ozone and acid rain, and have been implicated in exacerbating symptoms of asthma and triggering asthma attacks…affect breathing, may aggravate existing respiratory and cardiovascular disease, and have been associated with increased mortality [46-47]. This report relied on primary sources of information, namely telephone surveys and self-administered surveys of wide demographics within the population. 47%-67% of respondents had health concerns regarding air quality, 26%-32% had concerns regarding water quality, and 6%-19%
had health concerns regarding respiratory problems. Overall 18%-93% of people living in the area of the coal-fuelled plant had health concerns with living in the area.
3. Methodology
This report is purely a research based assessment for Australia for the replacement of coal fuelled power stations with renewable energy technology. Research methodology will be based in the analysis of literature pertaining to the experiences of other countries in their change to renewables. This will be extrapolated into the Australian context with the given resources for the country. The quantitative assessment of Australia’s energy mix will be attained from Government sites such as the department of industry innovation and science (DIS) as well as the Department of Industry and Science; Guide to the Australian Energy Statistics 2015.

The RETScreen program will be utilised in the quantification of the economic/financial and environmental variables analysed. The RETScreen program is an energy tool that allows for decision making regarding the financial viability, environmental impact and risk analysis of a renewable energy project. The conditions for the particular site may be set in the initial stage of the program. Then, an energy model with renewable variable inputs may be designed in the second part of the program. A cost analysis is then conducted with inputs such as inflation, discount rate and market interest rates as options for input. Then an emission analysis is performed with GHG emission savings resultant from the renewable energy model devised. Next, a financial analysis is performed with variables such as NPV, IRR and SPP calculated. Finally, a sensitivity and risk analysis is calculated. RETScreen is a powerful tool allowing for informed decision making regarding the viability of renewable energy projects.

Thus data collection will be predominately from secondary sources via peer reviewed academic journals, Government publications and industry publications. As the content is purely quantitative and research based in nature, there is no need for interviews or opinions. Reliance on the accuracy of government statistics is paramount for this report as they will form the basis for rate of return into the future using the time value of money for the investment into renewable technology. Thus the primary research methodology employed in the execution of this report is the use of secondary data sources such as industry and Government journals, for the purposes of quantitative calculations in the determination of the financial viability of the replacement with renewable energy technology. Political and environmental consequences of the shift
to renewables will be assessed through the experiences found in other countries through the literary reviews. Moreover, given the recent announcement of a double dissolution election in Australia on 2nd July 2016, the political aspects of this report are bound to be subject to change given the outcome of the election. Case studies from peer reviewed journal will form an integral basis to this research methodology as demonstrated by Yin, 1994, Hamel et al., 1993, Eaton, 1992, Gomm, 2000, Perry, 1998, and Saunders et al., 2000 in Rowley’s 2002 article. Case studies “are widely used because they may offer insights that might not be achieved with other approaches” [8-11].

One ethical issue central to this report is the unbiased presentation of scientific data pertaining to renewable energy and its integration and replacement of the current energy supply system. This report is heavily reliant on research and thus the use of relevant Government and peer reviewed journals will form the foundation of the presentation. This report will therefore avoid interviews and negate the need for consent from participants. Thus, paramount to the maintenance of high ethical standards, is the unbiased and dissociated presentation of the pertinent quantitative information relating to the subject matter and the subsequent projections for the transition to renewables for Australia [19].
4. Presentation of findings

4.1 Analysing the data

The total generation capacity of the operating coal-fired power plant fleet for Australia is 30 GW [12], with the coal component of electricity generation representing 75% of total energy production domestically [13]. The retail value of electricity for Australia is $51b annually with a growth rate of 4.8% [14]. Thus, the coal component of revenue is (0.75*$51b) $38.25b annually.

From the literature; the LCOE for solar photovoltaic is $225-$404/MWh [15], with the average being $314.5/MWh, the LCOE for wind power is $45-$135/MWh [15], with the average being $90/MWh, and the LCOE for solar thermal is $213-$267/MWh [15], with the average being $240/MWh.

The capital costs for building a solar photovoltaic plant is $4,060/kW [15]. The capital cost for building a wind farm is $1,725/kW [15]. The capital costs for building a solar thermal plant is $6,410/kW [15]. The resultant O&M costs for solar photovoltaic are $8/MWh [16]. For solar thermal the O&M costs are $8/MWh [16]. Finally, the O&M costs for wind is $10/MWh [16].

There is 576.2 million tonnes of carbon dioxide equivalent (Mt CO2-e) in 2008 [39] from coal power in Australia. Carbon dioxide emissions from coal-fuelled power stations totalled 122.03 million tonnes in 2008-2009 [38]. “Electricity generation (which in Australia relies mainly on coal ~75%) is the largest single contributor to CO2 emissions, at 37.2 per cent of inventory emissions” [39]. Australia produces around 1.8% of total world GHG ~28 tonnes of carbon dioxide equivalent per person per year, making Australia among the highest emitters for its population in the world [40]. Another environmental issue is water contamination. In 1996-1997, activities of mining used 570,217ML of water of the total 22,185,731ML consumed in Australia representing 2.6%.

The ageing state of Australia’s coal fuelled power station fleet is alas a major concern. By 2014, 29% of power stations were over 40 years old [41]. By 2020, 45% of power stations will be over 40 years old [41]. By 2030, 65% of power stations will be over
40 years old [41]. This raises the question as to what will they be replaced with when they are no longer operationally viable.

Coal mines spent $58.5 million on environment protection expenditure in 1997-1998 [43]. This represents \(0.75 \times 58.5\) million for coal-fuelled power stations is $43.875 million and is \($43.875m/38.25b\) 0.1147% of their annual revenue.
4.2 Answering the research questions

- What is the current electricity usage for Australia as measured in Watts derived from coal-fuelled power plants?

The total generation capacity of the operating coal-fired power plant fleet for Australia is 30 GW [12].

- What is the total revenue raised annually from this supply?

The amount of revenue derived from coal-fuelled power stations (0.75*51b) $38.25b annually [19].

- What is an appropriate mix of renewable energy technologies appropriate for Australia to replace the current coal-fuelled power plants; based on natural resources and overseas models?

An appropriate mix of renewable energies to replace the current 30GW of power derived from coal-fuelled power stations is highly dependent on the natural resources available domestic to Australia. Basing an energy mix for Australia based on overseas may be somewhat limiting in that regard as resources vary from country to country. For example, in Costa Rica and Argentina, there is a high natural resource for hydro power while that is not the case for Australia; hydro accounts for only 6.2% of current electricity production [17]. Thus, an assessment of the resources available can be seen in Figures 1 and 2 below.
Figure 1. Wind speed map for Australia [56].

Figure 2. Solar exposure for Australia [55].
Clearly for Australia, with its high wind and solar resources, a mix of wind farms and solar photovoltaic and solar thermal renewable energy technologies would make an appropriate energy mix.

- Provide a financial assessment of the viability of replacing existing fossil technologies with renewables using NPV and LCOE.

The formula used for calculating the LCOE of renewable energy technologies is:

\[ \text{LCOE} = \frac{\sum \text{NPV(Cap + Fin + O&M)}}{\sum \text{kWh}} \]

[16].

Thus, the net present value and therefore the time value of money is incorporated into the LCOE as well as operating and maintenance costs and capital expenditure involved in construction. Operation and maintenance (O&M) costs and capital costs can be found in appendix 1. The NPV incorporated into LCOE formulae can be found in appendix 2. The LCOE specific to renewable energy formulae can be found in appendix 3.

The total current wattage attributed to coal-fuelled power plants in Australia is 30GW and suitable renewable technologies for replacement for Australia’s natural resources include solar photovoltaic, solar thermal and wind plants. A mix of 15GW wind energy, 7.5GW solar thermal and 7.5GW solar photovoltaic is proposed for the renewable energy mix. The following assumptions are made for the purposes of the calculations:

A discount rate of 6% was used in the calculations. This was selected on the basis that US Treasury note rates since 1900 yields have ranged from a little less than 2%, to 15.3%; the average rate was 4.9%. An additional 1.1% (22%) margin was added for risk mitigation as the proposal of replacing coal fuelled power stations with renewables in Australia is a new proposition, untested and investors will demand a higher return for the resultant higher risk.

A lifespan of 20 years for all renewable technologies was selected. This lifespan was used as an extreme conservative estimate. It may account for natural disasters that affect the function of the renewable plant or unforeseen circumstances where their
operation is prematurely impeded. In reality, the expectation is that the renewable plants will operate for longer than 20 years but this conservative estimate was adopted to err on the side of caution and not to inflate the viability of the proposal.

The revenues from technologies are divided according to percentage of load; 50% wind, 25% solar thermal and 25% solar photovoltaic. These proportions are the foundation of the proposal in this report. They were adopted based on the natural resources available to Australia; with high solar resource central and west, and good wind resource in the south of the country. Constant costs and revenues over the lifetime of the project as inflation have the same impact on both variables and thus negate its influence.

Another RETScreen parameter adopted involves operation and maintenance (O&M) costs. They were determined to be; for solar photovoltaic are $8/MWh [16], for solar thermal $8/MWh [16], finally wind is $10/MWh [16].

The capacity factor of 95% was utilised in the RETScreen evaluation. This figure was used based on the premise that the locations for the renewable plants will seek to maximise the natural resources available. Thus, a high capacity factor is utilised in the calculations for the purposes of this report.

Revenue inputs for the financial analysis component of the RETScreen analysis were calculated to be $104.40/MWh based on the current market rate for electricity price in Australia. This was based on the highest average weekly price paid per State in Australia [54].

Solar thermal NPV:
Capital cost: 7,500,000kW*$6,410 = $48,075b
O&M cost: $8*365*24h*750MW = $52,560,000p.a.
Revenue: 25%*$38.25b = $9,5625b
Net cash flow annually = $9,562,500,000-$52,560,000 = $9,509,940,000
As seen above in Figure ST1, inputs for RETScreen data for solar thermal is 7,500,000kW at 95% capacity factor giving 62,415,000MWh at an export rate of $104.40 per MWh.
Figure ST2: Solar thermal cost analysis.

As seen above in Figure ST2, the cost analysis for solar thermal.
As seen above in Figure ST3, the emission analysis for solar thermal.
Figure ST4: Solar thermal financial analysis
As seen above in figure ST4, the financial analysis for solar thermal.
Figure ST5: Solar thermal risk analysis

As seen above in Figure ST5, the financial risk analysis for solar thermal.
Thus as seen in figure ST4, NPV for solar thermal is $26,061,592,811; a positive amount indicating a good investment proposition [19]. The IRR is quite a reasonable 12.1% and SPP 7.4 years. The annual CO2 saving is 12,252,065 tonnes.

\[
\text{LCOE} = \frac{\text{NPV}}{E/(1+r)} \\
= \frac{26,061,592,811}{7,500,000/1.06} \\
= \$3,683.37\text{p.a.}
\]

Solar photovoltaic NPV:
- Capital cost: 7,500,000kW*$4,060 = $30,450b
- O&M cost: $8*365*24h*750MW = $52,560,000p.a.
- Net cash flow annually = $9,562,500,000-$52,560,000 = $9,509,940,000

Figure PV1: Solar PV capacity

As seen above in figure PV1, the input data for RETScreen data for solar PV.
Figure PV2: Solar PV cost.

As seen above in Figure PV2, the cost analysis for solar PV.
Figure PV3: Solar PV emission analysis.

As seen above in Figure PV3, the emission analysis for solar thermal PV.
Figure PV4: Solar PV financial analysis

As seen above in figure PV4, the financial analysis for solar PV.
Figure PV5: Solar PV risk analysis.

As seen above in Figure PV5, the financial risk analysis for solar PV.
As seen in figure PV4, NPV for solar photovoltaic is $43,686,592,811, making it an economically viable proposition [19].

LCOE solar photovoltaic:
LCOE =NPV/(E/(1+r))

= $43,686,592,811, /(7,500,000/1.06)

$6,174.37 p.a.

Wind NPV:
Capital cost: 7,500,000kW*$1,725 = $12,937,500,000
O&M cost: $10*365*24h*750MW = $65,700,000p.a.
Revenue: 50%*$38.25b = $19.125b p.a.
Net cash flow annually = $19,125,000,000-$65,700,000 = $19,059,300,000

Figure W1: Wind capacity
As seen in Figure W1 above, the input data for the RETScreen analysis for the wind powered turbines.
Figure W2: Wind cost analysis

As seen above in Figure W2, the cost analysis for wind power.
Figure W3: Wind emission analysis
As seen above in Figure W3, the emission analysis for wind power.
Figure W4: Wind financial analysis

As seen above in Figure W4, the financial analysis for wind power.
Figure W5: Wind risk analysis

A seen above in Figure W5, the sensitivity and risk analysis for wind.
Thus NPV for wind is $122,850,329,916, making it an economically viable proposition [19].

LCOE wind:
LCOE = NPV/(E/(1+r))
= $122,850,329,916/(15,000,000/1.06)
$8,681.42

- Provide an analysis of the findings and recommendations based on financial indicators.

The proportion of solar thermal contribution to the renewable energy mix for this proposal was 25% or 62,415GWh. The export rate of electricity assumed was $104.40 and a discount rate of 6% over a lifespan of 20 years for the technology. This delivered an income of $6,516,126,000 and O&M costs of $52,560,000 annually. The NPV was $26,061,592,811 with an IRR of 12.1%. The SPP was 7.4 years. The sensitivity range of 10% for the risk analysis still showed positive IRR between 10.6% to 13.8%. The financial indicators are clear; solar thermal is a sound fiscal investment with positive NPV, short SPP, and a sound IRR.

The proportion of solar PV contribution to the renewable energy mix for this proposal was 25% or 62,415GWh. The export rate of electricity assumed was $104.40 and a discount rate of 6% over a lifespan of 20 years for the technology. This delivered an income of $6,516,126,000 and O&M costs of $52,560,000 annually. The NPV was $43,686,592,811 with an IRR of 20.7%. The SPP was 4.7 years. The sensitivity range of 10% for the risk analysis still showed positive IRR between 18.7% to 23.2%. The financial indicators are clear; solar thermal is a sound fiscal investment with positive NPV, short SPP, and a sound IRR.

The proportion of wind contribution to the renewable energy mix for this proposal was 50% or 124,830GWh. The export rate of electricity assumed was $104.40 and a discount rate of 6% over a lifespan of 20 years for the technology. This delivered an income of $13,032,252,000 and O&M costs of $65,700,000 annually. The NPV was $122,850,329,916 with an IRR of 50.1%. The SPP was 2.0 years. The sensitivity range of 10% for the risk analysis still showed positive IRR between 45.3% to 55.4%.
The financial indicators are clear; solar thermal is a sound fiscal investment with positive NPV, short SPP, and a sound IRR.

The RETScreen program was utilised in this study as a quantitative tool for financial, emission and risk analysis. The program provides SPP, NPV and IRR data that are internationally accepted tools of financial analysis. The emission analysis is based on CO2 savings with the adoption of the recommended technologies. RETScreen is an internationally recognised program for analysis of renewable technologies.

Clearly, wind showed the highest IRR between the three technologies, as wind has low O&M and is a well understood technology. Second was solar PV followed by solar thermal. As thin film and more experience with the installation of solar PV and thermal plants becomes apparent, these technologies will show higher IRR and become increasingly economically enticing to power companies. As all the financial indicators are clearly indicative of excellent investments, there remains only one reason for the failure for the change to renewables over fossil fuels. That is, subsidies for the coal electricity market make the change to renewables unenticing. A total of $145,000,000 was paid as subsidies to the fossil fuel industries for electricity generation in Australia 2013-2014 [53]. While this represents only 5% of total subsidies for electricity generation domestically, it begs the question as to why the Government is subsidising coal at all.

- What are the consequences to Australia’s economy in replacing coal-fuelled power stations with renewable technology?

The purpose of this paper is not to entirely negate the coal industry for Australia. Indeed, the export of energy resources contributes a substantial proportion to the GDP and the economy. Energy resource exports in 2012-2013 contributed $69billion in income [24], employed 123,000 people [25], and contributed $102billion (6.7%) to GDP [26]. The International Energy Agency (IEA) predicts global energy demand to increase by 33% by 2035 with almost 20% in the demand for coal [27]. The economic consequences to the coal industry therefore and thus the overall effect on the economy will be limited to the proportion of coal used domestically for electricity generation purposes. The extraction and use of fossil fuels as an energy source will meet its end in due course as renewable energy technologies become increasingly economically
viable. Unfortunately for now, “Most energy analysts confirm that coal will continue to be a major source of global energy for decades to come” [28].

A viable economic assessment of the effect of replacing coal-fuelled power stations with renewable energy must begin with the effects on national employment. This study has been conducted in a 2005 paper by Dr. Mark Disendorf for the Victorian government and can be found in appendix 1. The results are as follows:

“The coal-fired electricity industry, including the contribution of coal mining, provides about 63 job-years/TWh in Australia in total. In wind power, there are about 117-184 job-years/TWh in Australia (with 44% Australian content). With 80% Australian content, employment in wind power in Australia could rise to 213-335 job-years/TWh. So, with current Australian content, there could already be 2-3 times the job-years/TWh in Australia from wind power compared with coal power. If the Australian content of wind farms can be increased to 80% as projected, 3.6-5.6 times more job-years would be created per TWh in Australia from wind compared with coal” [29]. Thus, conservative estimates of an increase of between 2-3 (average 2.5) jobs with the replacement of coal for wind would contribute a sizeable increase to Australia’s GDP. Provided that similar increases would result in the photovoltaic and solar thermal industries, the following scenario would pursue with the proposed change to renewables for Australia:

- Coal component of electricity generation: 75% [13]
- Thus coal-fuelled employment in electricity generation: (0.75*169,900)=127,425.
- Increase to employment with switch to renewables: (2.5*127,425)=318,563
- Full time average weekly earnings for Australian adult: $1,484.50=$77,194pa. [31].
- Increase to GDP = $77,194*318,563=24,591,152,220pa.
- Thus percentage increase to Australia’s GDP = (24.591152220/2039.22)*100=1.206%
Therefore, the switch from coal fuelled power stations to renewables would result in; 318,563 additional jobs for Australia, and increase of $24,591,152,220 annually to GDP or an increase of 1.206%.

- Determine the environmental/health consequences of extracting and burning coal for electricity production in Australia

The environmental and health consequences of burning coal for electricity production in Australia are clear. Firstly, in the extraction of the coal, there is the inherent land degradation for open cut mines and the land subsidence issues for underground mines. The spontaneous combustion of coal occurs with alarming regularity with the interaction of oxygen in the air and the pulverised coal powder. The contamination of the water supply is also an issue of major concern in the extraction process. Then the issues of carbon dioxide (and other GHG’s) released into the atmosphere when the coal is combusted in the power plant. The anthropogenic warming of the planet is not a problem exclusive to Australia, but affects everyone on the planet. Other gases released from burning coal include sulphur dioxide, mercury and other particulates. These are known to cause respiratory health problems as well as acid rain and could be the direct result of human death and increase this mortality by up to 4% [46].

Specifically, the installation of the renewable energy mix proposed in this report would result in the saving of a total of 49,008,258t of CO2 annually. A saving of 12,252,064.5t from solar thermal and solar PV each; and 24,504,129t from the wind component. Clearly, the environmental consequences of a change to renewables for electricity production should be a priority for any Government serious about anthropogenic climate change.

The balance between energy security and the preservation of the environment and maintenance of the health of the human as well as wildlife populations must be met responsibly. While the mining and combustion of coal continues, clearly the environment, water supply, wildlife and people suffer. The price the Government puts on the health of the environment as well as its populous is the cheap, dirty coal that
fuels the power stations; and while there is an alternative with no such negative externalities, that price is too high.

- Determine the current political Renewable Energy Target (RET).
  
  As at 23/02/2016, the most current renewable energy target (RET) for Australia is from the Department of the Environment (DET) media release from 23 June 2015. It states that the new target for large scale generation of “33,000GWh in 2020 will double the amount of large scale renewable energy being delivered...compared to current levels” [48]. This means the current level of large scale renewable energy in the mix of 13.47% [49] will almost double to 23.5% of the total energy supply. This most current amendment to the RET also incorporates measures to:

  - “protect Australian jobs and help industries remain competitive by increasing assistance for all emissions intensive trade exposed industries to 100 per cent exemptions from all RET costs
  
  - remove the requirement for biennial reviews of the scheme and replace them with regular status updates by the Clean Energy Regulator, to provide more certainty to industry and transparency to consumers
  - Reinstate biomass from native forest wood waste as an eligible source of renewable energy, including the same safeguards that were in place prior to removal of this source from eligibility in late 2011” [48].

- Analyse any current renewable energy incentives operating in Australia
  
  Since 2011, the RET has been split into two parts; the Small Scale Renewable Energy Scheme (SRES), and the Large Scale Renewable Energy Target (LRET). The LRET is set to double with the latest amendment to the RET and is achieved through the legislation of Large-scale Generation Certificates (LGCs), where one LGC is equal to one MWh of renewable energy. The LGCs are tradeable under current legislation. The SRES focus is on household, small business and community renewable energy systems including; solar hot water, small scale wind, small scale hydro, heat pumps, and solar photovoltaics (PV). SRES is legislated through the issuing of Small-scale Technology Certificates (STCs).
5. Implications and recommendations

5.1 Financial/economic implications and recommendations

Wind technology had the highest IRR of 50.1% and the shortest SPP of 2.0 years. It is the most financially viable of the three technologies discussed in this report and thus has the majority of the contribution to the energy supply in the proposal (50%). Solar PV was the next most prudent financial investment with 20.7% IRR and a SPP of 4.7 years. The weighting in this report for solar PV was 25%. The remaining 25% was allocated to solar thermal. It’s IRR was 12.1% with a SPP of 7.4 years.

The recommendation of this report is to maintain the majority of investment in wind technology. While diversification is always a prudent investment strategy, it may be some decades before thin film technology reduces the overall cost of solar photovoltaic [7]. It may be the case, as discussed in the literature review, that government subsidies may be required in particular for solar thermal for an increasingly successful financial integration into the energy supply [5]. However, the financial indicators are such for all the three technologies that they are all financially viable without Government intervention. The strong wind and solar resources available in Australia remain powerful factors however in the combination of these three renewable energy technologies suited to Australia. Over time with increased research and development of thin film solar photovoltaics, the costs will decrease and thus the efficiency of the technology will increase accordingly [19].

The NPV and LCOE have been an excellent source of information regarding the viability of the investment propositions between the three renewable energy technologies. The NPV accounted for the time value of money over the 20 year lifespan of the energy plants and the LCOE utilised the NPV in providing the cost of electricity generation for each of the technologies over their lifespans. The importance therefore of NPV and LCOE calculations for the purpose of an accurate assessment of financial viability for investment purposes should not be underestimated. These two financial indicators have provided the means of accurate analysis between the investment opportunities and thus an informed decision may be reached [19].

Therefore, it is the final recommendation of this report that the balance of 25% solar thermal, 25% solar photovoltaic and 50% wind energy is maintained for the
replacement of the coal-fuelled power stations currently in use. All three technologies financial indicators are clearly indicative that they would improve the overall economy as well as abate anthropogenic climate change through significantly lowered GHG emissions. Advances in nanotechnology provide the basis for an exponential increase to the efficiency of thin film solar photovoltaics into the future and thus the technology can provide a sound basis for energy supply to Australia’s domestic market given its natural resources [19].

The economic impact of the switch to renewables is equally impressive for the domestic economy. The switch from coal fuelled power stations to renewables would result in; 318,563 additional jobs for Australia, and increase of $24,591,152,220 annually to GDP or an increase of 1.206%.
5.2 Political implications and recommendations

Since its inception in 2001, the RET has set in motion consequences for the political arena regarding the renewable energy sector. Over the past five years, renewable energy has been driven by the RET and has been annually compounding at a rate of 12.2% to its current value of $1.1 billion in 2014-2015 [50]. The 2015 amendment to increase large scale renewable by 2020 to 23.5% of the total energy supply [48] is one of the political implications for the country that will stimulate economic growth and benefit the country through increased GDP and employment. However, the dynamic nature of the RET can be observed over time with changing governments as well as changing public opinion regarding the importance of renewables for the domestic landscape.

The RET has changed the pricing opportunities for different consumers of energy in the electricity market. While the spot price of wholesale electricity has decreased, the retail price has increased resulting in a wealth distribution from the consumers of retail electricity to the wholesale exporting manufacturers. This discrepancy must be addressed as a weakness in the current structure of the execution of the RET policies. While it may be prudent to encourage the export industry for Australia’s domestic financial viability, perhaps the subsidising of export manufacturer’s electricity price is not an efficient vehicle in which to do it as it only leads to an inequitable redistribution of wealth and additional fiscal burden to the end consumer of retail electricity.

Political policies regarding renewable energy are shaped by public opinion and thus the onus of change is in the hands of the Australian people. Reliable media based on ethical, non-partisan research is essential for the education of the public. This in turn will develop political policies based on an educated public’s will. The 2015 increase to large scale renewable energy targets are admirable baby steps toward a 100% renewable energy sector but fall short of any mentionable consequence to the environment or economy. The exemption to RET for export industries may be a band aid solution to balance of payments for Australia, but a floating dollar is the invisible hand of Adam Smith that balances export demand; and thus can only be viewed as a window of opportunity for manufacturers to slip under the RET radar. Thus, the 2015
measures for RET may be viewed as more political propaganda and less actionable consequences for the renewable energy sector.
5.3 Environmental/health implications and recommendations

Clearly one aspect to consider is the spontaneous combustion of coal as a result of mining activities that contribute significantly to GHG emissions. The battle to keep the coal cool so as to prevent self-ignition is an ongoing one but the laws of thermodynamics are clearly victorious with “on average one underground coal mine has a major incident with the self-heating of coal every year, and you would find there would be a number of open cut mines that would be battling self-heating coal now.” [37].

The other environmental consequence of utilising coal for electricity generation is the resultant CO2 emissions totalling 122.03 million tonnes in 2008-2009 [38]. Approximately 28 tonnes of carbon dioxide equivalent per person per year is emitted in Australia, making Australia among the highest emitters for its population in the world [40]. The current calculations in this report show that the replacement of coal fuelled power stations with the renewable technologies proposed would result in 49,008,260tCO2 annually.

Time is not on Australia’s side when it comes to the shift to renewable energy. Already, a great proportion of the current coal-fuelled power stations are ageing presenting OHS concerns. In 2014, 29% of power stations were over 40 years old; by 2020, 45% of power stations will be over 40 years old; and by 2030, 65% of power stations will be over 40 years old [41]. The time is opportune to replace the aged, decrepit and inefficient antiquated coal technology with clean, renewable and efficient renewable energy technology.

The coal mining industry makes a miniscule effort in cleaning up the land degradation resultant from their activities. The coal component for electricity production spent on the environment is $43.875 million and is a miniscule 0.1147% of the annual revenue of the electricity sector derived from coal-fuelled power stations. To cause so much damage to the environment and show such little remorse in efforts to return the environment back to the state it was found may be considered abhorrent.

Clearly from the results of the 2007 Jardine paper, there is a great deal of public concern relating to the negative health impacts of residing close to a coal-fuelled
power station. Up to 93% of the respondents in the study had health concerns including air quality, water quality and respiratory issues. The 1997 Katsouyanni paper details the short term effects of sulphur dioxide and particulate matter resultant from coal-fuelled power stations as a factor to mortality rates in humans. The data was assessed over 12 European cities from the APHEA project (Air Pollution and Health: a European Approach) study. The report concluded that “an increase of 50 \text{ug/m}^3 \text{ in sulphur dioxide or black smoke was associated with a } 3\% (95\% \text{ confidence interval } 2\% \text{ to } 4\%) \text{ increase in daily mortality and the corresponding figure for PM10 was } 2\% (1\% \text{ to } 3\%). \text{ In central eastern European cities the increase in mortality associated with a } 50 \text{ fig/m}^3 \text{ change in sulphur dioxide was } 0.8\% (-0.1\% \text{ to } 2.4\%) \text{ and in black smoke } 0.6\% (0.1\% \text{ to } 1.1\%). \text{ Cumulative effects of prolonged (two to four days) exposure to air pollutants resulted in estimates comparable with the one day effects. The effects of both pollutants were stronger during the summer and were mutually independent” [46]. Thus, even short term exposure to sulphur dioxide and other particulates from the combustion of coal increases the mortality rates in the population by up to 4\%. While there is an alternative technology such as wind or solar thermal, with no particulates or sulphur dioxides resultant from their operation, a 4\% mortality rate is simply an unacceptable statistic.
6. Conclusion

Therefore there are many factors to consider when analysing the impact of changing from coal-fuelled power stations to renewable technology. Financially, the move is a viable proposition for Australia’s economy. The Net Present Value (NPV) for solar thermal was $26,061,592,811; a positive amount indicating a good investment proposition; and a reasonable Levelised Cost of Electricity (LCOE) of $3,683.37 p.a. Solar thermal also offered a relatively high Internal Rate of Return (IRR) of 12.1%, as well as a short Simple Payback Period (SPP) of 7.4 years. The NPV for solar photovoltaic was $43,686,592,811 making it an economically viable proposition; and a LCOE of $6,174.37 p.a. Solar PV also offered a high IRR of 20.7%, as well as a short SPP of 4.7 years. The NPV for wind was $122,850,329,916, making it a highly economically viable proposition, and a LCOE of $8,681.42. Wind also offered a high IRR of 50.1% and an extremely short SPP of 2.0 years [19]. The recommendation of this report is for the installation of the renewable technologies in the ratios of 50%, 25% and 25% for wind, solar thermal and PV respectively. The macroeconomic indicators are also promising for Australia’s economy. The creation of 318,563 net jobs is a major boost for the domestic economy, as well as the increase of $24,591,152,220 p.a. to the GDP. Clearly, the financial and economic indicators show a positive return for the Australian economy with a switch from coal-fuelled power generation to completely renewable technologies. The switch would create net employment, add to the GDP, and have a net positive NPV, indicative of a financially viable investment for the Australian economy.

The environmental consequences of mining coal are well documented and clear. Land degradation, water contamination, land subsidence, spontaneous combustion of coal are but a few consequences of coal mining activities. Then there are the GHG’s released with the combustion of coal in the electricity production; the carbon dioxide (49,008,260t annually), sulphur dioxide, mercury and other particulates. They contribute to; global warming, acid rain, and an increase of human mortality of up to 4% as a result of health and respiratory problems associated with these noxious gases [46].

The political standing of the current form of RET is the increase by 2020 to 33,000 GWh of renewable technology into the energy mix. This would increase
Australia’s proportion of the current 13.47% to 23.5% renewable proportion of total energy supply [49]. The LRET has inherent inequality of wealth distribution problems associated with its current form and will need to be addressed.

Thus, the financial/economic, environmental/health and political aspects of a switch from coal-fuelled power stations to renewable technology have been assessed. The recommendation of this report is that it is in the financial, economic, environmental, national health and political interests of the country to make the switch as soon as possible. Delay is not in the best interests to the country or its citizens. There is scope for further quantitative analysis under this topic to ascertain the most suitable geographic locations for the plants proposed; areas with high wind resources for that technology and areas with high solar radiation for solar thermal and PV applications. There is also scope for further qualitative analysis using primary sources of information as to the sociological impacts to the population with the introduction of renewable energy. That is, telephone surveys and questionnaires to determine the level of acceptance amongst the population regarding the change.
7. References


[25] ABS cat. no. 8155.0, Australian Industry (various issues)

[26] ABS cat. no. 5204.0, Australian System of National Accounts


[36] Peter Jelínek • Marian Marschalko • David Lamich • Is¸ık Yilmaz • Petra Zasteˇrova´ • Martin Bedna´rik • Silvie Hevia´nkova´ • Miroslav Kyncl • Maria´n Drusa • Hana Ru°cˇkova, Monitoring and analysis of burning in coal tailing dumps: a case study from the Czech Republic, Environ Earth Sci (2015) 73:6601–6612


Accessed 15/06/2016
[56] RenewablesSA, South Australian Government.  
Accessed 15/06/2016.
Appendix 1

The world’s largest manufacturer of wind generators, Vestas, has production facilities in Denmark, Germany, India, Italy and Scotland. On 31 December 2002 it had a total of 6,182 employees, although it did not specify how many of these were part-time. In year 2002 Vestas and its associated company installed 1,640 MW of capacity.

Although there are serious shortcomings and large gaps in the data, an attempt is made in Table 7 to compare job-years/TWh for coal-fired electricity and wind power in Australia. In constructing the table we draw upon the Danish and other European studies as well as upon MacGill et al. (2002). We also distinguish between global jobs and Australian jobs.

Table 7: Comparison of employment in coal and wind electricity (job-years/TWh).

a. COAL

<table>
<thead>
<tr>
<th>Method &amp; data source</th>
<th>Manufacture &amp; installation</th>
<th>Fuel operation &amp; maintenence</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Australian electricity industry without coal (ABS)</td>
<td></td>
<td></td>
<td>53</td>
</tr>
<tr>
<td>2. Australian coal industry (ABS &amp; Productivity Comm.) These jobs must be added to those in Row 1.</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>3. Australian electricity generators (from annual reports). These jobs should be included in those in Row 1.</td>
<td></td>
<td>12-21</td>
<td></td>
</tr>
<tr>
<td>4. Tarong North power station, includes some indirect jobs, Aust. content 26%, Aust. jobs only. (MacGill et. al. 2003)</td>
<td>7 (Aust. only)</td>
<td>42</td>
<td>49</td>
</tr>
</tbody>
</table>

b. WIND

<table>
<thead>
<tr>
<th>Method &amp; data source</th>
<th>Manufacture &amp; installation</th>
<th>Fuel operation &amp; maintenence</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Extrapolation from Danish data to global direct+indirect global jobs. (EWEA: <a href="http://www.eawe.org">www.eawe.org</a>)</td>
<td></td>
<td></td>
<td>418</td>
</tr>
<tr>
<td>6. Vestas, direct jobs only in countries where it has production facilities (<a href="http://www.vestas.com">www.vestas.com</a>)</td>
<td>59 (direct only)</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>7. Albany wind farm, includes some indirect jobs, Aust. content 44%, Australian jobs only (MacGill et. al. 2003)</td>
<td>65 (Australia only)</td>
<td>52</td>
<td>117</td>
</tr>
<tr>
<td>8. ditto with hypothetical Aust. content 80%, Australian jobs only</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Diesendörfer (2004)

21 In 2003 Vestas opened a components manufacturing plant in Wynyard, Tasmania and in 2004 the Victorian Energy Minister announced that another wind turbine manufacturer would open a factory in rural Victoria. With the Federal Government’s refusal to expand MRET, some of the new Victorian jobs and a proposed expansion of the Wynyard factory are now on hold.
Appendix 2

Material omitted for copyright.

[33]
## Appendix 3

Table 1: Power Stations and Emissions Intensity (2008-2009)

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Power Station</th>
<th>State</th>
<th>Emissions (million tonnes CO2e)$^2$</th>
<th>Generation (MWh)$^3$</th>
<th>Generation/ emissions change 2009-2008 (%)</th>
<th>Emissions intensity (CO2e/ MWh)$^4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Loy Yang A</td>
<td>VIC</td>
<td>18.81</td>
<td>17,071,000</td>
<td>1.0</td>
<td>1.10</td>
</tr>
<tr>
<td>2</td>
<td>Hazelwood</td>
<td>VIC</td>
<td>16.25</td>
<td>11,862,000</td>
<td>3.4</td>
<td>1.17</td>
</tr>
<tr>
<td>3</td>
<td>Yallourn W</td>
<td>VIC</td>
<td>15.00</td>
<td>11,620,000</td>
<td>2.6</td>
<td>1.20</td>
</tr>
<tr>
<td>4</td>
<td>Bayswater</td>
<td>NSW</td>
<td>14.92</td>
<td>16,298,000</td>
<td>1.2</td>
<td>0.92</td>
</tr>
<tr>
<td>5</td>
<td>Eraring</td>
<td>NSW</td>
<td>13.96</td>
<td>15,223,000</td>
<td>-3.8</td>
<td>0.92</td>
</tr>
<tr>
<td>6</td>
<td>Liddell</td>
<td>NSW</td>
<td>10.65</td>
<td>16,552,000</td>
<td>-13.3</td>
<td>1.01</td>
</tr>
<tr>
<td>7</td>
<td>Loy Yang B</td>
<td>VIC</td>
<td>9.80</td>
<td>8,353,000</td>
<td>-3.5</td>
<td>1.15</td>
</tr>
<tr>
<td>8</td>
<td>Vales Point B</td>
<td>NSW</td>
<td>8.01</td>
<td>8,339,000</td>
<td>-8.1</td>
<td>0.94</td>
</tr>
<tr>
<td>9</td>
<td>Stanwell</td>
<td>QLD</td>
<td>7.44</td>
<td>5,806,000</td>
<td>3.9</td>
<td>0.84</td>
</tr>
<tr>
<td>10</td>
<td>Mt Piper</td>
<td>NSW</td>
<td>7.19</td>
<td>8,367,000</td>
<td>-13.6</td>
<td>0.87</td>
</tr>
</tbody>
</table>

**Note:**
1. CO2e refers to carbon dioxide emissions
2. MWh refers to megawatt-hour of produced electricity
3. CO2e/MWh is defined as the ratio of tonnes of carbon dioxide emissions per megawatt-hour of produced electricity.