Adequate Electrical Transmission and Distribution Networks capable to cater for extensive Renewable Energy Utilization in Australia

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Abstract

The study portrays the present state of electricity generation and distribution in Australia and simulates the case where electrical transmission networks are interconnecting the eastern to the western parts of the continent. Adequate electrical transmission systems are required for allowing a transfer of renewable energy from generation sites to end-users in a reliable and economically sound manner. Further on, because the amount of energy needed at a particular location is seasonal and daytime specific, a capable transmission system shall be helping making use of time differences to transfer energy from locations on low-demand to others on high demand. Queensland in Eastern Australia, at off-peak times might supply Western Australia at soaring demand, Tasmania might supply the main land with wind electricity, while the solar-rich Northern and Central Queensland might supply load centres in states of Victoria and Southern Australia. Results are demonstrating that building interconnecting electrical networks of adequate carrying capacity covering long distances between different time-zones shall be improving services and economics of electrical power transmission and distribution.

Keywords:

Electrical Energy Generation, Transmission and Distribution, Peak Demand, Renewable Energy.

Introduction

The current electrical transmission grid in Australia, like many other places on the Earth, was built largely to transport energy from fossil fuel central power stations to load centres. Remote areas meant locations far from an economic electricity supply.
Renewable energies are covering all locations on Earth quite equally, however mostly at time differences. At the same time the amount of energy needed at a particular location besides being seasonal it varies according to the time of a day. Morning and evening peaks are common feature of a typical electricity demand as shown in **Figure 1** of a typical day in Queensland instantly communicated by the Australian Energy Market Operator AEMO (2009). In the figure, RRP is the regional reference wholesale price in $/MWh and the demand in MW.

Figure 2 summarizes the occurrence of electricity demand in Queensland showing a base-load of 4100 MW for the year 2008 and a maximum demand of around 8000 MW occurring at short periods of time. It is generally accepted that base-load power stations are those providing the most economic and most reliable operation 24x7; 365 days a year; those are producing the least possible electricity generation cost. Other power stations operated at any lesser rate are providing electricity at higher cost.

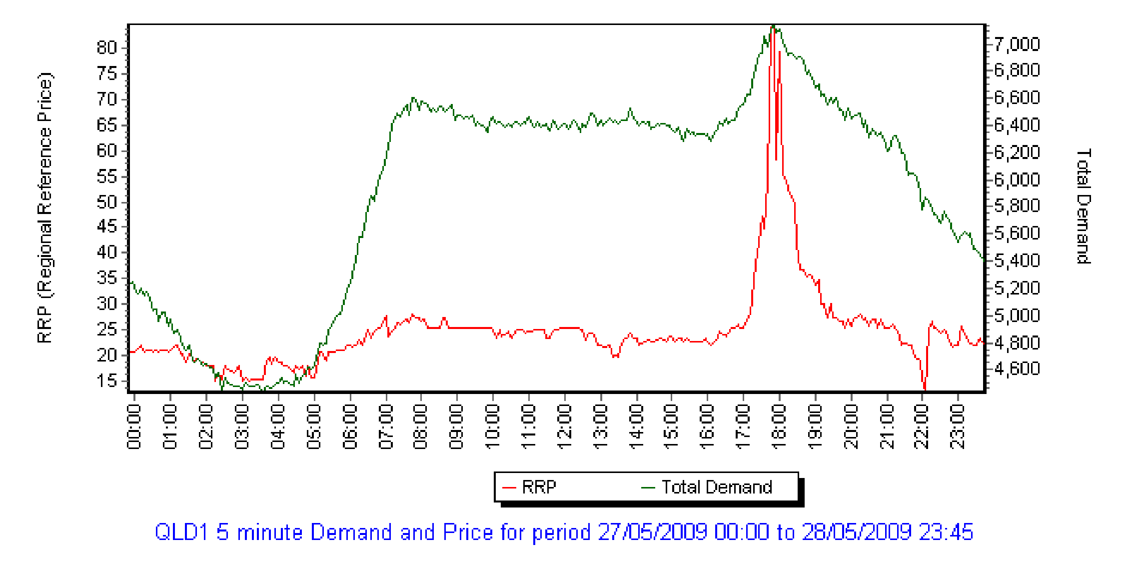

Figure 1 Demand in MW and wholesale price of electricity in AUD $/MWh for a typical day in Queensland on 28th May 2009; source: The Australian Energy Market Operator AEMO (2009).

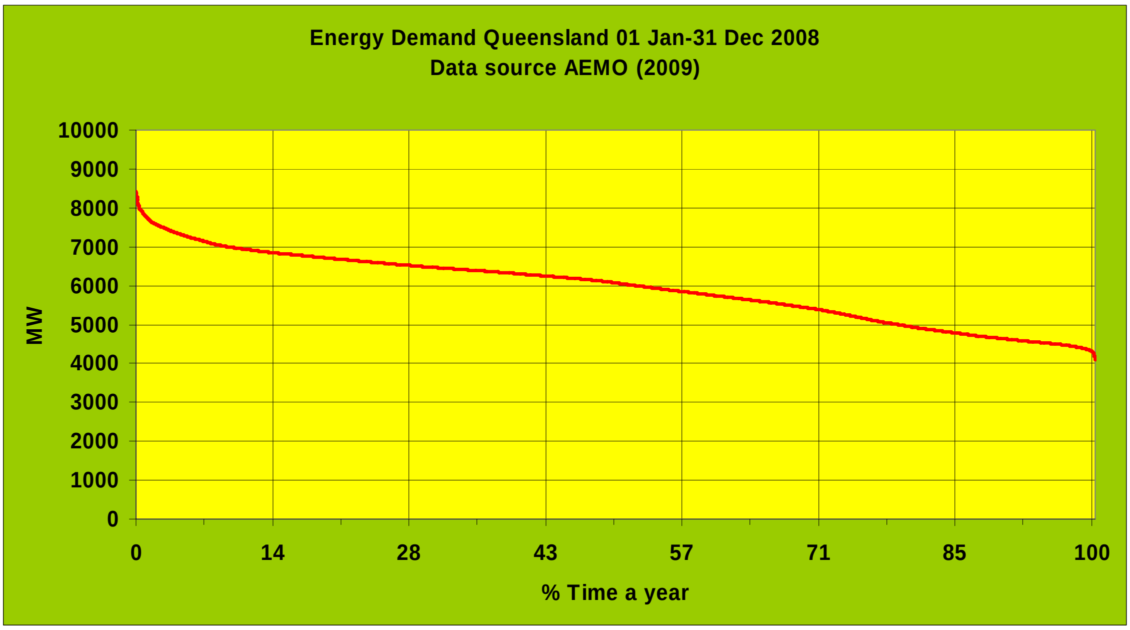

Figure 2 Electricity demand in Queensland in 2008, data extracted from the Australian Energy Market Operator AEMO (2009). .

Renewable energy sources being usually installed on user's premises; saving thus transmission and distribution costs, besides offering a long-term energy supply, they are demonstrated strong competitors to non-base-load power stations. A range of policy measures have been introduced to support the take-up and development of all renewable energy sources in Australia. Under a national Renewable Energy Target (RET) ”the government will require that 20 per cent of power generation comes from renewable energy sources” as reported in RET (2009) pp. 5 and in pp.6 “Australia has committed to reducing greenhouse gas emissions by 60 per cent from 2000 levels by 2050 and to meeting a medium-term national target to reduce emissions by between 5 per cent and 15 per cent below 2000 levels by the end of 2020”.

Figure 3 and **4** illustrate potential solar and wind energy resources in Australia.

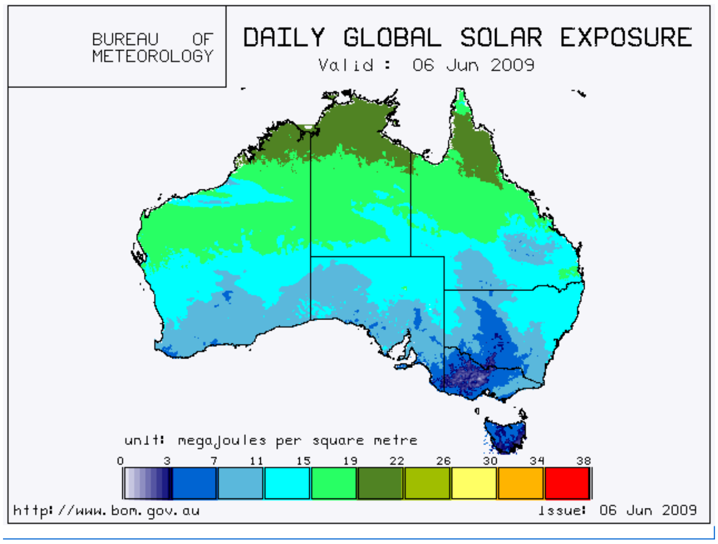

Figure 3 Solar Radiation Map – Bureau of Meteorology – Australian Government
Source http://www.bom.gov.au/sat/solrad.shtml Meteorology (2008)

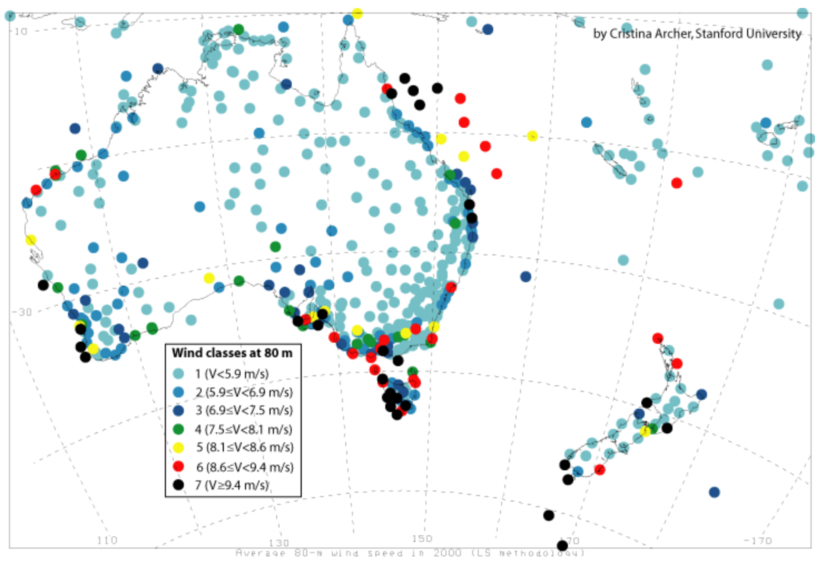

Figure 4 Wind Energy Resources in Australia, source GENI (2000)

Huber (2008) is describing a backbone grid built with state-of-the-art high-voltage technology and spanning the **North-American** continent. Such a grid could readily move 25 percent of America's power over very long distances, at a cost well under 0.5 cents per kilowatt-hour moved. Overlaid on the existing, fragmented system, a backbone grid will let cheap power chase high demand around the clock and across the country. In **Australia**, the Carbon Pollution Reduction Scheme (CPRS), designed to achieve least-cost economy-wide reductions in carbon emissions, will be implemented in 2010 with an emissions reduction trajectory, including associated carbon prices, RET (2009) pp21.

Present situation in the Australian electricity industry

Present situation in the Australian electricity industry and the contribution of renewable energy technologies are presented in **Table 1** and **2**. **Figure 5** presents accredited renewable energy power plants and **Figure 6** transmission lines and generators in Australia.

Table 1 Capability of the electrical network in E-Australia RET (2009) pp27.

Australian major power network transfer capabilities, 2007-08			
Interconnector	Location	forward capability MW	Reverse Capability MW
New South Wales to Queensland (QNI)	Armidale to Braemar	486	1 078
New South Wales to Queensland (Direct	Terrinora to	105	234
Snowy to New South Wales	Murray to Dederang	3 309	1 090
Victoria to Snowy	Buronga to Red Cliffs	1361	1 786
Victoria to South Australia (Heywood)	Heywood to Tailem	460	300
Victoria to South Australia (Murraylink)	Red Cliffs to Berri	220	220
Tasmania to Victoria Basslink expected	Seaspray to	594	469
Transmission and distribution length (km)		Overhead	Underground
		781 383	102 725
Sources: Energy Supply Association of Australia, *Electricity gas Australia 2008.*			

Table 2 Renewable electricity generation in Australia RET (2009) pp34

Capacity of renewable electricity generation in Australia, 2007									
	Wood			Other					
	biogas	bagass	waste	renewables	hydro	wind	solar	other	total
	MW	MW	MW	MW	MW	MW	MW	MW	MW
NSW a	68	16	42	36	4 275	18	4.0	0.5	4 459
VIC	78	0	0	34	566	134	0.7	0.0	813
QLD	17	359	15	4	659	13	0.4	0.1	1 066
SA	22	0	10	0	5	740	0.7	0.0	778
WA	27	6	6	63	32	201	0.7	0.0	336
TAS	5	0	0	0	2 276	144	0.0	0.0	2 425
NT	1	0	0	0	0	0	1.6	0.0	3
Other d							63		63
Aust	218	380	73	137	7 814	1 249	71	1	9 942
a Includes the ACT. b Black liquor, crop waste, municipal waste and biodiesel. c Oceanwave and geothermal. d Domestic, recreational and remote installations. *Sources*: Geoscience Australia; NEMMCO; Watt, M 2007. National Survey Report of PV Power Applications in Australia.									

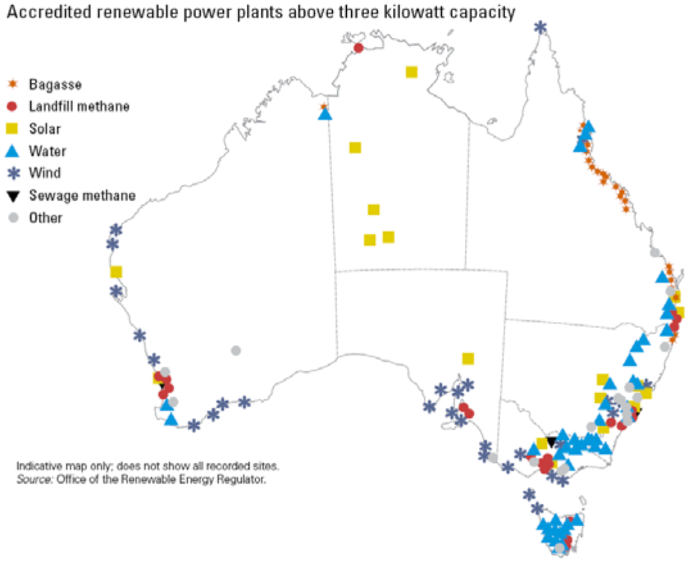

Figure 5 Accredited renewable energy power plants in Australia RET (2009) pp.37.

Electricity market

The Australian Energy Market Operator AEMO (2009) manages power flows across the Australian Capital Territory, New South Wales, Queensland, South Australia and Victoria (Tasmania joined in 2005). **Figure 7** shows electricity average regional reference price; data extracted from the AEMO (2009). The Independent Market Operator (IMO) in Western Australian is responsible for the administration and operation of the Western Australian Wholesale Electricity Market IMO). **Figure 8** shows electricity average demand and regional reference price for the IMO WA – Data extracted from IMO (2009).

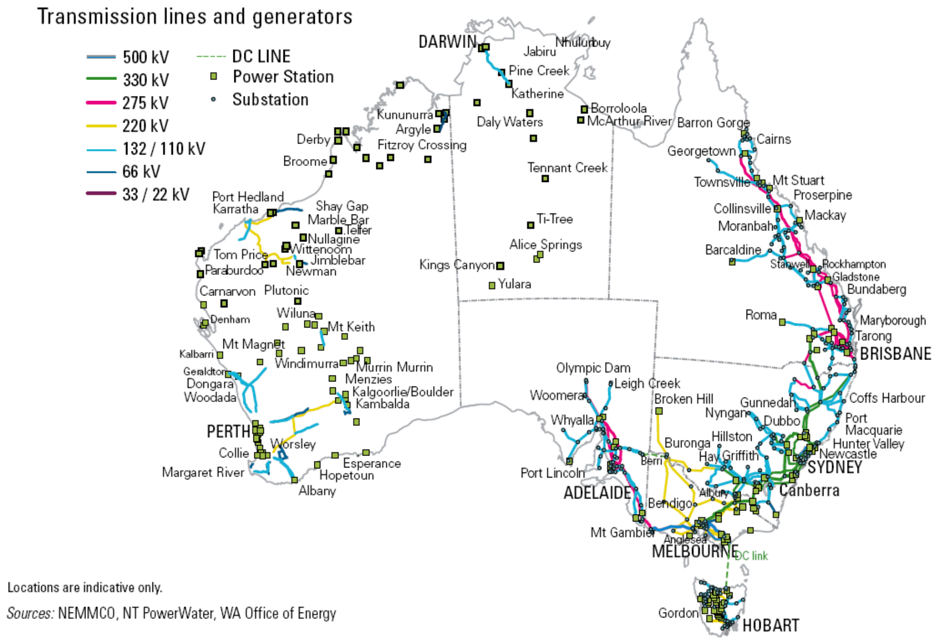

Figure 6 Transmission lines and generators in Australia Source RET (2009) pp.31 Energy in Australia 2009.

While the electricity consumers are insulated from price volatility by 'flat' electricity prices, they are in fact paying a significant and undisclosed (hard to evaluate) premium in their retail electricity prices to cover the retail costs of managing the risks of the extreme price volatility and for building sufficient electricity generation and networks to meet the short-time peaks in physical electricity EUAA (2005) pp16. The network has to be built to cater for those peaks, which is expensive, involving significant investment in augmentation.

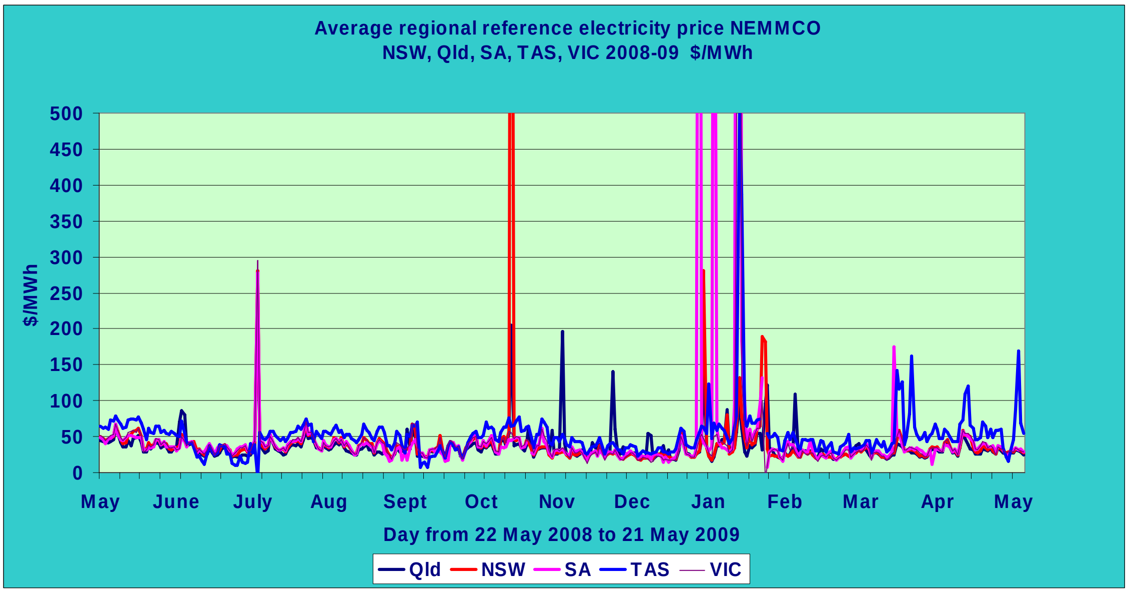

Figure 7 Electricity average regional reference price for the NEM – Data extracted from The Australian Energy Market Operator AEMO (2009).

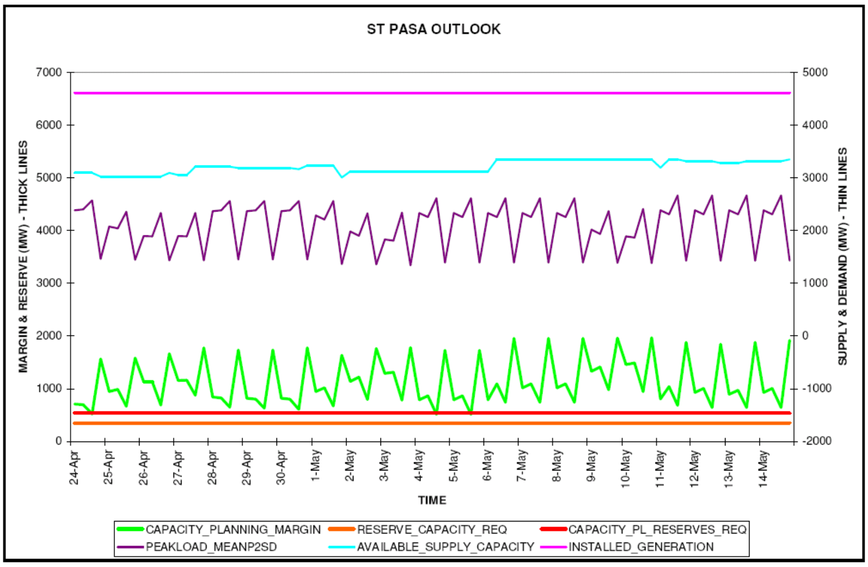

Figure 8 Electricity average demand and regional reference price for the IMO WA – Data extracted from IMO (2009)

Electrical energy demands in NSW, Qld, VIC and Tasmania for the 14th May 2009 are presented in **Figure 9** according to data extracted from the Australian Energy Market Operator. The overall peaking demand featuring each individual network is similarly characterising the total demand, which is the simple mathematical summation of the mentioned networks. The four networks are falling in the same time-zone so that the consumption is occurring at the same real time.

Figure 10 however is showing the hypothetical case of electrical networks lying in different time-zones. The sum of those demands is taking into account the time differences, i.e. two hours between Qld and Western Australia and half an hour between Qld and South Australia. **Figure 11** is comparing total demands in both cases i.e. case one: connecting East, West, South and Tasmania falling in different time-zones with the contrasting case: connecting East Australia with Tasmania falling in the same time-zone.

Discussion

The analysis reveals that the impact of time-zone differences is in fact improving the shape of the peak demand. A close observation of **Figure 11** shows a clear relative flattening of the total demand of the interconnected network compared to the present situation. Observed improvement of peaks around 9AM and 7PM lies simply on the fact that while the demand is peaking in Queensland it is in fact not peaking yet in Western Australia because of time difference. This indicates an improved plant capacity factor of the total network leading to improved energy cost besides better reliability.

Conclusions could be drawn from the above analysis that building interconnected electrical networks of adequate carrying capacity covering long distances between different time-zones shall be improving services and economics of the entire electrical network. Further on a strong and long outreaching grid shall additionally allow feeding of several renewable energy supplies along the line. This help further improve economics and reliability of both electric networks and electricity energy generators.

Australia, a continent endowed with unlimited energy resources and surrounded by seas and oceans is naturally privileged by durable and sustainable sources of wave and wind energy. Further more the vast continent is daily receiving whelming quantities of solar radiation well distributed across its total area; technically mature to be transformed into electricity. Conscious and dedicated investments in massive and modern electrical grid interconnecting the whole continent shall be allowing harnessing of durable, sustainable and secure renewable energy sources.

Conclusion

Building interconnected electrical networks of adequate carrying capacity covering long distances between different time-zones shall be improving services and economics of electrical power transmission and distribution. Further on a strong and long outreaching grid shall allow feeding several renewable energy supplies along the line. This demonstrates further improved economics and reliability of both electric networks and electrical energy generators.

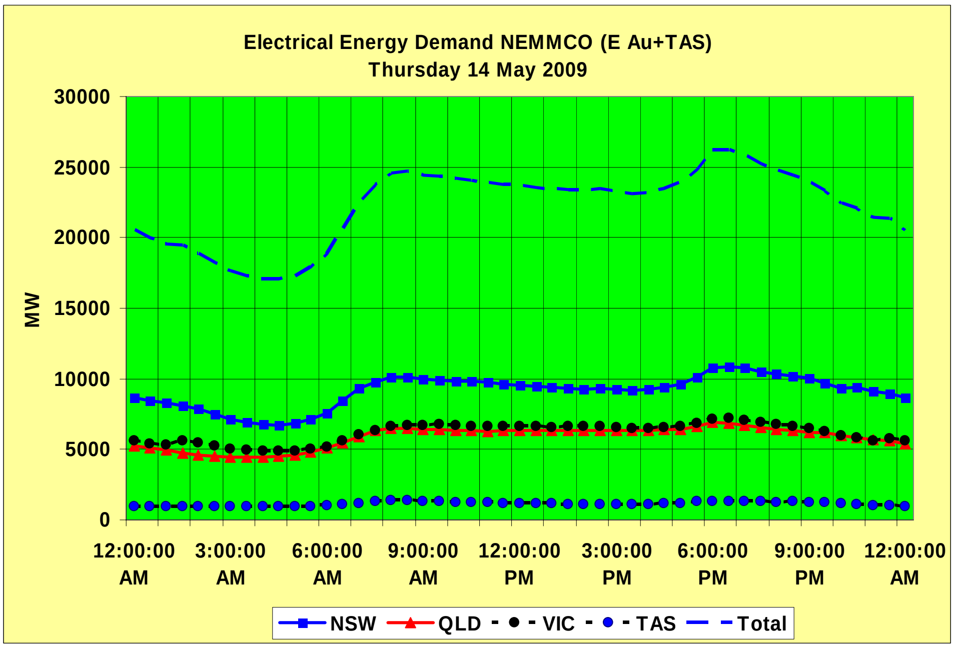

Figure 9 Data extract from the AEMO (2009)

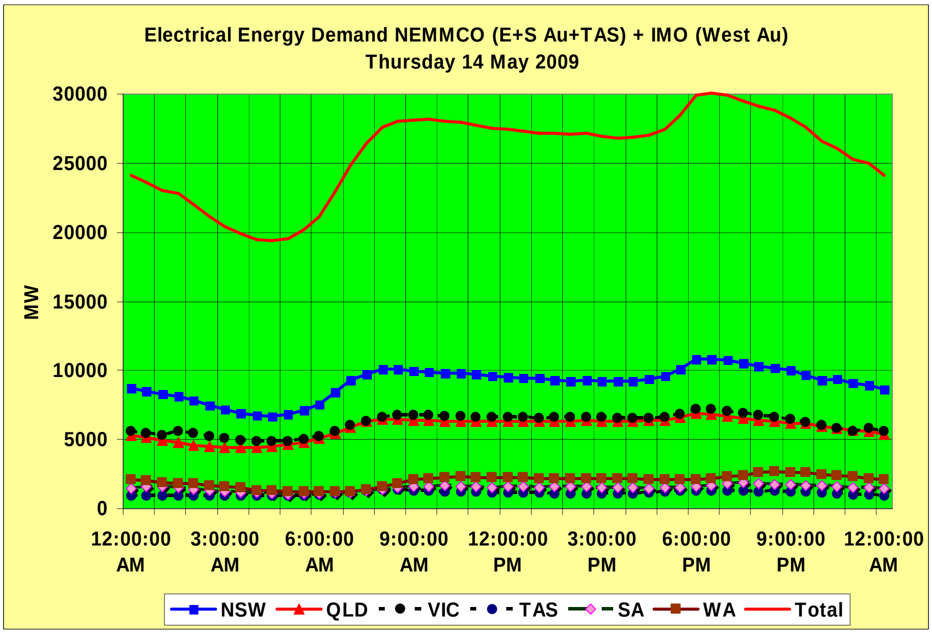

Figure 10 Electrical energy demand for East-South-Australia, Tasmania and Western Australia

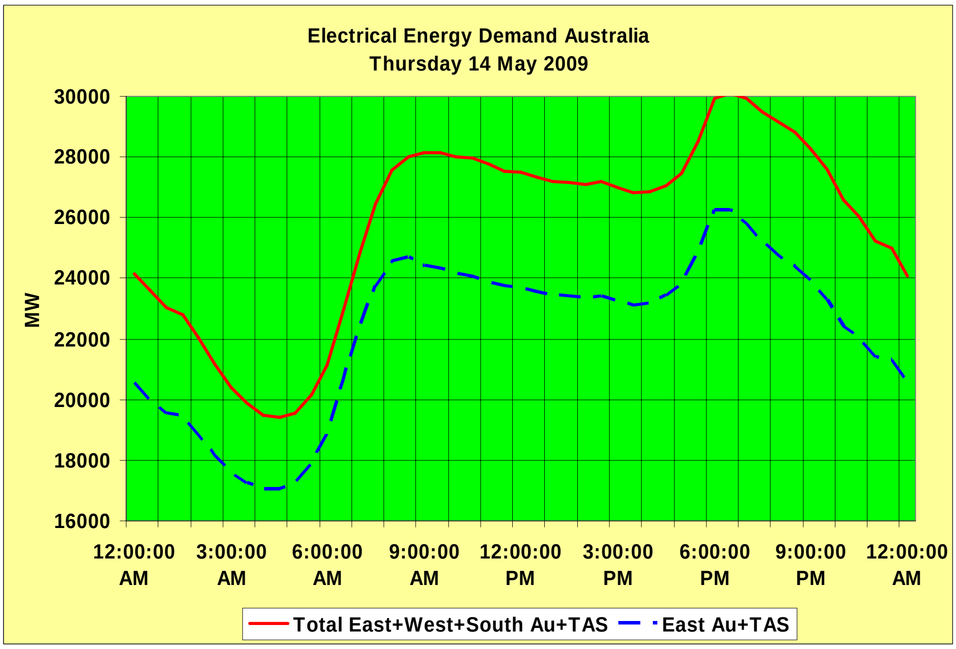

Figure 11 Simulation of total electrical energy demand for East-South-Australia, Tasmania and Western Australia.

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