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Transitioning Queensland to Clean Energy

Our Sunshine State has a world class solar resource, and good wind, wave and biomass resources. So people often ask me, “What would it take for Queensland to transition away from fossil fuels to clean renewable energy (RE), combined with energy efficiency. Is it technically and economically possible to do this?” The answer to the last question is a resounding yes (Bloomberg, 2013; Elliston et al, 2014; HSBC, 2015; IRENA, 2014)! The answer to the earlier question is explained here.

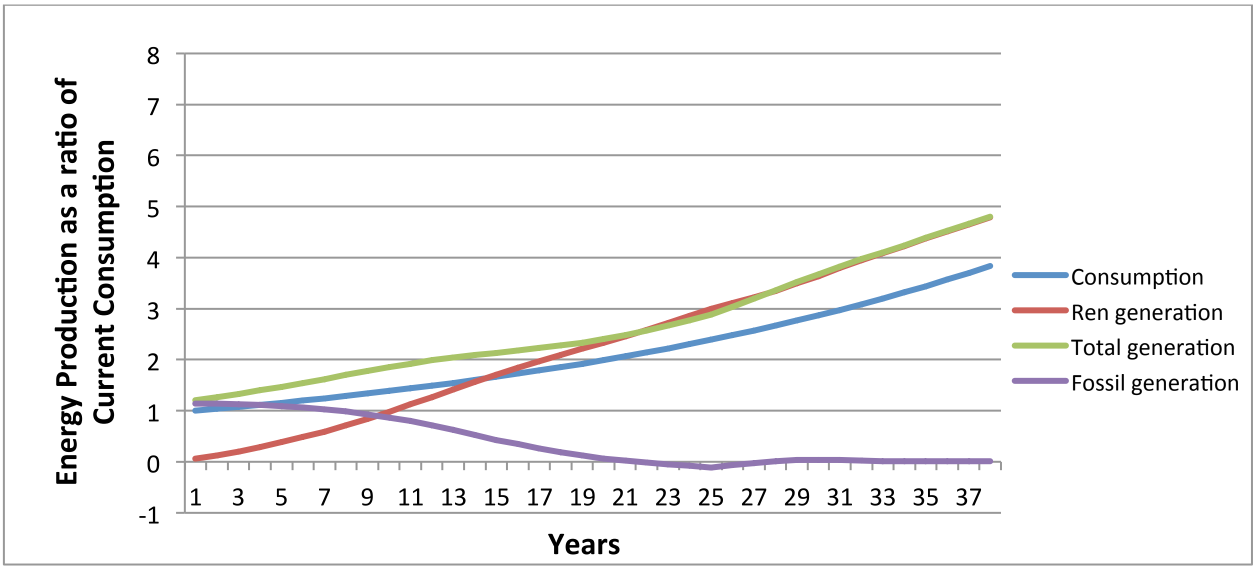
As the International Energy Agency reports show, such an energy transition is happening internationally, but slowly in Australia (Climate Council, 2015). Denmark, China, Germany and other EU countries are leading the way, with Germany on the path to cutting total primary energy use by 50 percent and generating 80 percent of electricity from renewables by 2050. It is already generating 30 percent of electricity from renewables (Morris & Pehnt, 2014; Morris, 2015). Denmark, with 39% of electricity consumption from wind in 2014, is on track towards its target of 100% renewable electricity and heat by 2035 (Danish Ministry of Climate, Energy and Building, 2013).

Figure 1 – 420MW Macarthur Wind Farm by AGL and Meridian, 290km west of Melbourne

There is huge growth occurring internationally in RE with 59 percent of all new electricity capacity coming from renewables in 2014, and investment expenditure of $270 billion. Globally renewables are providing 23 percent of electricity generation, and 19 percent of total final energy use. There are over 7.7 million people employed directly and indirectly in RE jobs (REN21 report, 2015). Levelized costs of energy for electricity generation from biomass plant, hydro, wind and solar PV are now competitive with new coal and gas plant in most parts of the world (IRENA, 2014; Bloomberg, 2013).

In Australia, Tasmania, South Australia and ACT are the leaders, with SA providing 40 percent of its electricity demand from the wind and sun. A transition to a largely RE based electricity system in Queensland had started under the Bligh Labor Government's Queensland RE Plan (DEEDI, 2012). Modelling showed that this transition could have been achieved over about 20 years, as shown in figure 1, if the RE Plan's momentum had been maintained.

Figure 2 – Modelling of former Labor Government RE Plan and Projected Transition to 100% RE Electricity (Source: Berrill, 2012)



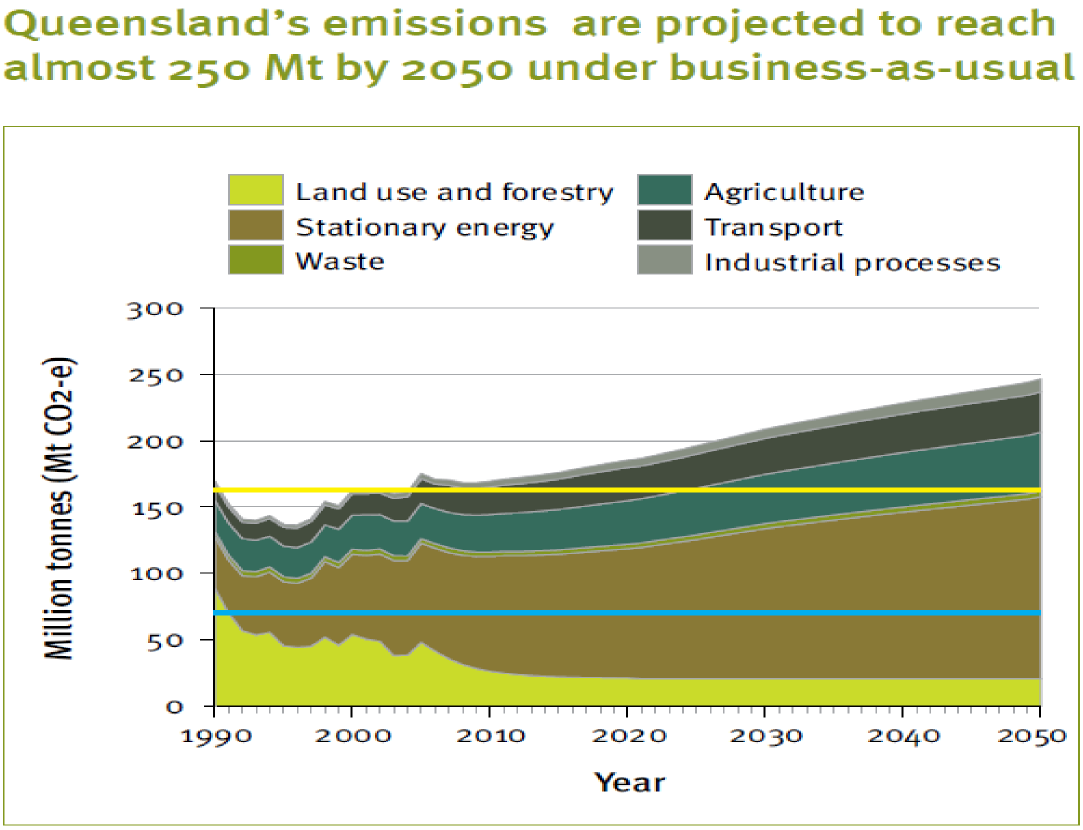
Note: For assumptions in this modelling, see Berrill, 2012.

The Australian RE industry has grown dramatically since about 2008 according to Clean Energy Council (CEC) reports, with a peak of over 24,000 direct jobs in 2012. This dropped to about 20,000 by 2014, similar to current employment in Queensland's coal industry (Qld. Government Data Service, 2015), due to lack of policy support by Federal and State LNP governments. Renewables now generate about 14 percent of Australian electricity demand, with total investment since 2001 exceeding $26 billion (CEC report, 2014). Some State and Local governments are getting behind the RE industry again, as they realise ***that future jobs and investment lie in the RE industry, not coal and gas.***

Queenslanders have the dubious honour of the highest per capita greenhouse gas emission in the world, more than 40 tonnes per person per year according to the State Government's 2009 ClimateQ report (DERM, 2009). We have a lot at stake with our world heritage areas and agriculture already feeling the impacts of global warming. So we know we need to pull our weight in addressing global warming.

Figure 3 - Queensland's CO_2e Emissions Projection under Business as Usual

Source: DERM, 2009, Chp.3:20



Note: The yellow line indicates 2000 emissions. The blue line denotes the national target of 60 percent (as of 2009) reduction below 2000 levels by 2050 applied to Queensland's emissions.

We are trying, with over 400,000 roof-top solar PV systems and about 240,000 solar hot water systems on homes (CEC report, 2014). Almost 30 percent of homes now have solar systems. That's a great effort and shows our willingness to use solar if given the right signals. Currently we have about 2,300 Megawatts (MW) of renewables, large and small, generating an estimated 4,400 Gigawatt-hours (GWh) annually (excluding hydro pumped storage). This is enough energy for about 570,000 homes. Biomass plant (30%) and solar PV (38%) generate most of the renewable energy, with hydro (run of river) (20%) and solar water heating (11%) making large contributions (Berrill, 2015).

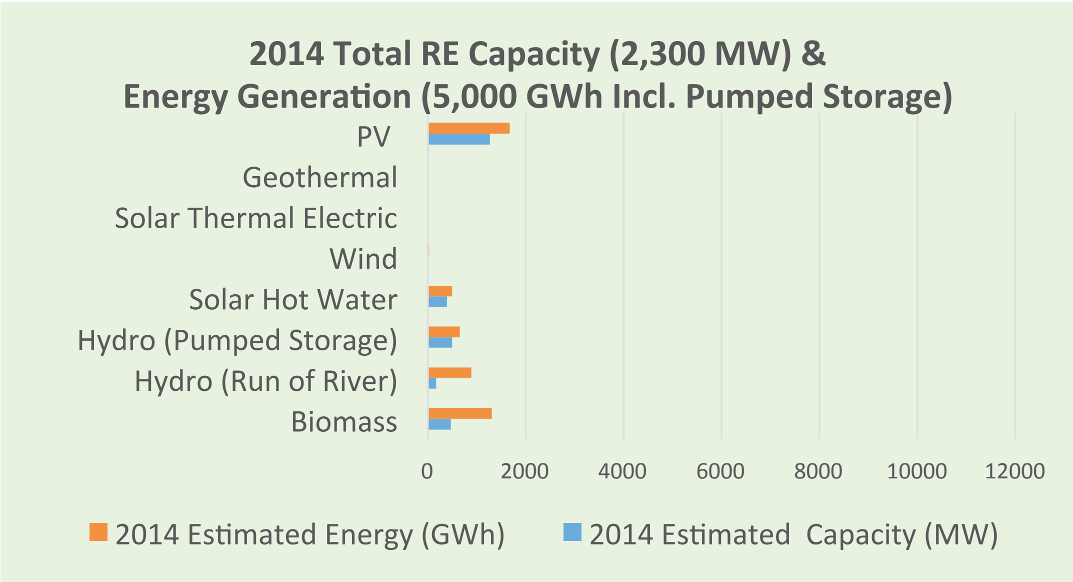
In total, renewables currently provide almost 10 percent of total electricity consumption. Clearly we need to do better and we need to address other sectors such as transport and agriculture if we are to shift to a largely renewable energy powered society. ***The role of government is essential in providing the right signals and addressing structural issues.***

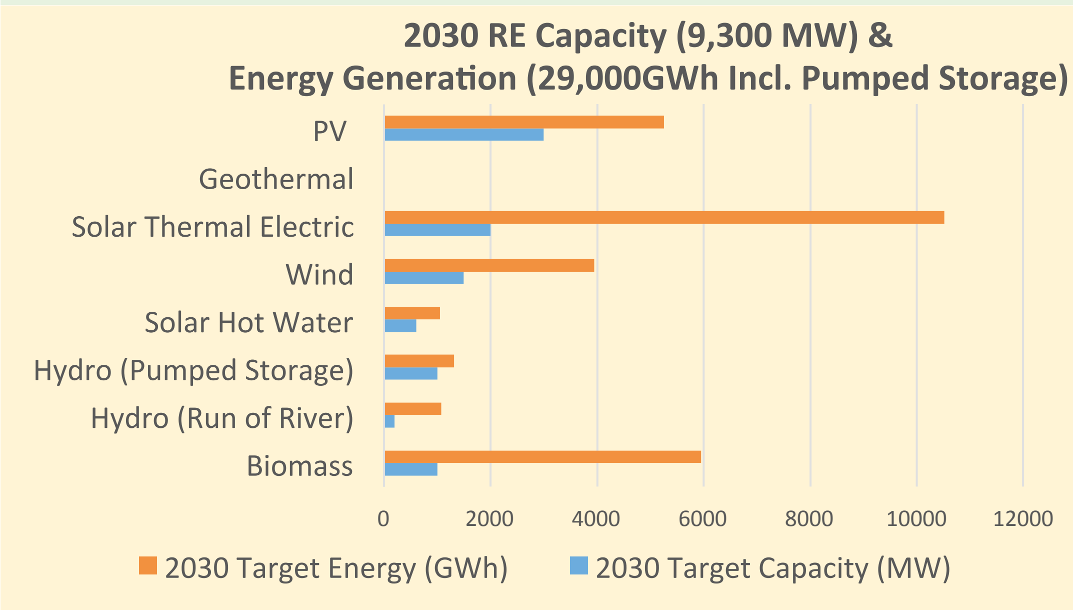
The State Government has stated an ***aspirational goal of 50 percent RE electricity generation by 2030*** (ALP, 2015), which is a laudable target. So just how much RE generating capacity would be required to meet projected electrical energy demand by that time, and what might be the most appropriate RE technologies to use? Clearly, it will be a mix of the most economically viable technologies. Both Bloomberg (2013), inter-governmental agency, IRENA and International Energy Agency (IEA) reports show that the most competitive technologies are hydro power, wind farms and solar hot water, solar photovoltaic (PV), and biomass plant (E.g. sugar mills). Solar (concentrating) thermal electric (STE) is more expensive but expected to be competitive with coal by 2020 (IEA Road Map – Solar Thermal Electric, 2014). Hot rock geothermal and wave power plant have potential but are still in the R&D phase.

To achieve the government's 50 percent RE target by 2030, we need about 9300MW of RE capacity made up of a 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 STE plant (currently zero)
- 3000MW solar PV both small and medium-sized rooftop and on-ground power stations (currently about 1300MW)

Figure 4 – RE Capacity (MW) and Energy Generation (GWh) 2014 and 2030





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. The tables in the appendices show more details. Such a portfolio would form a distributed generation network across the State, with embedded storage at strategic locations within the network, and controlled with smart communications (known as the smart or intelligent grid). ***The result would be a cleaner, more resilient, reliable and efficient electrical energy system (CSIRO, 2011), one that could handle the more frequent extremes in weather that are already a consequence of global warming. Furthermore, this would assist regional development with farmers diversifying their income by leasing non-productive land to wind or solar farms (Berrill, 2014).***

Figure 5 – Spanish Concentrating Solar Thermal Electric Power Stations by Abengoa Solar

So what level of investment and jobs could result from this scenario? Using CEC and IEA reports, I estimate that such a RE portfolio would involve up to about $19 billion of direct investment, depending on final installed costs due to falling STE, PV and storage costs. Using data from an extensive study of RE job creation in the USA (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.

The keys to achieving the 50 percent renewable energy target by 2030 will be strong, long term policy that drives the industry forward, and the removal and redirecting of subsidies from the fossil fuel industries to support renewables and energy efficiency. You can view suitable policy measures and details of subsidies to fossil fuels in my recent energy policy paper, "Sustainable Queensland - Transitioning to a Clean and Efficient Energy System". The paper can be downloaded at www.sustainablequeensland.info.

NB. Other relevant reports by the author are available at his website www.trevolution.com.au

About the Author

Trevor Berrill is an award winning, private consultant in sustainable energy (SE). He has worked in both renewable energy (RE) and energy efficiency (EE) for almost 40 years, including in RE system design and installation, energy efficient building design and energy auditing, research at UQ, QUT and GU, product development, RE education and training and policy.

He is the author of "Solar Electricity Consumer Guide" and author/co-author to a range of RE technical training resources books. Trevor was branch president of the Australian Solar Council and a founding member in Queensland of the Alternative Technology and Wind Energy Associations.

Trevor is trained in mechanical engineering and energy auditing at QUT and has a Masters of Environmental Education degree from Griffith University. He lives in a fully solar powered, energy efficient home which includes the first grid connected solar PV system in the Redlands. He windsurfs regularly at Wellington Point, just to test the power of the wind.

Appendix 1 – RE Capacity (MW) and Generation (GWh)

Technology	2014 Estimated Capacity (MW)	2014 Estimated Energy (GWh)	2030 Target Capacity (MW)	2030 Target Energy (GWh)	Assumed Capacity Factor
Biomass	464	1301	1000	5957	0.68
Hydro (Run of River)	167	895	200	1069	0.61
Hydro (Pumped Storage)	500	657	1000	1314	0.15
Solar Hot Water	397	493	600	1051	0.2
Wind	12	30	1500	3942	0.3
Solar Thermal Electric	0	0	2000	10512	0.6
Geothermal	0.12	0.89	0.2	1.5	0.85
PV	1267	1676	3000	5256	0.2
	(MW)	**(GWh)**	**(MW)**	**(GWh)**	
Total Renewable Energy Capacity (MW) & Generation (GWh)	**2807**	**5052**	**9300**	**29102**	
Energy Efficiency and Demand Management	**246**	**NA**	**NA**	**11619**	
Year & Qld. Electricity Consumption from AEMO	**2013/14**	**46442**	**2029/30**	**58242**	
Renewable Energy as Percentage of Consumption (%)		**10.9**		**50**	**%**
Energy Efficiency as Percentage of Consumption (%)		**NA**		**20**	**%**

Sources:
Berrill, 2015 – www.sustainablequeensland.info - includes additional output of hydro pumped storage.
AEMO (2014) - http://www.aemo.com.au/Electricity/Planning/Forecasting/National-Electricity-Forecasting-Report

Notes:
Growth rates in consumption and energy efficiency savings are based on AEMO projections - approximately 1.4% pa. for total consumption from 2014, and 20% pa. energy savings, starting at 611GWh for 2014-15.

Capacity factors for the following technologies taken from:

- Biomass – Australian Sugar Milling Council submission to RET Review 2014, Sucrogen Aust. Pty. Ltd. and Stanwell Corporation reports (by Burbidge) for long term on-site biomass storage.
- Hydro (both run of river and pumped storage) – from Green Energy Markets analysis (Brazalle, 2014) and Stanwell Corporation Annual report (2010).
- Solar Hot Water – calculated as the equivalent electrical capacity of 238,000 x 1.67kW PV systems (Berrill, 2015)
- Wind – conservative estimate averaged across windfarm locations as AGL estimates for Coopers Gap Wind Farm and Mt Emerald windfarm, both forecast higher capacity factors. Wind may be combined with local pumped storage as wind farms tend to be located in elevated terrain (Blakers et al, 2010).
- Solar Thermal Electric – molten salt storage on site as per Spanish power tower systems. IEA roadmap reports show capacity factors from 0.45 to 0.75.
- PV – Calculated from typical industry values for PV arrays facing north. Will be a little lower for east or west facing arrays.

Appendix 2 – Employment Creation and Investment 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:

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).

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