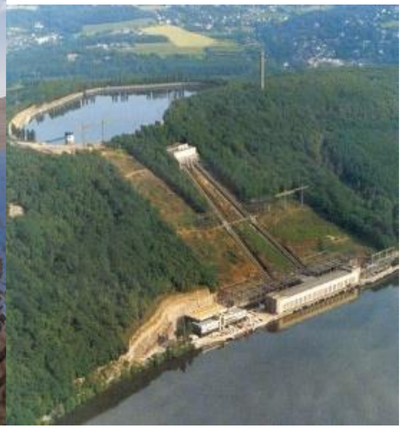
The Renewable Energy Revolution

Making it happen in the Sunshine State

Submission on behalf of Sustainable Queensland Forum

www.sustainablequeensland.info

Author: Trevor Berrill

Sustainable Energy Systems Consultant

www.trevolution.com.au

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Acronyms

ACF – Australian Conservation Foundation

AEMO – Australian Energy Market Operator

ALP – Australian Labor Party

ASC – Australian Solar Council

ATA – Alternative Technology Association

BZE – Beyond Zero Emissions

CEC – Clean Energy Council

DEEDI – Department of Employment, Economic Development and Innovation

DERM – Department of Environment and Resource Management

DEWS – Department of Energy and Water Supply

DIP – Department of Infrastructure and Planning

DIRD – Department of Infrastructure and Regional Development

EE – Energy Efficiency

EROEI – Energy Return on Energy Invested

ESQ – Energy Skills Queensland

EV – Electric Vehicle

FTE – Full-time Equivalent Jobs

GBR – Great Barrier Reef

IEA – International Energy Agency

IMF – International Monetary Fund

LNP – Liberal National Party

QEPP – Queensland Environmental Protection Policy

RE – Renewable Energy

RMI – Rocky Mountain Institute

Executive Summary

Queensland needs a very different energy fuel mix to the current one. This is urgently needed to address the global warming challenge facing the world community, as well as other emissions and costs from our fossil fuel use (Rockstrom et al, 2009). This is even more necessary given the failure of Federal Government policy in recent years to address global warming.

This submission aims to assist policy development for a rapid transition to renewable energy (RE) and energy efficiency (EE), whilst establishing an alternative economic base to coal and gas mining. As Beyond Zero Emissions' comprehensive technical reports demonstrate, Australia has the opportunity to be a global clean energy super power (BZE, 2016).

The focus of this submission is on electricity generation, since this is the largest contributor to all emissions from fossil fuels. However, **other sectors such as transport, mining and agriculture need to be carefully considered in order to transition all sectors to renewable energy and energy efficiency. Hence this submission to the Queensland Renewable Energy Expert Panel Issues Paper is written in this larger context**, as a 50 percent renewable energy target is only part of what is required to transition our energy use away from fossil fuels.

With regard to achieving the State Government's goal of a 50 percent of electricity generation from RE by 2030, the following key policies recommended in this submission are:

1. A renewable energy portfolio approach should be taken to support a mix of RE generating technologies, to provide a reliable, resilient and cost effective solution to a longer term goal of 100 percent RE generation across Australia. One such possible mix of RE generators is given in this submission. This approach is necessary due to:
    a. The inability of the market to solve complex societal problems such as global warming. Market failure in the energy sector is discussed in detail below.
    b. The urgency of the need to address global warming and preferably keep global temperature rise to less than 1.5 degrees Celsius.
    c. The need to diversify the energy mix to increase reliability and resilience to extreme disruptive events such as weather extremes or terrorism, whilst minimising energy storage losses and costs. This also assists with capturing synergies between variable RE sources where they exist.
    d. The need to assist less cost effective technologies such as solar thermal electric (STE) (also called concentrating solar power systems or CSP) with thermal storage to be scaled up and costs reduced. This is because such systems can provide high capacity factors and dispatchable power.
2. The RE portfolio should be underpinned with modelling to identify the optimum mix of RE generators and energy storage across the Queensland electricity network, as undertaken by groups such as University of New South Wales (Elliston, 2013 & 2014) and Beyond Zero Emissions (Wright & Hearps, 2010).
3. Implement reverse auctions within the RE portfolio sectors to provide competition and reduce costs within sectors.
4. Provide a feed-in tariff (FIT) rate for small roof-top photovoltaic (PV) systems (maximum of 30kVA inverter rating), on homes and small business, equivalent to the day time retail electricity rate (approximately 20 to 25 cents/kilowatt-hour). Such a one for one FIT rate

provides clarity to PV system owners and simplifies customer metering and billing, and more fully reflects the true value of solar PV (Maine Public Utilities Commission, 2015).

5. Provide incentives for energy storage, both large and small scale, that are structured to reduce the incentive level progressively over say 10 years. This provides planning certainty to industry and helps reduce storage installation costs rapidly as industry learns the requirements of best practice.
6. Introduce smart gross metering on all homes and businesses to facilitate the expansion of the smart, distributed grid to ensure that both energy generation from embedded generators and energy consumption can be fully metered.
7. Develop a suite of complementary policy measures to implement energy efficiency, in conjunction with the National Energy Productivity Plan.
8. Upgrade current industry training to incentivise a best practice approach rather than just meeting minimum standards. Even these are not met in far too many cases at present. This is essential to ensuring safety and long life and good performance from energy systems. This should be supported with ongoing random system inspections to ensure compliance with codes and standards.

Globally, an energy transition to renewable energy and energy efficiency is already happening in many countries. Queenslanders strongly support these technologies and Government policy should reflect the people's wishes. Whilst recent State Government commitments to renewable energy are to be applauded, Queensland lags behind most other States in the uptake of renewable energy (CEC, 2014:9), particularly large scale systems, and energy efficiency.

Submission Structure

This submission follows on from two previous policy papers presented by Sustainable Queensland to the Department of Energy and Water System during 2015. These include a policy paper (Berrill, Jul 2015) which discussed the political, economic, environmental and social reasons why government should strongly support renewable energy and energy efficiency. It reported on the current status of and barriers to renewable energy contributing to electricity generation in the State. Finally, it outlined a range of supportive policy initiatives. These initiatives are represented here and some are expanded upon in this submission.

The second paper(Berrill, Dec 2015) outlined one possible scenario of the scale of a mix of renewable energy generators required to meet State Government's stated target of 50 percent renewable energy electricity generation by 2030. It gave estimates of the required investment and jobs created. Parts of both these papers are reproduced here, partly or in full.

The first sections outline the current contribution of renewable energy to electricity consumption in the State, the scale of RE generation, investment and employment to achieve a 50 percent RE target, and summarise reasons to support renewable energy.

The later sections identify and discuss important barriers and issues that need to be addressed and policy options that should be considered to achieve a transition to a renewable energy powered and energy efficient society.

Guiding Principles of Sustainable Energy Policy

Key elements to a sustainable energy policy that guide this policy paper are:

- Acceptance of global warming science and the need for action via targets and other initiatives.
- The need for very low or no polluting emissions from energy supply technologies to address all emissions and costs from fossil fuel use.
- The need for highly efficient energy conversion to minimise waste.
- Provision of a reliable and resilient energy supply.
- Maximise the safety of workers and the community.
- Provision of affordable energy cost to the end-user.
- Promotion of regional development through diversification of income streams.
- Users pay a fair share of their energy costs and impacts.
- Responsibility for the global commons.

These key principles are expanded upon in previous work by this author (Berrill, 2012)

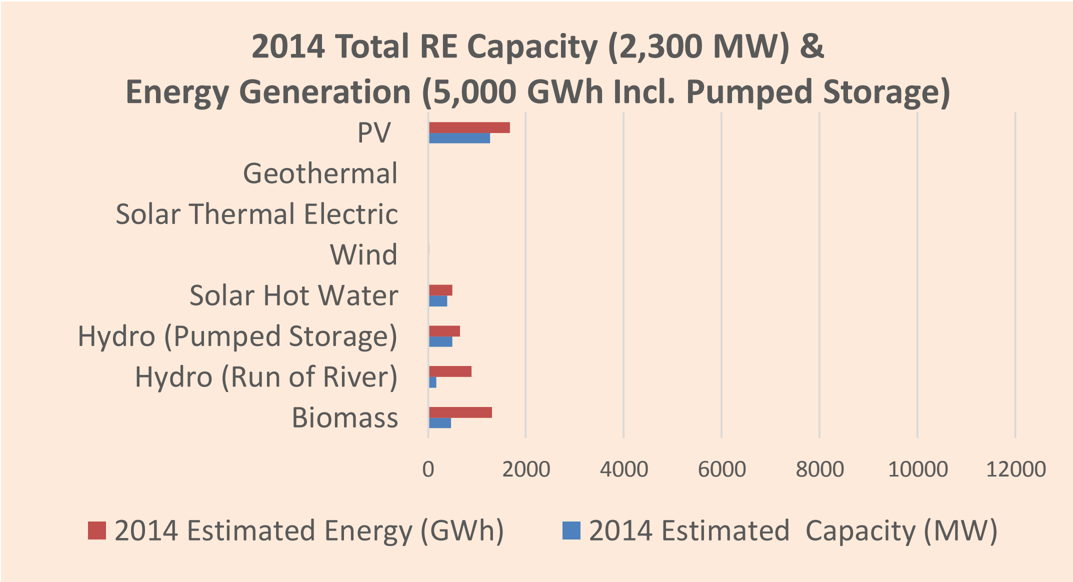
Energy Systems in Transition – Where we are at and what's required

This section outlines the current status of renewable energy to the Queensland electricity system in 2014 and projects the potential generation capacity required by 2030 for one mix of RE technologies. It uses AEMO projections of energy consumption growth. From 2008 to 2014, RE contribution of electricity consumption in Queensland grew from 6 to 9.5 percent, including the reduction in consumption due to solar water heating (Berrill, Jul 2015 - see appendix 2 for details). This is equivalent to an annual growth rate of 8 percent.

It is important to calculate distributed RE generation as a proportion of consumption, not generation. This best reflects the contribution of RE to final end-use consumption that is required, before the final end-use conversion to the energy service we need - light, heat, sound, motion etc. This is because RE is in the main generated close to the consumption point, minimising transmission losses. This is one reason why transmission losses are lower than in the past in Queensland. The difference between generation and consumption is WASTED energy, which should always be avoided.

Figure 1a shows the author's estimate of the contribution of RE to electricity consumption in Queensland in 2014. This analysis includes the contribution of solar water heating to reducing electricity consumption as this is a major contributor and often overlooked. Figure 1a clearly shows the important contribution from renewables that solar PV is now making to total electricity consumption.

Figure 1a – RE Capacity (MW) and Energy Generation (GWh) in 2014



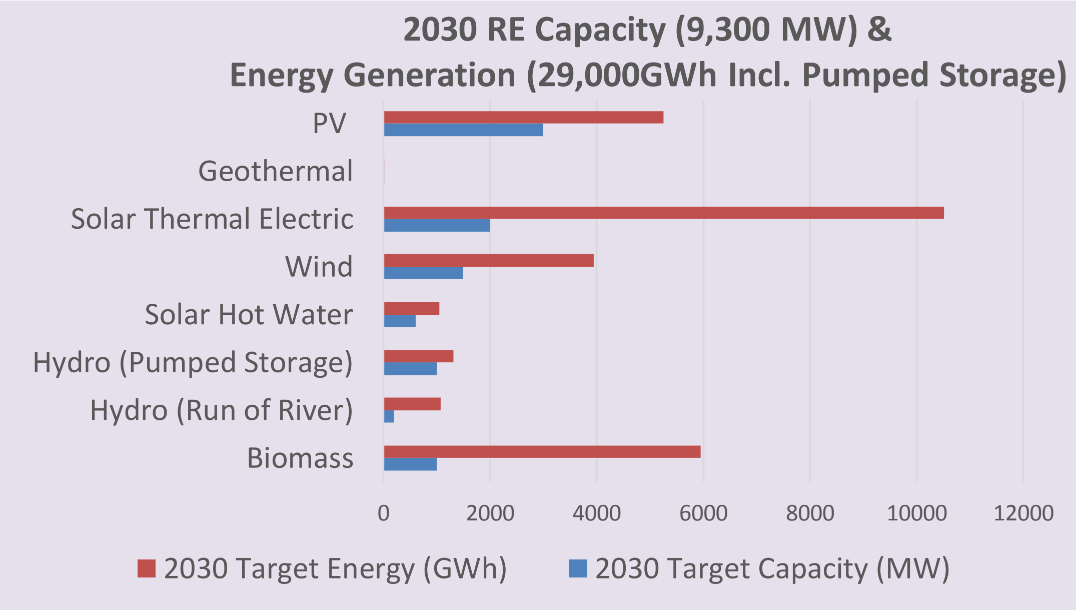
Analysis in the author's December 2015 energy transition paper showed that, to achieve the government's 50 percent RE target by 2030, **Queensland needs about 9300 MW of RE capacity. When combined with very modest energy efficiency measures to reduce the projected growth in energy consumption (AEMO, 2015), this RE portfolio would provide an estimated 50 percent of projected electrical energy consumption by 2030, or about 29,000GWh.** This could be made up of a diversified portfolio of technologies such as:

- 1000MW of biomass plant (currently 464MW)
- 200MW hydro plant (run of river)(currently 167MW)
- 1000MW hydro (pumped storage)(currently 500MW)
- 600MW solar hot water equivalent (currently 397MW)
- 1500MW wind farms (currently 12MW)
- 2000MW solar thermal electric (STE) plant (currently zero)
- 3000MW solar PV both small and medium-sized rooftop and on-ground power stations (currently about 1300MW)

Figure 1b shows the rated maximum capacity (MW) and projected energy generation (GWh/yr) from this mix of RE generators. The mix is based on the historical generation from biomass and hydro in Queensland, and the author's estimates for what are the most likely technologies to play a role in Queensland given political, economic and social and environment factors. Solar thermal electric (STE - also called concentrating solar thermal power (CSP)) is included due to the high capacity factor available when molten salt thermal storage is included. This gives it an advantage over solar PV for dispatchable power. Full details are given in appendix 2.

This projection shows a similar RE capacity (MW) but lower generation (GWh) to that forecast by ACIL Allen report (QPC, 2016). This is largely because ACIL Allen figures are based on estimates of energy sent out by 6300 MW of additional large scale wind farms, but no details of assumed capacity factors or transmission losses are given.

Figure 1b – RE Capacity (MW) and Energy Generation (GWh) required by 2030



A diversity of renewable energy technologies is essential to:

- Provide a more resilient and reliable system,
- Achieve synergies or complementarities between demand and generation where they occur,
- Maximise capacity factors and energy return on energy invested ratios (EROEI)
- Minimise energy storage losses and costs.

The optimal mix of renewable energies for electricity generation and supportive long term policy measures need to be guided by modelling of the electricity network as performed by UNSW (Elliston et al, 2013 & 2014).

Employment and Investment

What level of investment and jobs could result from this scenario? Using CEC and IEA reports, it is estimated that such a RE portfolio would involve between **about $10 and $19 billion of direct investment**, depending on final installed costs due to falling STE, PV and storage costs (See appendix 3 for assumptions and references). Using data from an extensive study of RE job creation in the USA, and a Queensland Government report (Wei et al, 2010; ESQ, 2011), I calculate over 18,000 direct and indirect full-time equivalent job years (FTE - a standard unit of employment measurement) by 2030, increasing from about 4000 FTEs in 2014. This is a very conservative estimate as it allows for job losses in other parts of the economy, as workers transfer across to renewables, which may or may not occur. Most industry estimates are higher.

Why Renewable Energy and Energy Efficiency are Important

There are important political, economic, environmental and social reasons why Queensland should put in place policies that strongly support the adoption of renewable energy and energy efficiency. These are summarised below. Full details with references are given in Berrill, July, 2015.

Political Reasons

- **The public overwhelmingly support the uptake and use of renewable energy and energy efficiency** as shown by survey after survey over decades.
- **A clean energy future is now a significant political issue** at both State and Federal levels, with public support firmly behind RE and EE, not coal or gas.
- **The threat to the Great Barrier Reef from climate change** and other impacts is likely to play an increasing role in public support for RE.

Economic Reasons

Renewable energy provides:

- **Cheaper energy –** The levelised cost of RE generation have continued to fall, making RE by and large cheaper than new coal or gas plant. As well, more capacity is being installed and more money is now being invested in renewables than in coal, oil and gas power generation. This is despite low oil prices and fossil fuels receiving 4 times the subsidy dollars globally than renewables (REN21, 2016).
- **Longer term energy price certainty** as the fuel cost is free and the infrastructure costs continue to decrease.
- **Job creation and associated skills –** it is more labour intensive per unit of delivered energy than the fossil fuel industry.
- **Economic / regional diversification** away from reliance on fossil fuels - helps avoid boom and bust cycles, could diversify income streams for farms, and replaces job losses in fossil fuels as many construction jobs are transferable.
- **Households and businesses can greatly reduce and secure their cost of electricity** by on site RE generation and energy efficiency.
- **Increased resilience** of the electricity system against extreme weather or acts of terrorism via a distributed, intelligent (or smart) grid and energy storage.
- **Opportunities for the development of innovative products/services** and resulting in new market opportunities in both RE and EE.
- **Opportunities to build energy self-sufficient new suburbia or villages** in regional areas without upgrades to transmission and distribution systems.

Energy Efficiency consists of three components:

1. **More efficient technology** which has a lower operational and life cycle energy consumption.
2. **Demand side management** where energy use is shifted from peak to off-peak periods to reduce peak demand and associated infrastructure costs.
3. **Behavioural change** to improve energy management practices.

These measures provide:

- **Ongoing reduction in energy costs** for businesses and households.
- **Reductions in the need for new construction or delays in upgrades** to power generation, transmission and distribution systems.
- **Job creation and skills training** for energy auditors/managers, product development, manufacturer, sales, distribution and installation/maintenance staff.
- **Opportunities for the development of innovative** products/services and resulting new market opportunities.

Environmental Reasons

- **Queenslanders have one of the highest environmental footprints per capita in the world**, including greenhouse gas emission.
- **Renewable energy, combined with energy efficiency, is now the cleanest and cheapest** energy option.

Social Reasons

- **Communities are less likely to suffer social and economic disruption** with a decentralised distributed generation system as this provides a more resilient electricity supply, protecting against extreme weather events and terrorism threats.
- **Renewable energy such** as wind and solar PV farms can **assist regional development** by providing additional long term jobs and revenue for cash-strapped primary producers and rural communities.
- **Home owners and businesses can reduce energy costs** and take greater personal responsibility for **pollution reduction** from fossil fuels.
- **The jobs created are long term jobs** that are not subject to mining boom/bust cycles. This provides for stability in jobs, families and society generally and hence increased social cohesion.

Key Barriers and Issues to a Clean Energy Future

There are a number of key barriers and that need to be addressed and issues to consider before a clean and efficient energy future can be achieved. These are outlined below.

Barriers

Barriers include:

Market Failure

There has been and continues to be on-going market failure in the energy sector for many years through:

The avoidance of paying external costs of fossil fuels over their life. For full details, see the Sustainable Queensland Energy Policy paper attached. These range from $19/Megawatt-hour (gas), $40/MWh (black coal) (Australian report by Biegler, 2009) to as high as $200/MWh (coal) based on the comprehensive Harvard University study in the USA (Epstein et al, 2011). The Biegler study is a very conservative estimate and the cost in Australia is likely to be between $40 and $200/MWh for coal. This is because many environmental costs such as mine rehabilitation are predicted to be billions of dollars across the State (Main & Schwartz, 2015) as there are over 15,000 abandoned mine sites (of all types) across Queensland (See map in appendix 1). Ultimately, economics can't put a full price on preventing the deterioration of our natural wonders such as the Great Barrier Reef and the Wet Tropics due to global warming and other pollution. University of Queensland economist, Professor John Quiggin, in reviewing the International Monetary Fund's (IMF) report estimating $5.3 trilllion of subsidies to fossil fuels in 2015 (Coady, 2015:6), suggested that the Australian Government is in denial about these sobering external costs. He states that "the costs of burning fossil fuels outweigh the benefits in many cases" (Quiggin, May, 2015).

State Government subsidies to the fossil fuel industry. Subsides to the fossil fuel industry includes monies for port development, rail, road and electricity transmission infrastructure development that directly benefit the fossil fuel industry. Both my own research (Berrill, 2012) in reviewing 5 years of State budget papers and similar work by The Australia Institute (Peel, 2014) show that Queensland Governments have been contributing about $1 to 2 billion annually to this industry. Similar subsidies have happened in New South Wales (Climate & Health Alliance, 2015). The Federal Government also provides subsidies to the fossil fuel industry. The Grattan Institute (Wood et al, 2012:12) and an Australian Conservation Foundation report (ACF, 2011) state that these subsidies range between about $8 and $12 billion annually, well in excess of that spent on renewable energy or energy efficiency, as shown by Riedy's review in 2007 (Riedy, 2007).

These factors contribute to market distortions as mature industries should not require subsidies. These distortions are well recognised by the International Energy Agency (IEA) and the IMF and the Queensland externalities and subsidies are discussed in the Sustainable Queensland energy policy paper (Berrill, 2015). These subsidies produce the following negative impacts:

- Distort markets and create barriers to clean energy investment
- Encourage wasteful consumption
- Increase CO_2 emissions and exacerbate local pollution
- Discourage investment in (clean) energy infrastructure

Cross-subsidies are another form of market failure and contribute to wasteful energy use (measured in Gigawatt-hours) and peak demand (measured in MVA). Air conditioning is particularly problematic and has contributed greatly to peak demand and costs across the network (EY, 2015:11). Previous estimates have put the cost to upgrade the network at between $10,000 and $13,000 per kilowatt of air conditioning. This cost is subsidised by the 25 percent of homes that don't need, choose not to have or can't afford air conditioning.

There is also substantial cross subsidising of the commercial and industrial sectors by the residential sector. This is because electricity tariff costs to both commercial and industrial users have historically been lower than residential users, even though each sector consumes about 30 percent of total electricity generation (GWh).

Metering

The issues paper has correctly identified the advantages and disadvantages of different metering options. There is a need for smart metering on all customers and gross smart metering is the preferred option. This is because:

- Smart meters monitor average half-hourly power consumption and allow determination of the load profile (Power VS Time) of individual homes and businesses. This facilitates full cost reflective pricing and peak demand management. This should be mandatory.
- Gross smart metering (separate meter for PV output and consumer load) allows for:
    - Full performance assessment of PV system output – this could be done via the inverter energy meter as most inverters log power / energy output. This allows Government to use performance assessment rather than deem the output of PV systems. It gives feedback to PV owners regarding the performance of their systems.
    - Measurement of the energy use (kWh) and peak power demand (MVA) within residences or businesses allows full assessment of energy efficiency measures. This allows Government to measure the benefit of energy efficiency policy. It gives feedback to home and business owners regarding the benefits of energy efficiency.

The current net metering using a single 'dumb' meter with import and export registers is a low cost compromise that:

- Does not allow full measurement of demand with residences or businesses and so can't fully measure energy efficiency savings.
- Only measures the exported part of PV energy generation and so doesn't show that part that is supplied direct to home or business appliances.

Reforming the Electricity Industry

The current revenue model of the electricity industry provides little incentive for the distribution companies to support variable (non-dispatchable) renewables such as wind and solar without storage. This is because distributors' costs and revenue are dominated by peak demand (MVA) and hence demand charges ($/MW), rather than sales of units of energy ($/kilowatt-hours). The distribution companies however do benefit from:

a. Renewables with energy storage, both large and small scale, as it allows shifting of renewable energy to peak periods and hence peak demand (MVA) reduction,
b. Energy efficiency measures as these measures generally reduce peak demand also.

Transitioning to an Energy Services Model based around a Smart Distributed Grid

A fundamental problem is that the current electricity supply model is outdated, being based around large centralised generators, remotely located near coal mines, supplying all energy use via long transmission/distribution systems to end users. It continues to encourage growth in electricity consumption as it generates its income via sales of units of electricity, and in some sectors by demand changes. Historically, it tried to forecast consumption (GWh) and demand (MVA) growth over long time periods, and build large centralised plant to meet both consumption and peak demand. Long term planning by these projections led to large step increases in generation capacity (e.g. 1500MW). This has invariably led to both over-supply (too much generation capacity) and over-building of the transmission and distribution network, via over-estimates of peak demand. This planning method mostly ignored the impact of energy efficiency and embedded generation such as solar PV. As we have seen over the past 5 years across the NEM, these growth predictions were completely wrong.

This is an unsustainable model that is rapidly being replaced by a new model, the smart (or intelligent) distributed grid model. As CSIRO has pointed out in its Intelligent Grid program, the new model is cheaper, helps maximise efficient use of energy and minimise emissions, and is more resilient to extremes in weather or terrorist attacks. In this model, embedded, modular, variable scale generators can be added rapidly to follow the long term trend in electricity demand.

The Rocky Mountain Institute has long promoted the alternative utility model, the Energy Services Model. This is where energy utilities change their focus from sales of units of energy to the supply the energy services we need (light, sound, heat, coolth etc.) at the least cost (including environmental cost). It has been stated many times that it is not gigawatt-hours that we need but the service the energy provides. This model also assists to decouple energy use and emissions from gross domestic product growth. This is essential if we are to address the global warming crisis. This is the approach that the most forward looking countries such as Germany are now adopting. Germany's energy transition program aims to halve all primary energy use by 2050 and supply 80 percent of electricity from renewable energy. It is well on the path, already generating 30 percent of electricity from renewables.

Over-investment in Fossil Fuels

The State Government has invested about $1 to $2 billion each year in assistance to the fossil fuel industry over the past 6 years or so. These investments are effectively subsidies. Government subsidies are designed to help emerging industries that Governments see as needing assistance to establish and grow, to achieve societal goals, or have been temporarily impacted by events beyond their control. In the past, extreme weather events have been one example. **Subsidies that support mature, profitable industries are perverse as they distort markets.** Note that there is no agreed upon definition of fossil fuel subsidies by the G20 group of countries (EIA, 2011; IMF, 2013).

It is now recognised that this huge investment by the State Governmentthat is very likely to lead to 'stranded assetts' if climate change is to be addressed in accordance with the urgency of the science and the allowable global carbon budget (Caldecott, 2014). However, there has been a commitment by the State Government to continue to expand coal and gas mining, including the Gallilee Basin and more recently oil and gas in the Cooper Creek Basin. Funding these projects assumes a healthy, long term, return on investment. Royalties are often stated by the Queensland Minerals Council to be part of this return. This mis-represents the purpose of royalties. Furthermore, the Adani project has been extensively reviewed now via the recent court action by the Environmental Defenders Organisation. It have been found to be making vastly inflated claims to government about employment opportunities and financial returns to the State Government (Quiggin, April, 2015).

Key Issues

Other key issues include:

Security of Energy Supply

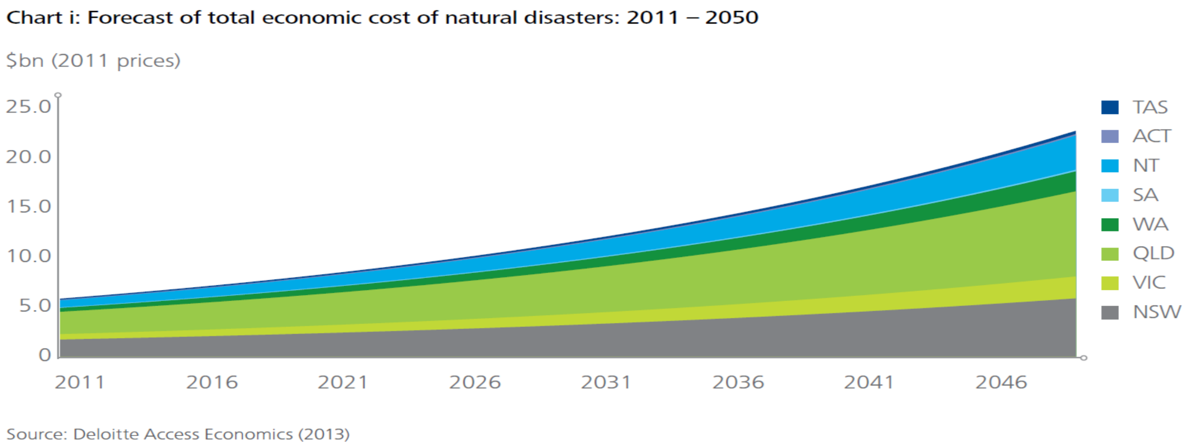
Energy supply security is key to a functioning society. Climate change is contributing to instability in the Middle East including Syria, and Asia. Also there is conflict over oil reserves in the South China See. This in turn threatens our oil supply. *Automotive gasoline, for example, is sourced entirely from Singapore (52 per cent), Taiwan (27 per cent) and Korea (21 per cent) while 67 per cent of Australia's petroleum imports must transit through the waters of the Indonesian archipelago* (Medcalf & Brown, 2014). As a result, Australia spends many millions of dollars each year on maintaining a military presence in both Asia and the Middle East. The rapid development of a renewable energy based electricity system combined with a shift to electric transport is now possible and happening. It would contribute to avoiding the need for military expenditure in defending our access to oil.

Disaster Relief Cost Growth

Disaster relief costs due to extreme weather event impacts are increasing. Disaster relief costs in Australia were about $6.3 billion in 2011 and are expected to grow at about 3.5 percent per annum (Deloitte Access Economics, 2013). This is in line with climate science predicting for decades more extreme weather events. Communities can be made more resilient to extreme weather events through distributed generation and hence renewables have a key role to play in reducing societal costs due to these extremes.

Figure 2 -Projected Disaster Economic Cost ($billions/yr)

Source: Deloitte Economics, 2013

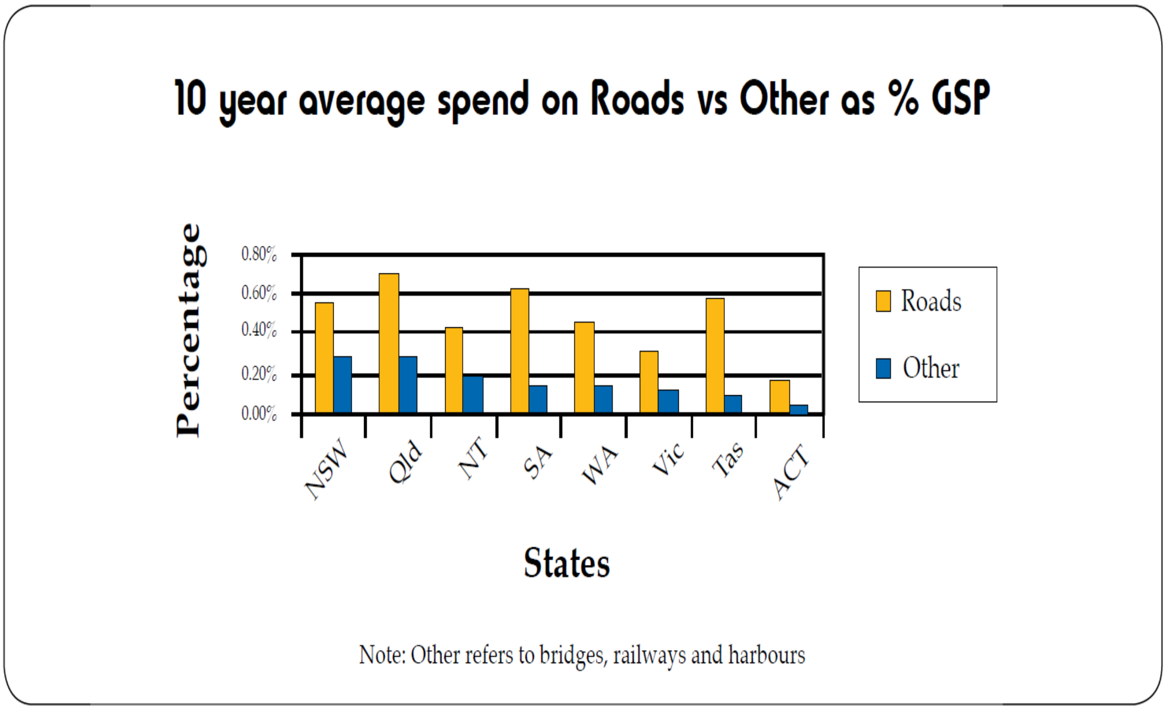


Transitioning Other Sectors

If we are serious about transitioning to a clean energy future, government needs to give much more attention to transport and especially the impact on transport demand of urban planning. Current urban planning models are still predominantly locking people into car use, with spending on roads exceeding other transport modes for example by about 2.5 to 1 (See figure 3). This comes largely at the expense of public transport and has the effect of generating more road traffic, not less. While improvements have been made, Brisbane and other Queensland regional centres have relatively poor public transport systems by international standards. There is also a need for greatly improved facilities for walking and cycling. Without these improvements, there will be continuing needless energy use and social costs. Congestion costs alone resulting from reduced energy efficiency are estimated at $15 billion each year across Australian capital cities (DIRD, 2014:10).

Figure 3 – State Expenditure on Roads versus Other Transport

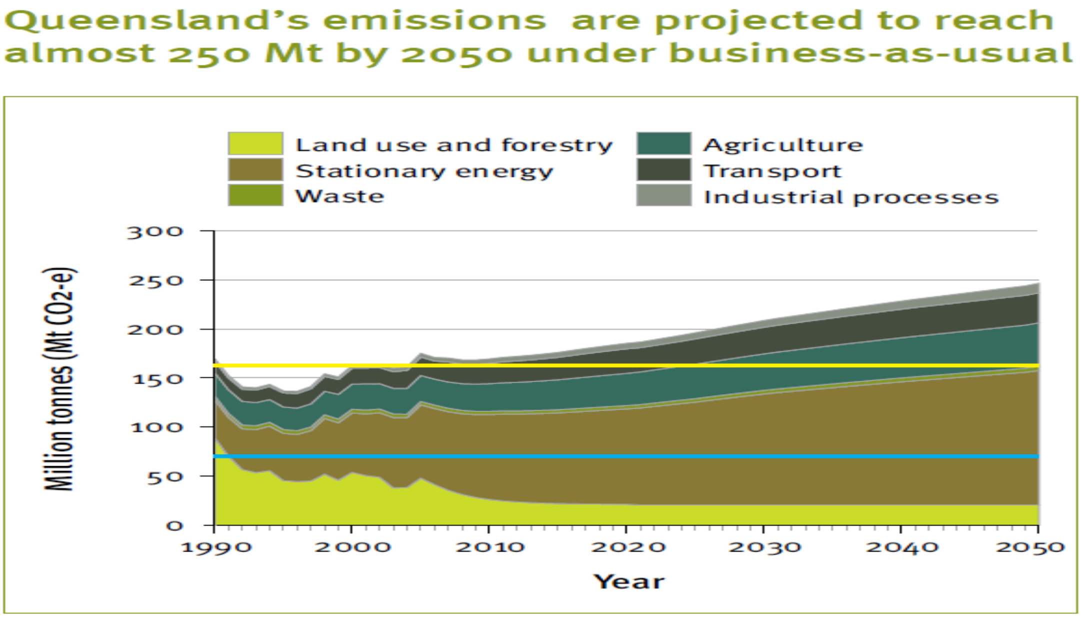
Source: ACF, 2011:5



Source: ABS (2010) Engineering Construction Activity from Catalogue 8762.0 including Electronic Tables 13, 16, 19, 22, 28, 31, 34

Figure 4 - Queensland's CO_2 Emissions Projection under Business as Usual

Source: DERM, 2009, Chp.3:20



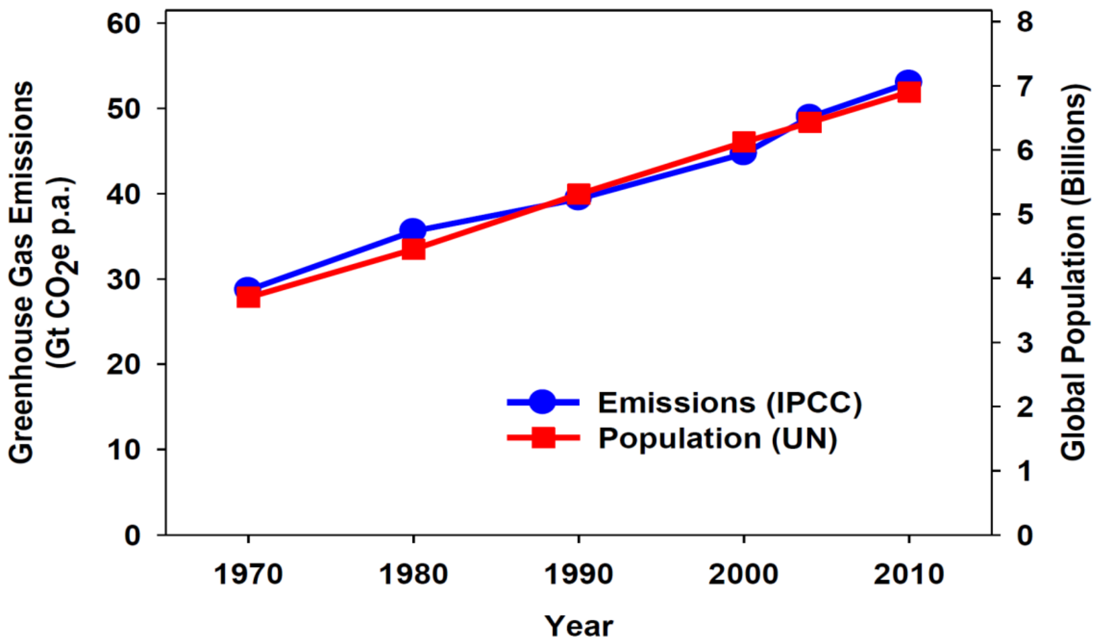
Population Growth, Energy Consumption and Emissions

The task of reducing energy use and associated emissions is dramatically impacted by a rate of population growth. Queensland's population growth rate of about 2 percent for the past 15 years (DIP, 2009) is more like that of a poor Third World country than a modern economy (World Bank, 2015), although it has slowed recently to about 1.5 percent (Queensland Economy Watch, 2015). As well, Queensland Governments have for many years encouraged a strong inter-State migration. Land released for housing is used inefficiently, with Australia having the dubious honour of the largest houses now on average in the world (ABC, 2011). This is at a time when the average household consists of about two and a half people.

Some governments embrace population growth under the belief that it is good for the economy. The evidence for that is very weak (Cocks, 1996; O'Conner & Lines, 2008, O'Sullivan, 2014:7), but the evidence that it increases energy use and associated emissions is very strong (O'Sullivan, 2013:5). The current population growth rate makes the 2030 target much more difficult to achieve, as energy consumption then would be about 30% greater than today on a business-as-usual trajectory.

Figure 5 - Historical Relationship of Population Growth, Energy Consumption and Emissions

Source: O'Sullivan, 2013:5 (data from IPCC and UN Population Division).



Energy Consumption re Processing/Transporting Fossil Fuels

There is a large and increasing energy demand for exploration, mining, storage, transporting and processing fossil fuels for export, particularly liquefaction. There is very little local benefit from this energy consumption but very large global negative impacts. The impacts of our fossil fuel use include global scale air, land and water pollution (Rockstrom et al, 2009). Nowhere is this more evident than in the massive scale of particulate pollution now over Asia, or from oil spills such as in the Gulf of Mexico, or Brisbane's air pollution, exacerbated by temperature inversions.

Figure 6a – Air Pollution over China and Yellow Sea from Space (Left), Gulf of Mexico Oil Spill from Space (Right). Source: Wikipedia & Google Images

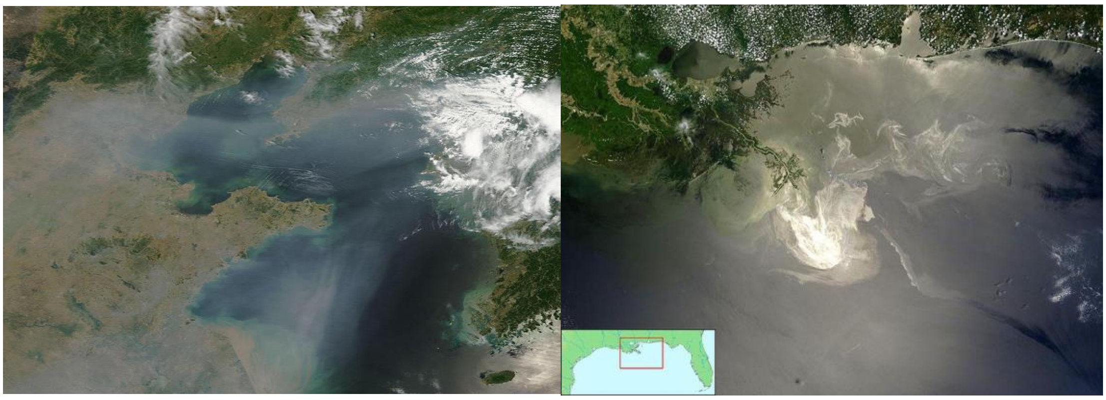


Figure 6b – Air Pollution over Brisbane

© Ian Bridge

Is CSG the Transition Fuel?

Coal seam gas is promoted as a "cleaner" fossil fuel and therefore as a transition fuel to renewables. Firstly, gas generation is now more costly than large scale wind, hydro and some biomass (Bloomberg, 2013; REN21, 2016). More recently, large solar PV in particular, and concentrating solar thermal power levelized costs are starting to out-compete gas generation. Secondly, many countries/regions/cities renewable energy transition plans do not involve a shift to gas generation first and then renewables. As Beyond Zero Emissions have pointed out, this is misdirection of funding to address global warming in the ever decreasing time frame required as there are now sufficient mature renewable energy technologies available to transition to a mix of renewable energies combined with energy efficiency (BZE, 2015:VII). Thirdly, there is now growing evidence that coal seam gas's life cycle GHG emissions may be much higher than commonly suggested and in some cases may be no better than coal (Howarth, 2010; Tollefson, 2012). Research by Wigley from the US National Centre for Atmospheric Research and reported by Pears (2012) suggests:

> "The gas industry has promoted shifting to gas as the panacea to cut greenhouse gas emissions. A recent study by climate specialist Tom Wigley has challenged this……………….…There are actually two independent factors at work in Wigley's study. First, there is the effect of a reduction in coal use, which cuts emissions of CO_2 and methane leakage from coal mines, reducing warming. But it also reduces air pollutants such as oxides

> of sulphur and carbon particulates, which reduces their short-term cooling effects. Wigley's paper suggests this loss of cooling will offset most of the reduction in warming from cutting coal use until mid-century, when the long-term effect of reducing CO_2 begins to swamp the air pollution effect."
>
> "Unconventional gas emissions up to seventy times worse than industry claims - immediate moratorium a must - Real time air sampling of gas fields in the US has shown leakage rates of up to over seventy times greater than the rates assumed by industry and accepted by government in Australia. The study by the US National Oceanic and Atmospheric Administration (NOAA) and the University of Colorado, has found rates of fugitive emissions up to 7.7%, with a mean of 4%." (BZE, 2012)

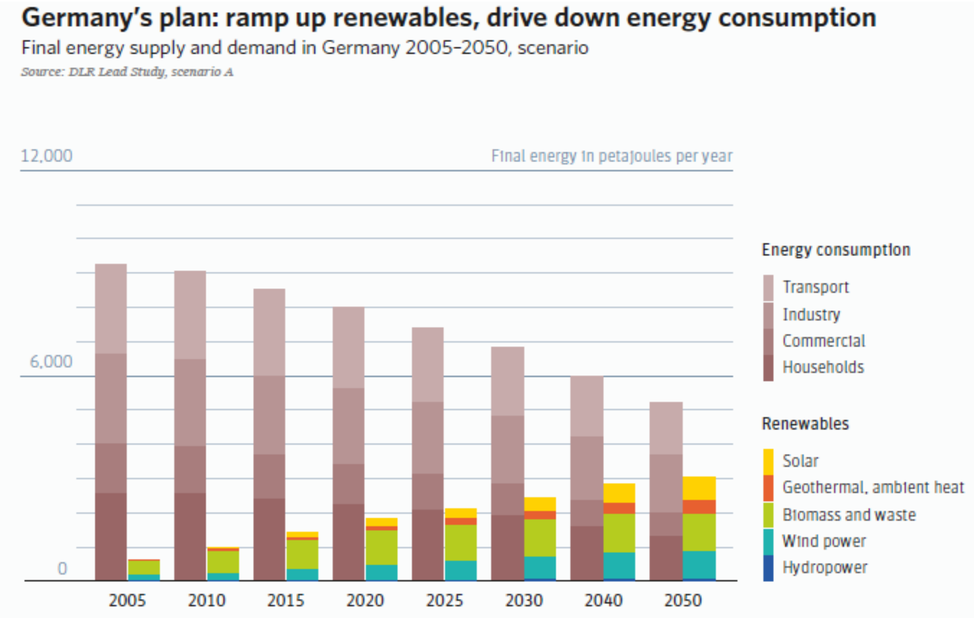
Finally, Queensland Government GHG emission estimates shown in the "ClimateQ: toward a greener Queensland" (DERM: 2009:Chp. 10, p.82) show fugitive GHG emissions becoming an increasingly larger proportion of total energy sector emissions when projected out to 2050 under business as usual, from the current estimate of 6 percent. This is a major concern as much of these fugitive emissions are methane, which is a much stronger GHG than CO_2. If the studies by Howarth, (2010) and Tollefson (2012) are indicative of fugitive emissions from CSG mining, then our "cleaner" gas industry may lose that image and sales quickly.

Achieving Energy Efficiency

There have been many starts and stops over the years in Australian government support for improving energy efficiency. It has been very similar to the boom/bust cycles imposed on the renewable energy industry. There has been a lack of coordination and consistency between State programs and this has resulted in poorer policy outcomes in some cases. In other cases, programs were poorly implemented. The incorrectly named 'pink batts' policy fiasco is one example. While achieving some worthwhile energy savings in many homes, it was hastily implemented and resulted in the death of some workers. This then brought about the shut-down of the scheme, rather than it being improved with higher quality training and appropriate safety measures. Australia now finally has a nationally energy productivity plan (COAG, 2015).

By comparison, many countries have implemented energy efficiency plans and use far less energy per capita than Australia. Denmark and Germany are two examples, using about half that of Australia (World Bank, 2015). Yet Germany has a goal to further reduce all energy consumption by a further 50 percent by 2050 (Morris, 2015). Australia has much more low hanging fruit to harvest through efficiency gains. Setting an energy efficiency target (GWh reduction), in conjunction with a demand target (MVA reduction) will make the task of achieving a 50 percent renewables target by 2030 easier.

Figure 7 - Germany Transition (Source: Morris, 2014 & 2015)



Transitioning to Renewable Energy and Energy Efficiency – What we need to do to get there.

The following points outline recommended policy directions that the State Government should consider in the following areas:

Planning and Targets

- **Clean Energy Office** - Establish a new Office of Clean Energy or similar department, dedicated to developing and delivering the "Renewable Energy and Energy Efficiency Transition Strategy". This office should report directly to the Premier.
- **Renewable Energy and Energy Efficiency Plans** – A RE plan is under development but it is crucial to address the waste of energy in the Queensland economy via an energy efficiency plan.
- **Carbon Budgeting** – Design energy and emissions policy around the carbon budget approach, that identifies the ''burnable proportion" of remaining fossil fuels to keep global temperature rise to no more than 1.5 degrees Celsius rise (Steffen et al, 2015).
- **Targets for Renewable Energy and Energy Efficiency** - **The Government's target of 50 percent renewable energy electricity generation by 2030 is an appropriate target. Note however that it should be consider a minimum target. In addition, an energy efficiency target for the reduction in electricity consumption and transport energy use should be set.** Ensure there are suitable measurement and reporting systems. These targets should be consistent with the carbon budget approach. These combined targets should aim to reduce CO_2 emissions by at least 50 percent below 2000 levels by 2030. That would place Queensland in line with the CO_2 emissions targets suggest by the Climate Change Authority (CCA, 2014:9).

- **Industry Consultation** – Continue to consult with both the renewable energy and energy efficiency sectors to identify barriers, policy solutions and targets. This should include the Australian Solar Council, the Clean Energy Council, the Australian PV Institute, the Alternative Technology Association, Solar Citizens, the Energy Efficiency Council and associated local businesses.
- **Scenario Analysis** – Undertake hourly simulation modelling of the operation of the Queensland electricity system with 100 percent renewable energy electricity system, based on the work of the University of New South Wales (See appendix 5 for more information re Elliston et al, 2013 & 2014). This process helps to inform policy with regard to the best mix of renewable energy technologies that, in combination, can provide a reliable and affordable electricity generation system.
- **Energy Return on Energy Invested Ratio (EROEI)** – Select, whenever possible, those renewable energy technologies that give the highest EROEI ratio. This ensures the highest potential net energy generation is delivered from renewable energy and therefore displaces fossil fuel use more rapidly (See Berrill, 2012:23-27).
- **Energy Portfolio Approach** – There is a mix of RE technologies that are likely, when combined, to provide for an optimised sustainable energy system in Queensland. This is because:
    - A mix of RE technologies assist with achieving complementarity/synergies across RE generators, assist with matching supply and demand, and minimising storage requirements and costs. Examples include:
        - the wind does blow at night when the sun doesn't,
        - solar generation increases during times of drought when run of river hydro and biomass production are reduced, and vice versa,
        - maximum potential generation and availability of solar/wind/hydro resources shift location with time of year as the passage of southern ocean high pressure systems change the latitude of their passage from west to east across the Australian continent.
    - There is within the RE sector competing technologies and vested interests regionally. Established industries often wish to protect their market share. For example, the sugar industry recently protested against PV farm proposal on sugar cane production areas in northern Queensland (Robertson, 2015). This highlights the necessity to prioritise strategic cropping land.
    - A diversified and distributed/embedded energy system structure increases resiliency and reliability of the overall energy supply system, particularly during extreme events or acts of terrorism.

Hence, it is recommended that a RE portfolio approach be taken to support the RE generation technologies outlined in the RE scenario presented in this paper, as these are the most likely contenders to provide the required mix of RE generation.

Incentivising and Financing

- **Incentivise Projects and Remove Barriers** - Provide policy settings that incentivise the adoption of existing commercially available renewable energy and energy efficiency and remove barriers. This may include streamlining the application process for larger scale renewable energy projects connecting to the grid, and examining leasehold land legislation (See www.renewablessa.sa.gov.au/.../110628-guide-to-proposed-changes.pdf).

  For example, wind farm development has been hindered in Queensland. Key recommendations made to the wind farm codes review recently were:
    - Increase the noise limits to be in line with noise limits for wind farms in other States and to be consistent with QEPP noise requirements for other industry.
    - Increase the noise measurement distance from buildings/facades to 5 metres as per AS4959.
    - Decrease the set-back distance to 1000 metres maximum or less, depending on noise level assessments. Hence the distance may vary around different sides of the wind farm, depending of the prevailing wind directions and distance to adjoining sensitive land uses.

- **Financing Projects** – Help provide appropriate access to finance by working closely with the Clean Energy Finance Corporation (CEFC). This includes both renewable energy and energy efficiency projects. See http://www.cleanenergyfinancecorp.com.au/what-we-do.aspx. If the CEFC is shut down by the LNP Federal Government, then establish similar State based programs to those currently run by the CEFC.
- **Power Purchase Agreements and Tariffs** - Establish fair power purchase agreements and tariffs for the export of renewable energy fed into the electricity network. These tariffs should reflect fully the benefits to society and the network of distributed renewable energy generators (See appendix 4 for PV example). An important sector to consider here is the medium size commercial PV installations that have the potential to significantly reduce peak demand (MVA) during summer heat waves on local networks and aggregated demand (MVA) across the whole network. This is because solar output better matches the demand profile during these extreme weather events.
- **Feed-in Tariffs Roof-top PV** - It is recommended that a feed-in tariff rate equivalent to the daytime retail price be paid to PV generators, particularly for those that can generate power to offset daytime energy demand such as air conditioning or refrigeration demand (See appendix 4 for more detailed analysis).
- **Large Scale Renewables via Reverse Auction –** Reverse auctions are an excellent tool to facilitate the uptake of larger scale renewables. The State Government’s suggested 60MW reverse auction proposal is welcomed, but is very small capacity (MW) by world standards. Stronger targets should be set. As coal and gas plants are retired and if energy consumption (GWh) increases again, then much larger reverse auctions will be required.

- **Innovation and Threats to Business as Usual –** There are a range of innovative emerging technologies, that are rapidly developing and reducing in cost, and are already impacting on the current business model for electricity generation and sales. These include roof-top solar PV, energy management technologies, on-site energy storage and electric vehicles. Energy policy should embrace the adoption of these new technologies as there are clear environmental, economic and social benefits.
- **Incentivising the Distribution Companies to support Renewables –** Identify and implement strategies to incentivise Ergon and Energex to support distributed renewable energy electricity generation and storage, and energy efficiency technologies.
- **Energy Storage** - Implement measures to encourage the uptake of energy storage technology to facilitate integration of renewables to displace fossil fuels. This should recognise the benefits energy storage brings to network peak demand management, and ensures fuller utilisation of renewable energy. Energy storage can be both small and larger scale. An example of small scale storage is the Tesla energy storage "Power Wall" product recently released, which is set to make local storage for solar PV affordable (http://www.teslamotors.com/powerwall). An example of large scale storage is the potential use of pumped hydro-electric storage along the Great Dividing Range of Eastern Australia as outlined by ANU researchers (Blakers et al, 2010; 2014). Note that research by Elliston et al (2013; 2014), modelling a mix of renewable energy electricity generators, examines the extent of energy storage required for 100 percent renewable energy electricity with a diversified, distributed electricity system.
- **Electric Vehicles** – Implement policies to support the uptake of electric vehicles, particularly for urban use as electric vehicles can become a source of energy storage for renewables and assist network peak demand management. This could be done via charging stations at home, work or shopping centres. It should operate on a voluntary basis where the car owner could nominate a maximum amount energy they are happy to have discharged from their car battery. They could receive a discounted rate at the charging station for the amount of energy (kWh) purchased over the charging/discharging time.
- **R&D** – Provide incentives for research and development projects by working closely with the Australian Renewable Energy Agency (ARENA). If the ARENA is shut down by the LNP Federal Government, then establish similar State based programs to those currently run by the ARENA.

Reinforcing Existing Polices

- **Electricity Market Reform** – Work with the Federal Government and AEMO to incentivise energy generators/retailers to shift to the ***energy services model*** **(RMI, 2011)**, rather than the outdated energy sales model, and to reward retailers and distributors for implementing energy efficiency and on-site RE generation and storage.
- **Regional Development** – Promote regional development through the use of renewable energy farming or energy storage (such as pumped hydro-electric storage) on marginal soil areas to complement traditional food production on good quality soil. This diversifies the farmers' income and improves resilience during weather extremes such as droughts. As wind and solar energy farming would still have to complete against low cost energy from old coal generators at $30 to $50 per Megawatt-hour (MWh), the

currently higher cost of solar and wind farming could be funded, at least partly, from monies usually provided to farming communities after extreme weather events, and by redirecting subsidised funding away from the profitable coal and gas mining industries. Furthermore, the State Government has recently allocated $200 million over 2 years to support regional development programs. Such monies could be directed to renewable energy and energy efficiency projects in regional areas.

- **Sustainable Buildings** - Establish ***best practice*** sustainable buildings policies, for both new and retrofitted buildings. These should assist the uptake of solar PV, solar hot water and energy efficiency and management systems, as well as energy storage. Best practice helps to raise the bar above minimum standards and encourages innovation.
- **Social Housing** – Establish programs for low income home owners or renters to access solar PV, solar hot water systems and energy efficient technologies in their homes. Examine the South Australian government's three-way contracting model as a possible model.
- **Government procurement polices** – Introduce government renewable energy and energy efficiency procurement plans for both State and Local Government.
- **Local Government** – Facilitate Local Governments' role in assisting a renewable energy transition. This could include ***community owned renewable energy*** systems on public buildings, and energy efficiency education and implementation programs.
- **Education and Training –** Provide one stop shops for consumer information and ensure **current training programs meet the needs of the rapidly changing energy industries**, both on the demand and supply sides. The focus of training should be on **best practice delivery**, not just competency to meet minimum standards or guidelines. This means it is necessary to incentivise, monitor, report on and improve policies that support best practice training programs. As well system installation quality needs to be monitored over time via random inspections to ensure best practice is the new norm, not minimum standards. **In my own work, in development and delivery of RE training over more than 30 years, and more recently in assessing PV installations, shows that there is still a lot of poorly installed PV systems with potential problems occurring much earlier in their life than should be the case. This means that the true generation capacity of the technology over its life is not being achieved.**

Removing Subsidies and Exemptions

- **Remove subsidies, including infrastructure expenditure, to the fossil fuel industry** and redirect these monies to the development and deployment of renewable energy and energy efficiency technologies.
- **Moratorium on New Fossil Fuel Power Stations** - Put in place a moratorium on the building of new coal fired and gas power stations unless they are fuelled by renewable energy sources such as biomass.
- **Exemptions for Large Industry and Projects -** Remove the exemption for major industries and ''significant projects" from the purchase of gas powered or renewable energy electricity. Note that a threshold consumption of 750GWh per year applies to these industries or projects.

Retiring Aged Fossil Fuel Generators

- There is currently an oversupply of peak capacity in Queensland. This is a partial barrier to the uptake of renewable energy. There is about 2332 MW capacity of fossil fuel generators about 40 years old or more, that could be retired to facilitate the uptake of renewables. This includes Callide A (coal), Gladstone (coal), Mackay (gas) and Swanbank B (gas) generators. A timeframe should be set to commence decommissioning this plant (Queensland Government Business and Industry Portal, 2015).

Appendix 1 - External Costs of Coal-Fired Electricity over Life Cycle

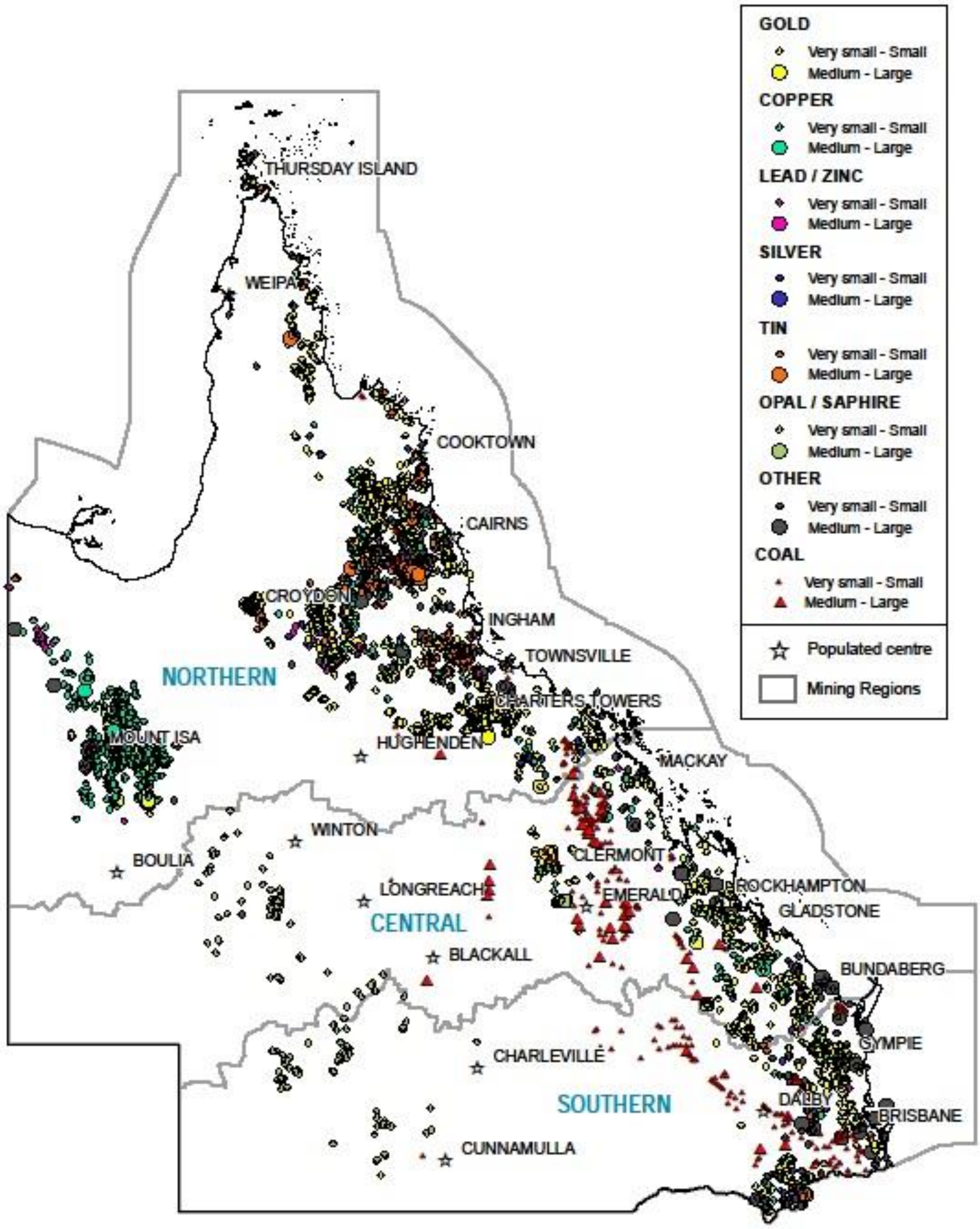
Mean values from Study by Epstein, P. et al (2011). Full cost accounting for the life cycle of coal. Published in Annals of the New York Academy of Science: Ecological Economics Reviews

Table 1 – Breakdown of External Costs

Life Cycle	Externalities	External Cost (c/kWh) US
Mining	Subsidies – electricity/water/fuel rebates Reduced Prop. Values Displacement of other industries / Jobs / long term earnings – Agriculture/Tourism Econ. Boom/bust cycle of commodities Mortalities/Morbidity workers / community Trauma surrounding communities Accidents and Fatalities – workers/ transport /subsidence Hospitalisation costs Heavy metals and contaminated land / rivers /estuaries / GBR Loss of habitat and species Air pollution Acid mine drainage Methane emissions Rehabilitation and monitoring	4.4
Transportation - 70% of rail traffic is for Coal (USA)	Subsidies Rail and road repairs Accidents and Fatalities Hospitalisation costs GHG emissions Air pollution Vegetation damage	0.09
Combustion	Mortality/Morbidity Hospitalisation costs GHG emissions Other Air pollutants (NOx, mercury, arsenic, selenium , Ozone and particulates) Infrastructure deterioration – acid rain Rail and road repairs Water and Marine pollution Soil contamination, coal ash and other wastes Freshwater use	12.7
Abandoned Mines and Waste Disposal	Heavy metal health impacts – contamination, trauma following spills, tailing dam failure	0.44
Transmission	Energy losses Ecosystem disturbance Vulnerability of grid to climate change events	0.01

Figure 8 - Abandoned Mine Sites in Queensland – An example of a very significant external cost that is not fully included in current mining costs.

Source: https://www.dnrm.qld.gov.au/__data/assets/pdf_file/0003/262659/abandoned-mines-map.pdf



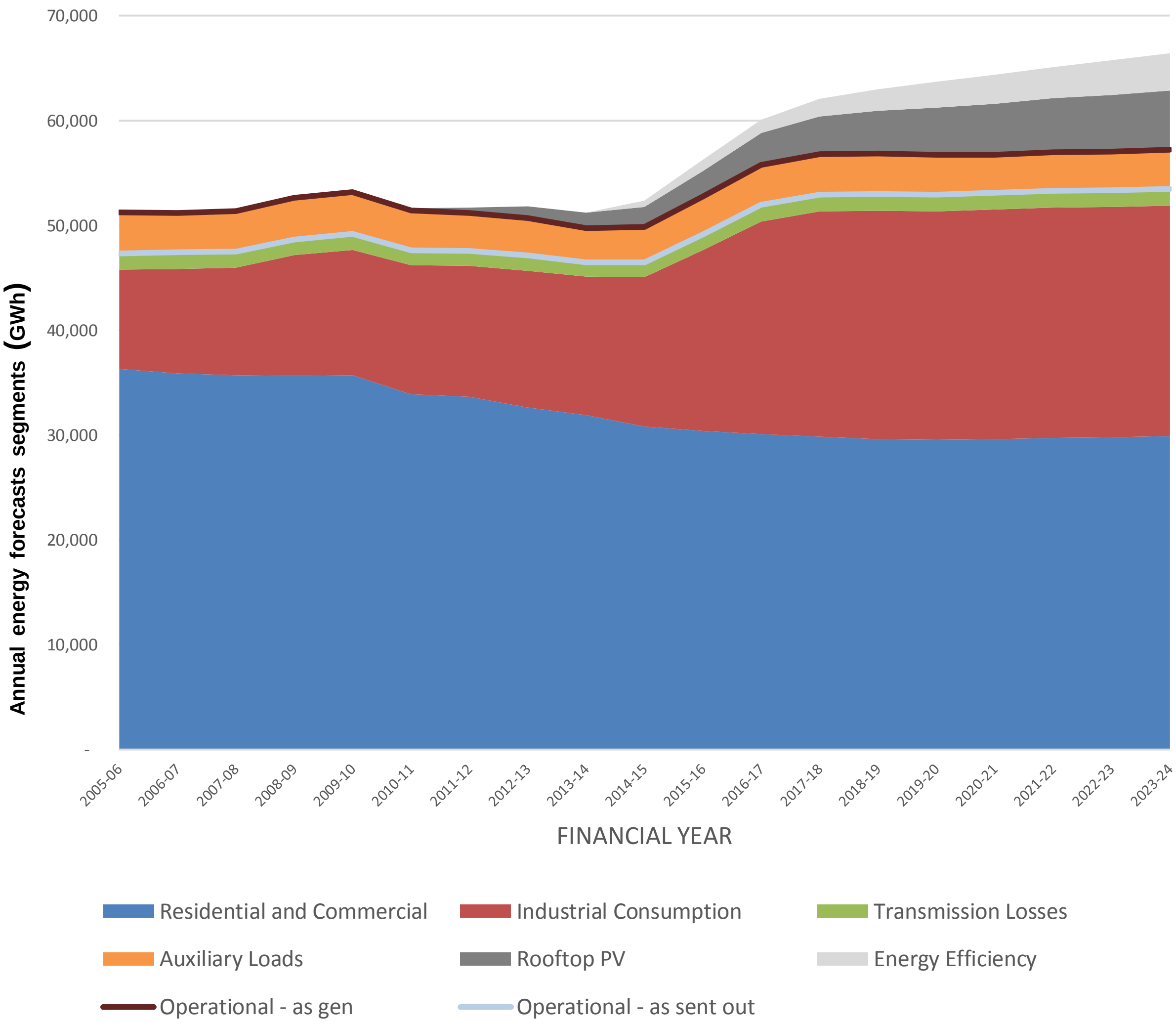
Appendix 2 – RE Generation Queensland 2014

Figure 9 below shows Australian Energy Market Operator past and projected electricity generation and consumption for Queensland as follows:

- Electricity Consumption (top of red/blue segments = sum of industrial, commercial and residential sectors)
- Transmission losses and Auxiliary Loads
- Rooftop PV (from 2011/12) and Energy Efficiency (from 2013/14 only)
- Operational Energy Generated (Note: this includes large RE generators such as sugar mills, hydro-electric plant and a wind farm)
- Operational Energy Sent Out (Generated Energy less Auxiliary Loads)

Figure 9 – Projected Queensland Electricity Consumption and Generation

Source: AEMO, 2015



Queensland electricity consumption was 46,422 Gigawatt-hours in 2013/14 as shown in figure 10, with 28 percent for industrial use, 69 percent for residential and commercial use and about 3 percent for transmissions losses.

Figure 10 – Queensland Electricity Consumption by Industry Sector 2013/14

Source: AEMO, 2015

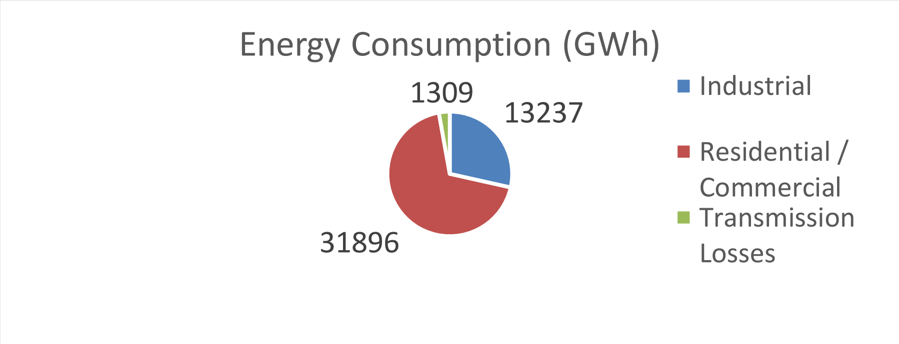


Table 2 shows the estimated installed capacity (MW) and energy production (GWh) from renewable energy generators in 2014.

Table 2 – Comparison of Renewable Energy Installed Capacity (MW) and Generation (GWh) in Queensland.

Technology	2009 QREP 2008 Capacity (MW)	2008 Estimated Energy (GWh)	2012 QREP 2011 Capacity (MW)	2011 Estimated Energy (GWh)	2014 Estimated Capacity (MW)	2014 Estimated Energy (GWh)
Biomass	415	1818	407	1783	464	1301
Hydro	169	740	167	731	167	895
Solar Hot Water	144	252	295	517	397	493
Wind	12	32	12	32	12	30
Solar Thermal Electric	0	0	0	0	0	0
Geothermal	0.08	0.60	0.08	0.60	0.12	0.89
PV	6	11	355	622	1267	1676
	MW	**GWh**	**MW**	**GWh**	**MW**	**GWh**
Renewable Energy Totals Capacity and Generation	**746**	**2853**	**1236**	**3685**	**2307**	**4395**
Energy Efficiency and Demand Management	>1	NA	>4.7	NA	>246	NA
Qld. Electricity Consumption from AEMO	**2007/08**	**47514**	**2010/11**	**47621**	**2013/14**	**46442**
Renewable Energy as a Percentage of Consumption (%)		**6.0**		**7.7**		**9.5**

Notes:

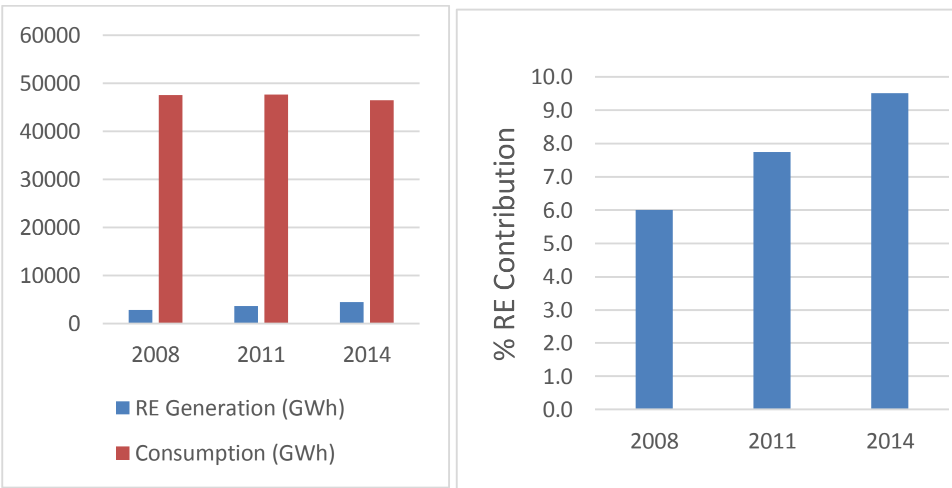
Data for 2008 and 2011 are from Queensland Renewable Energy Plans 2009 and revised 2012 (DEEDI, 2009 & 2012) as estimated by Berrill, 2012..

Data for energy production for 2014 are from:

- R. Brazzale (http://greenmarkets.com.au/resources/review-of-the-nem-in-2014 and GEM Estimates based on LGC creation and baselines.
- Clean Energy Council 2014 annual report.
- For solar water heating, system numbers are estimated from CEC 2014 report at about 238,000 systems. The capacity (MW) is calculated as equivalent to this number of 1.67kWp PV systems. This equates to the savings from electric hot water systems using 7kWh/day, by solar water heaters with a solar fraction of 0.81 (Australian Standard 3500.4) I.e. (238000 x 7kWh x 0.81 x 365days)/ 1,000,000 = 493GWh
- Consumption data is from Australian Energy Market Operator: National Electricity Forecasting Report 2014 - Summary Spreadsheet (AEMO, 2015).
- Demand management and energy efficiency programs by both Ergon and Energex have quantified demand savings (MVA) but have not measured or estimated fully energy savings (GWh).

Figure 11 shows the estimated contribution of renewable energy to electricity consumption for 2008, 2011 and 2014.

Figure 11 – Renewable Energy Generation Contribution to Consumption, including solar hot water.



Some important observations are:

On the Consumption Side

1. Commercial and residential consumption (GWh) does not include that part of roof-top solar PV that is supplied directly to the loads within a home or commercial premises and does not pass through utility meters. This results in an underestimate of final energy consumption within premises. Hence energy efficiency savings are not fully metered. This results from the use of net metering of roof-top PV systems via import/export meters. It can be rectified with gross metering using two separate meters (one for the load, one for PV output). Note that PV output is already metered via the inverter energy meter.

2. Australian electricity consumption (GWh) has been reducing since about 2009/10 due to a combination of roof-top solar PV, energy efficiency and reduced consumption from some large industry shutting down.
3. The Queensland consumption decline is consistent with the national trend although it is predicted by the AEMO to increase again sharply from 2015/16. This is based on predictions of proposed large industrial applications such as LNG processing coming on line soon. The AEMO has consistently overestimated growth in electricity demand in recent years and has been criticised for this (Rio Tinto, 2014).
4. Transmission losses are very low. This is in part due to local on-site generation from roof-top solar PV and energy efficiency measures, both of which reduce the need to transmit electricity over long distances.
5. Energy efficiency and demand (MVA) management programs have been in place for many years but measurement and reporting of the energy saving (GWh) seems very poor. For example, both Energex and Ergon have demand management programs in place (Energex, 2014; Ergon, 2014) and report regularly to the Australian Energy Regulator. Both these 2014 reports quantify the demand savings (E.g. 246 MVA reduction between 2010 and 2015) **but not all the energy savings (GWh) as a result of peak demand savings, or other efficiency measures**. As stated in point 1 above, net metering does not capture and record energy savings in homes and businesses. Separate gross metering of the loads and PV output is required.
6. Policies such as sustainable housing policy for homes, minimum energy performance standards for appliances, and the Greenstar commercial buildings rating system contribute significantly to reducing both energy and peak demand, but reliable data outlining the extent of savings are not available for Queensland.
7. There are some very large industrial users of electricity in Queensland. In particular, the mining and mineral processing industries currently consume more that 15 percent of electricity demand. This is expected to increase with LNG processing. This group wish to see electricity prices reduced. They argue this is necessary to maintain their international competitiveness (Rio Tinto, 2014).

On the Supply Side

1. Renewable energy (RE) generation (GWh) as a percentage of consumption has increased from about 6 percent in 2008 to almost 10 percent in 2014, include savings from solar hot water systems.
2. Most of the increase in RE capacity is from roof-top solar. No large scale (>30MW) solar PV or wind farms were approved and built.
3. If electricity demand begins to increase as forecast by the AEMO, then a higher growth rate in the adoption of renewable energy and energy efficiency will most likely be required to meet any targets such as for renewable energy and greenhouse gas emission reductions.

How does Queensland compare to other States?

Figure 12 below shows the 2013 electrical energy generation from fossil fuels and renewable energy (in Gigawatt-hours) for each State.

Figure 12 – Comparison of Renewable Energy Generation by State

Source: Clean Energy Council, 2014 report, p. 9

PENETRATION OF RENEWABLE ENERGY - BY STATE

State	Total generation (GWh)[7]	Fossil fuel generation (GWh)	Renewable generation (GWh)	Penetration of renewables
SA	11,933	7115	4817	40%
WA	18,425	16,082	2343	13%
VIC	53,203	48,037	5166	10%
TAS	11,004	584	10,420	95%
NSW	60,594	57,226	3368	6%
QLD[8]	57,683	53,797	3885	7%

Notes: Renewable energy generation calculated above is a percent of total generation, as opposed to total consumption used in table 1, and does not include solar hot water savings in electricity consumption, which is included in table 1.

There are some significant differences between Queensland and other States. These include:

- Queensland has the lowest percentage of renewable energy generation of all the States in 2013/14, except New South Wales.
- South Australia is a shining example of where strong policy support for renewable energy has resulted in 40 percent of electricity generation now coming from renewable energy.
- Most of the growth in RE capacity in Queensland has been via small rooftop solar PV and solar hot water systems.
- While significant large scale project proposals for wind and solar farms were proposed in Queensland, including several hundred Megawatts of wind farming and 1.5Gigawatts of solar PV farming, the only large scale systems that were built were cogeneration systems using bagasse at sugar mills. Hence there exists a huge potential to build large scale solar and wind energy systems across the State as identified in the previous Labor Government's Renewable Energy Plan.

Appendix 3 – Employment Creation and Investment by 2030

Table 3 – Employment and Investment for a 50% RE Target by 2030

Technology	Current Jobs 2014 (FTEs)	Additional Jobs (FTEs)	Additional Investment ($mill.)	$mill. per MW
Biomass	520	1862	1608	3.00
Hydro (Run of River)	260	50	28	0.85
Hydro (Pumped Storage)	191	191	425	0.85
Solar Hot Water	217	246	549	2.70
Wind	10	1252	2992	2.01
Solar Thermal Electric	0	4625	10000	5.00
Geothermal	0.4	0.3	0.2	3.00
PV	2765	5908	3466	2.00
	Jobs (FTEs)	**Jobs (FTEs)**	**Total Investment ($ mill.)**	**Average $mill/MW**
	3962	**14134**	**19068**	**2.05**
	Total FTEs	**18096**		

Sources:

CEC reports and specific Australian RE project websites.

IEA Roadmap 2012 - Bioenergy Power and Heat

IEA Roadmap 2012 - Geothermal Power and Heat

IEA Roadmap 2014 – Solar Photovoltaic Energy

IEA Roadmap Roadmap 2014 - Solar Thermal Electric

IEA Roadmap 2013 – Wind Energy

RE job study USA – see reference for Wei et al, 2010.

Notes:

The investment estimate is likely to be an upper limit due to rapid cost reductions projected for solar thermal electric power systems as the IEA roadmap (2014) outlines.

Full-time job equivalent (FTE) - One FTE is full-time employment for one person for 1 year. This is taken here as 1762 work hours per year per full-time employee based on 38 hours per week, 4 weeks annual leave and 8 public holidays (ESQ, 2011).

Appendix 4 - A Fair Price for Solar PV

A fair price for solar PV electricity should attempt to include a value against each of the categories in the following table from the Rocky Mountain Institute, as reported in the Clean Energy Council's report, "Calculating the Value of Small-scale generation to Networks" (CEC, 2015:23).

Table 4 – Rocky Mountain Institute PV Cost/Benefit Categories

Table 1: DPV cost/benefit categories as described by the Rocky Mountain Institute [16]

Cost/benefit categories	Cost/benefit sub-categories
Energy	Energy
	Energy losses
Capacity	Generation capacity
	Transmission and distribution capacity
	DPV installed capacity
Grid Support Services	Reactive supply and voltage control
	Regulation and frequency response
	Energy and generator imbalance
	Synchronised and supplemental operating reserves
	Scheduling, forecasting, and system control & dispatch
Financial Risk	Fuel price hedge
	Market price response
Security Risk	Reliability & resilience
Environmental	Carbon emissions
	Criteria air pollutants (Sox NOx, PM10)
	Water
	Land
Social	Economic development (jobs and tax revenues)

The avoided cost method previously used by the Queensland Competition Authority (QCA) was too narrowly focused on wholesale price displacement, fees and network losses in deriving a regional value of 6.348c/kWh for exported PV energy. The QCA report stated incorrectly that there was no benefit to the 75 percent of electricity consumers who didn't yet have solar PV systems. This completely ignores the substantial environmental and social benefits of this technology in avoiding climate impacts, pollution and health impacts of fossil fuels. Hence the QCA method undervalued the benefits of solar PV energy, as set out in the table above, and has resulted in:

- A slowing in the uptake of solar PV across the State, including a substantial loss of jobs in this sector. Continued growth in PV uptake helps to off-set job losses in the mining sector due to the boom-bust nature of this industry, and the predicted decline of the coal industry in particular.
- The electricity retailers get to make a handsome profit by on-selling exported PV energy at a typical retail rate of 20 to 26 cents/kilowatt-hour, having paid around 6 to 11c/kWh only to the PV owner.

Simplicity & Pricing

The table below shows the value given to solar PV generation from the QCA and the Alternative Technology Association (see ATA submission to QPC inquiry). This is compared to a comprehensive study of distributed PV generation by the Maine Public Utilities Commission (MPUC). The US c/kWh are not adjusted for the exchange rate.

Table 5 – Comparison of PV generation valuations

Comparison of Valuations	
QCA Value of Solar PV (AUS c/kWh)	
Wholesale Energy Cost	5.57
NEM and ancillary service fees	0.083
Value of network losses	0.695
Total	6.348
ATA Valuation of Solar PV (AUS c/kWh)	
First 10 years – Wholesale+Avoided Market Fees+Merit Order Effect	29 - 34
Value thereafter	9 - 14
Main Public Utilities Commission Study 2015	
First Year Value (US c/kWh)	18.2
25 Year Levelised Value (US c/kWh)	33.7

Table 6 shows that more comprehensive analyses such as the MPUC study are likely to give a more accurate reflection of the real value of PV generation. This value is well above the QCA's valuation. Details from the MPUC study are as follows:

Table 6a - Maine Public Utilities Commission Analysis of PV Costs and Benefits

Figure ES- 1. CMP Distributed Value – First Year ($ per kWh)

First Year		Distributed Value ($/kWh)	
Energy Supply	Avoided Energy Cost	$0.061	Avoided Market Costs $0.090
	Avoided Gen. Capacity Cost	$0.015	
	Avoided Res. Gen. Capacity Cost	$0.002	
	Avoided NG Pipeline Cost		
	Solar Integration Cost	-$0.002	
Transmission Delivery	Avoided Trans. Capacity Cost	$0.014	
Distribution Delivery	Avoided Dist. Capacity Cost		
	Voltage Regulation		
Environmental	Net Social Cost of Carbon	$0.021	Societal Benefits $0.092
	Net Social Cost of SO_2	$0.051	
	Net Social Cost of NO_x	$0.011	
Other	Market Price Response	$0.009	
	Avoided Fuel Price Uncertainty	$0.000	
		$0.182	

Table 6b - Maine Public Utilities Commission Analysis of PV Costs and Benefits

Figure ES- 2. CMP Distributed Value – 25 Year Levelized ($ per kWh)

25 Year Levelized		Gross Value A ($/kWh)	×	Load Match Factor B (%)	×	Loss Savings Factor (1+C) (%)	=	Distr. PV Value D ($/kWh)	
Energy Supply	Avoided Energy Cost	$0.076				6.2%		$0.081	Avoided Market Costs $0.138
	Avoided Gen. Capacity Cost	$0.068		54.4%		9.3%		$0.040	
	Avoided Res. Gen. Capacity Cost	$0.009		54.4%		9.3%		$0.005	
	Avoided NG Pipeline Cost								
	Solar Integration Cost	($0.005)				6.2%		($0.005)	
Transmission Delivery Service	Avoided Trans. Capacity Cost	$0.063		23.9%		9.3%		$0.016	
Distribution Delivery Service	Avoided Dist. Capacity Cost								
	Voltage Regulation								
Environmental	Net Social Cost of Carbon	$0.020				6.2%		$0.021	Societal Benefits $0.199
	Net Social Cost of SO_2	$0.058				6.2%		$0.062	
	Net Social Cost of NO_x	$0.012				6.2%		$0.013	
Other	Market Price Response	$0.062				6.2%		$0.066	
	Avoided Fuel Price Uncertainty	$0.035				6.2%		$0.037	
								$0.337	

Gross Values represent the value of perfectly dispatchable, centralized resources. These are adjusted using

- Load Match Factors to account for the non-dispatchability of solar; and
- Loss Savings Factors to account for the benefit of avoiding energy losses in the transmission and distribution systems.

The load match factor for generation capacity (54%) is based on the output of solar during the top 100 load hours per year. The load match factor for Avoided Transmission Capacity Cost (23.9%) is derived from average monthly reductions in peak transmission demand.

The Distributed PV value is calculated for each benefit and cost category, and these are summed. The result is the 25-year levelized value, meaning the equivalent constant value that could be applied over

Appendix 5 – Modelling Renewable Electricity Generation on the National Electricity Market

Diesendorf and colleagues from the University of New South Wales have now undertaken thousands of simulations of the hourly operation of the national eastern electricity grid, when supplied by electricity from a geographically distributed mix of renewable energy technologies. “This research demonstrates that 100 percent renewable electricity in the NEM is technically feasible for the year 2010, meeting the NEM reliability standard with only six hours in the year where demand is unmet. This result is obtained by using renewable energy technologies that are either in full mass production (wind, PV, hydro and bio-fuelled gas turbines) or a technology in limited mass production (Concentrating Solar Thermal (CST) with thermal storage).” (Elliston et al, 2013; 2014). This work confirms similar modelling in the Beyond Zero Emissions (BZE) Stationary Energy Plan (Wright & Hearps, 2010). Similar studies have been undertaken in other countries such as Germany and the USA, all with similar results (NREL, 2012).

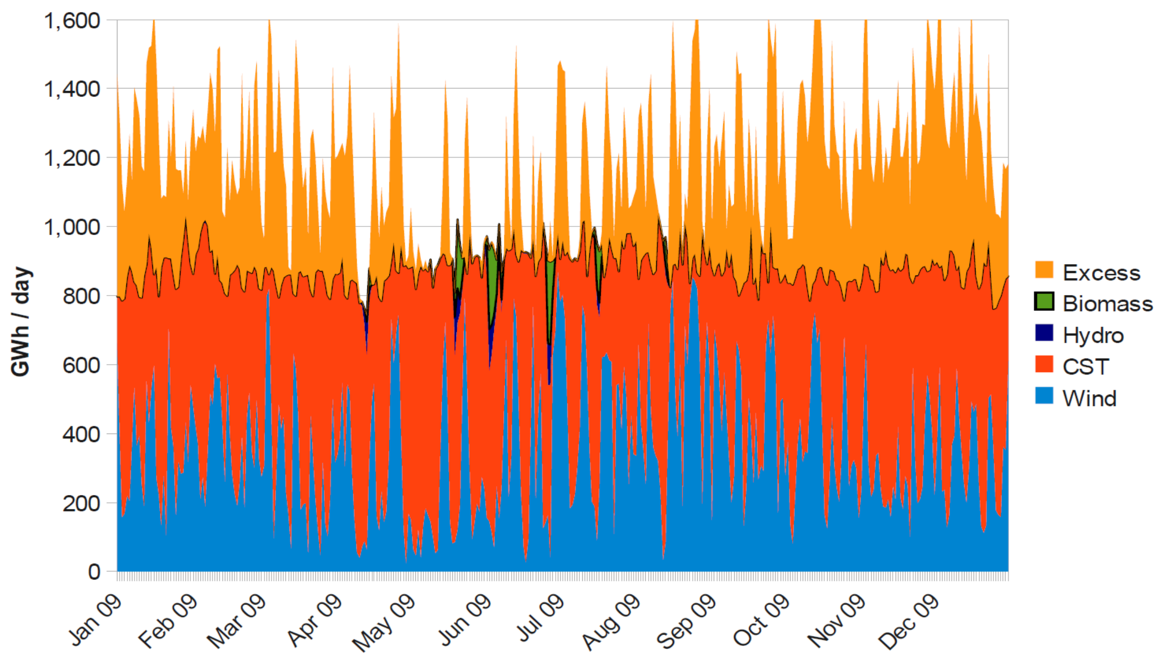
Most importantly, these studies dispel the myth that renewable energy technologies cannot replace a fossil fuel based electricity system, including the provision of base load. They also show that this is the most economic option when combined with energy efficiency, and when a modest level of carbon price is included.

Figure 13 - BZE Modelling of NEM, 2009, showing 100% Renewable Energy Supply

Note: Demand Curve is the thin dark blue line at the top of the red section.

Source: Wright & Hearps, 2010:81.

FIGURE 4.2
ZCA2020 Grid Model, 2009 (Results shown in daily averages, underlying model on half-hourly data)



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Glossary

Death Spiral

The traditional model of electricity generation via large centralised plant is based on a return on investment mostly via sales of electricity (units of energy) and peak power demand charges (cost per peak MW over a half-hour period in any billing period). They also charge a fixed cost for maintenance and metering. The death spiral for these generators occurs when their ability to remain profitable is threatened. It occurs when large generators such as coal and gas fired power stations lose market share to on-site generators and energy efficiency measures as both reduce sales of electricity. In order to try to remain profitable, they increase fixed charges to customers. This increases customers' costs and encourages them to seek cheaper options such as more on-site generation or energy efficiency or both. Hence the large generators become increasingly less profitable which results in a ''death spiral'' for their business (Diesendorf, 2014:247).

Energy versus Power (Demand)

Often different terms are used for energy and power, sometimes incorrectly and interchangeably. The term 'demand' is one such term that is used for both energy and power. For the purposes of clarity and consistency in meaning:

Energy (joules) is measured as the product of power (joules/second) and time. Energy in electrical systems is converted from joules to typically kilowatt-hours, Megawatt-hours and Gigawatt-hours (See Units section below). The terms for energy produced or used in this paper are energy generation or energy consumption or use. Typically they are stated in Gigawatt-hours.

Power is the rate at which energy is generated or consumed each second. It is measured in joules per second where 1 joule per second equals 1 watt. The common unit used here is the Megawatt (MW). For example, a power station might be rated at 200MW maximum power. However, when dealing with **peak power** of the alternating current (AC) electricity network, the term **demand** is used. It measured in MegaVolt-Amperes (MVA). This is called the apparent power within the electrical transmission and distribution system. It is calculated as the real power (MW) divided by the system power factor. Power factor accounts for the effect of different types of electrical loads on the relationship between voltage and current in alternating current systems.

Merit Order Effect

Different power stations make offers to sell their power at each 15 minute time period throughout each day. Participants are incentivised to offer power at the short-run marginal costs of generation. This includes fuel and operating costs. The energy market operator then accepts the lowest to highest cost power providers in order until demand is met.

For wind and solar power, the fuel cost are zero and operating costs are very low. Hence these power providers can bid at very low prices and displace fossil fuel generators. This forces the fossil fuel generators to offer at prices lower than they would like and may be below profitable return rates (Diesendorf, 2014:244).

Units

Units of Energy are listed as Gigawatt-hours (GWh) - 1GWh = 1,000Megawatt-hours (MWh) or 1,000,000 kilowatt-hours (kWh).

1 kilowatt-hour (kWh) = 1000 watt-hours (E.g. 10 x 20 Watt light-bulbs running for 5 hours)

1 megawatt-hour (MWh) = 1 million watt-hours

1 gigawatt-hour (GWh) = 1000 million watt-hours

Units of Power are listed as Megawatts (MW) – 1MW = 1000kilowatts (kW).

Units of Peak Demand are listed as MegaVolt-Amperes (MVA)

1000MW of power generated for 1hour = 1000MWh or 1GWh

Conversions

1 kilowatt-hour = 3.6 megajoules

1 megawatt-hour = 3600 megajoules or 3.6 gigajoules

1 gigawatt-hour = 3600 gigajoules or 3.6 terajoules