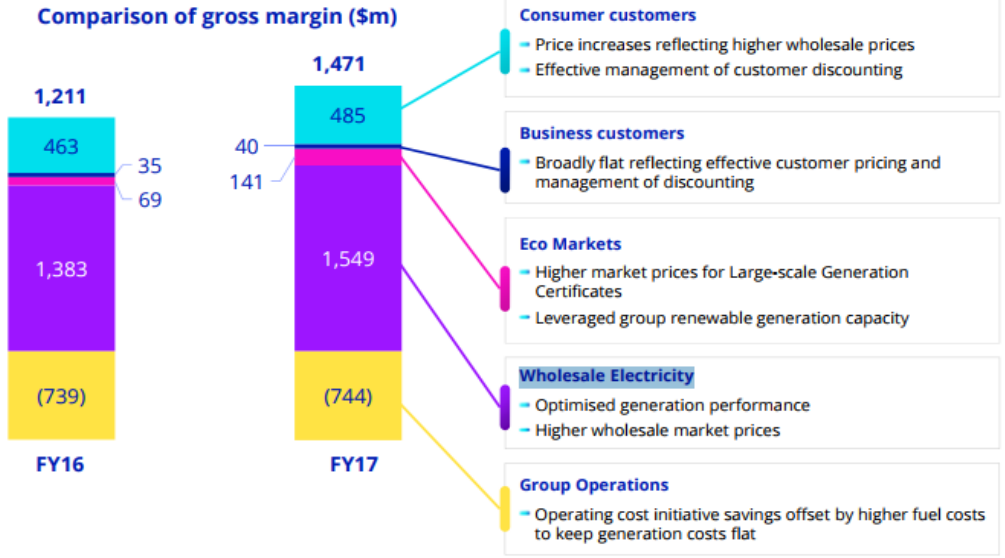
LEP in Data Science
Group 1

Company Analysis and Industry Outlook

Customer Profiling: AGL

Largest generator in National Electricity Market (NEM)

Largest privately-owned portfolio of renewable generation asset



10,246MW of electricity generation assets (1890 MW is renewable)

22% of total capacity in NEM

25% of wind capacity

67% of utility-solar capacity

80% in NSW & VIC

Electricity Industry Outlook

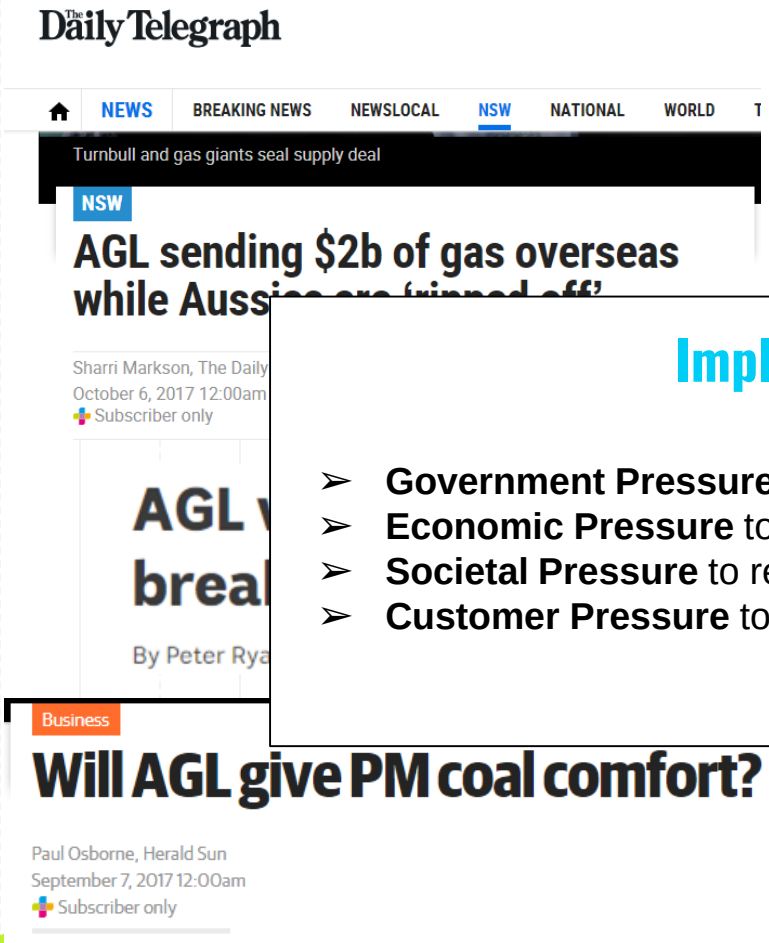
Traditional Centralised generation model → Distributed and integrated energy supply chain

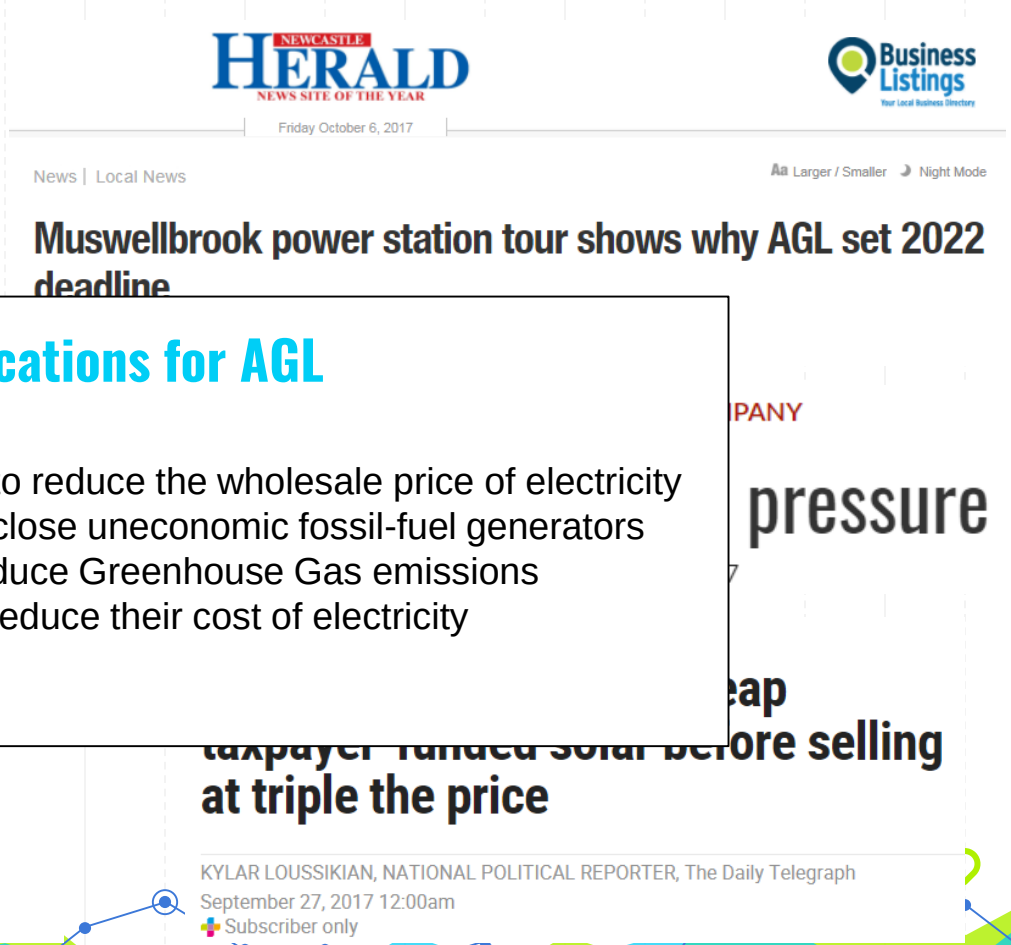
Transformation in Energy Industry driven by:

- **N**ew emerging technologies
- **E**volving government policy
- **C**hanging customers' demands
- **P**ressure to Reduce greenhouse gas emissions

Increase in Wholesale Electricity Price driven by:

- **R**etirement of old coal-fired generation from the market
- **I**ncreasing cost of gas
- **C**ost of new capital to replace aging generation fleet within NEM



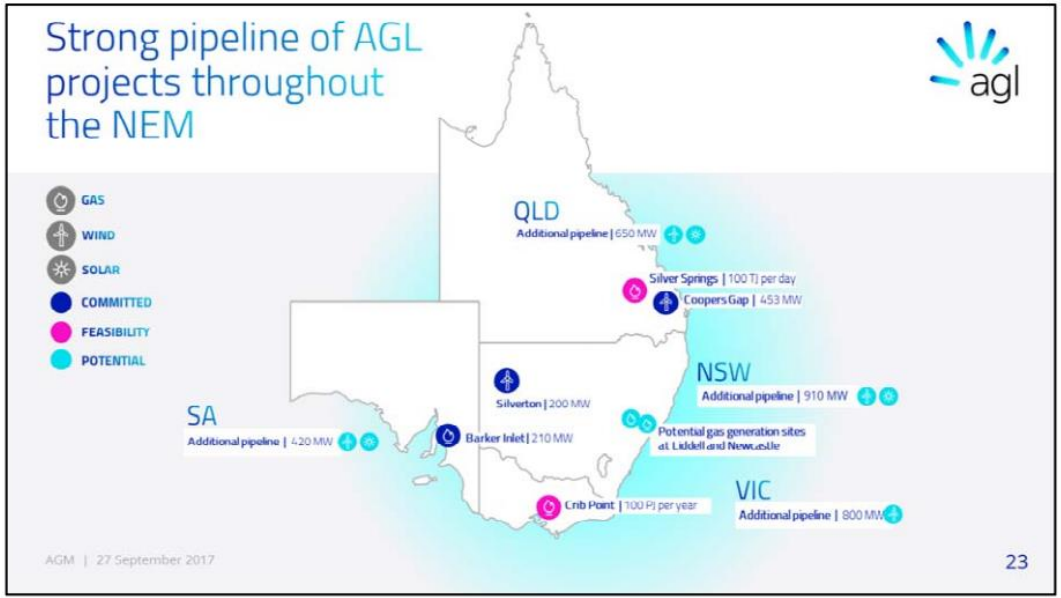


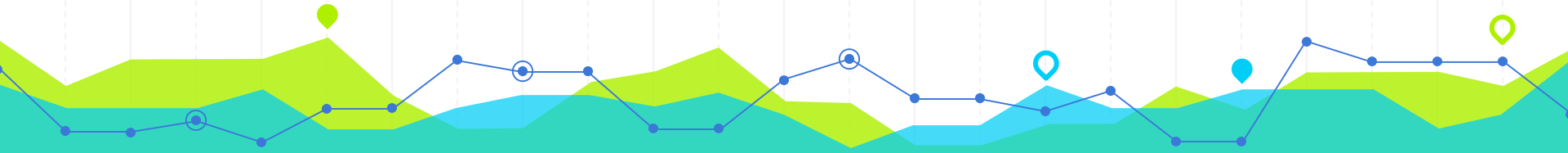
Implications for AGL

- **Government Pressure** to reduce the wholesale price of electricity
- **Economic Pressure** to close uneconomic fossil-fuel generators
- **Societal Pressure** to reduce Greenhouse Gas emissions
- **Customer Pressure** to reduce their cost of electricity

A Way Forward

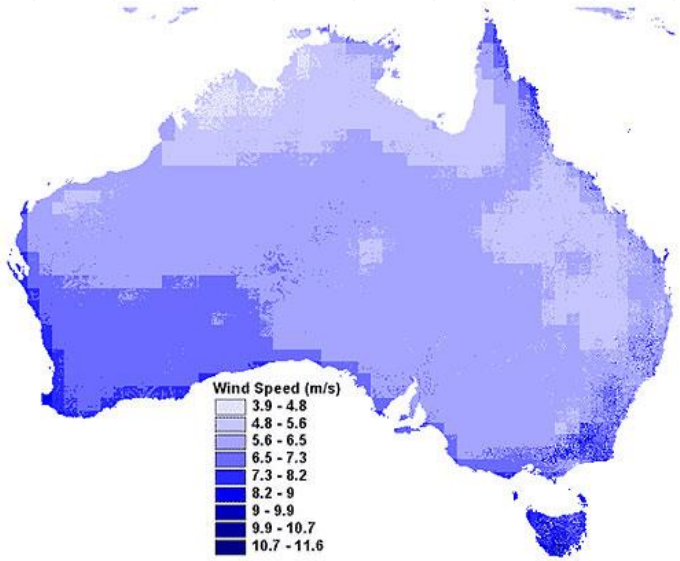
- AGL has committed to exit its coal-fired generation assets by 2050 and remain as an innovator in renewable investment.
- **Some of the investments include:**
  - **P**owering Australian Renewable Fund
  - **W**orld largest Virtual Power Plant (VPP)
  - **F**unded a project to investigate blockchain distributed ledger technology
  - **D**rive uptake of electric vehicles in Australia





Which Renewables to Invest in?

Wind



Positives:

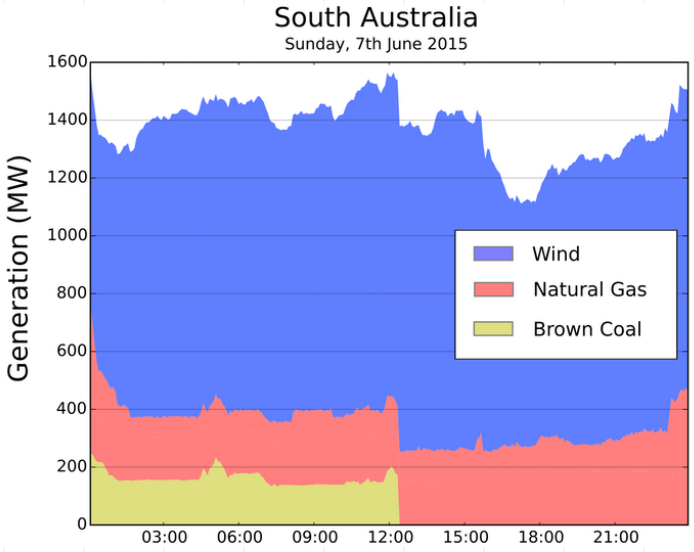
1. Cost-effective, lowest priced energy sources available today
2. Sustainable source of energy - 24 hours energy generation
3. Ability to generate up to 13,000 MW a year using a turbine with a capacity 3.6 MW

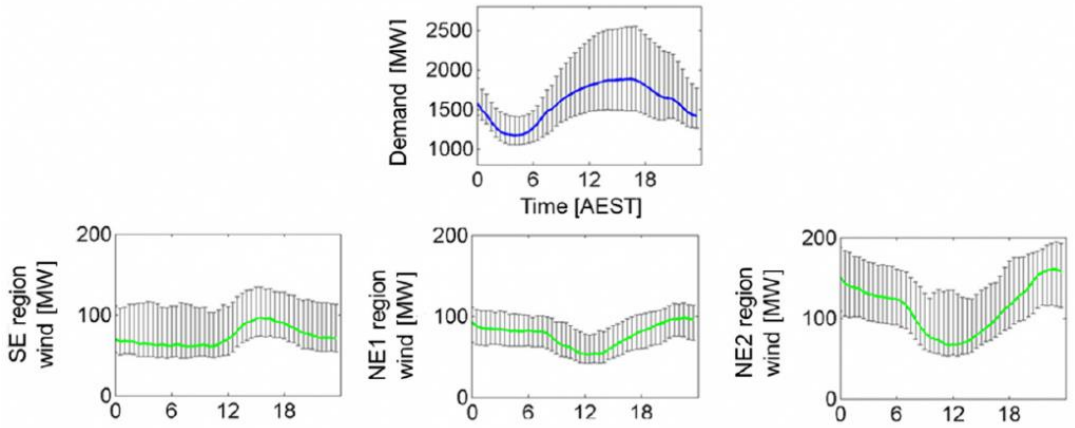
Negatives:

1. Depends heavily on location
2. Strong variance at hourly, daily or seasonal timescales
3. Higher initial investment than fossil-fueled generators
4. Noise and aesthetic pollution

A single offshore turbine can power more than **3,300** Australian households.

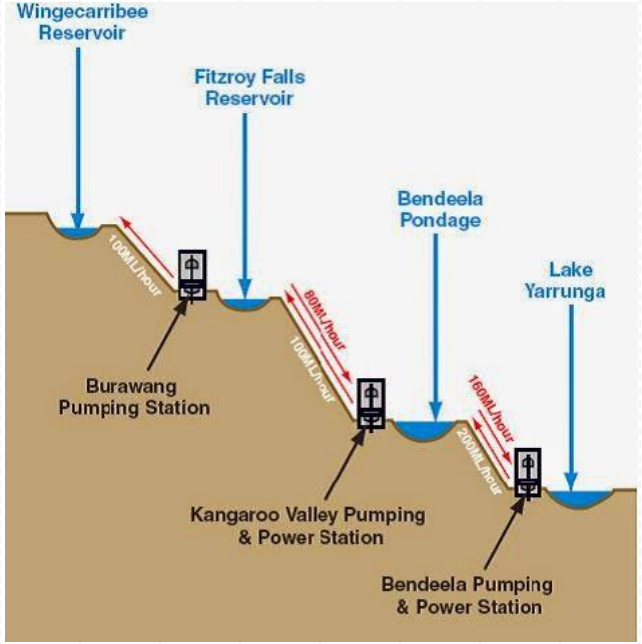
Wind





Example: South Australia Wind Production

Pumped Hydro



Positives:

1. Generating electricity at lower cost during high demand
2. No flowing water supply is required
3. Pumped storage plants can be operated all year
4. Very reliable and little fluctuation in energy output

Negatives:

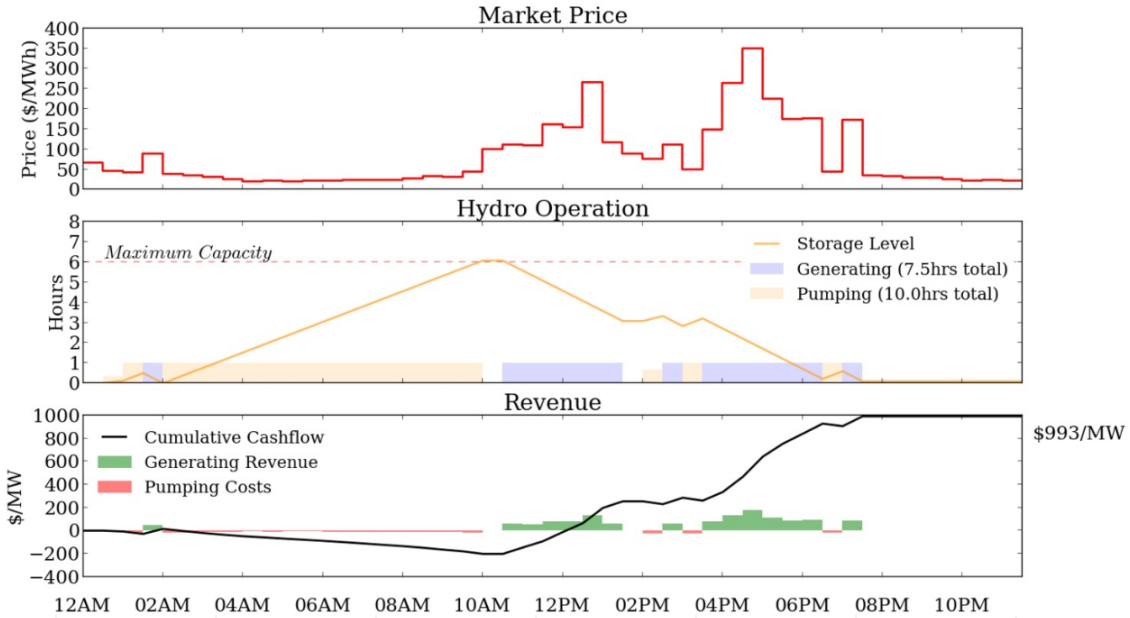
1. High initial capital cost to build and install required hardware
2. Limited reservoirs to install due to demanding site requirements
3. Require large availability of water - droughts can affect this

Pumped Hydro

Pumped Storage Hydroelectricity:

The conventional solution to over-supply of electricity generated by wind at times when it is not needed, is to store the electricity generated during the off-peak times using pumped-hydro.

Using this system ‘as a battery’, by pumping water uphill and then releasing it later, will provide better storage and revenue generation



Solar

State/territory	Total installed capacity (systems under 100kW)	Penetration among dwellings	New installations (as of April 2017)	Same time April 2016	Rate of increase
ACT	59,000	13%	2024	1841	10%
NSW	1,216,000	14%	51,096	34,956	46%
NT	41,000	10%	2777	1871	48%
QLD	1,718,000	31%	61,581	39,823	55%
SA	727,000	32%	22,618	15,482	46%
TAS	105,000	15%	3155	2596	22%
VIC	1,060,000	15%	41,021	32,878	25%
WA	706,000	15%	43,515	25,422	71%
Total	5,633,000				

- **L**arge-scale: in NSW, the 102 MW Nyngan Solar Plant provide enough energy to power more than 40,000 average Australian homes in financial year 2017.
- **S**mall-scale: 1.67million PV installation in Australia (April 2017) which can generate 8,400 GW hours of electricity each year.

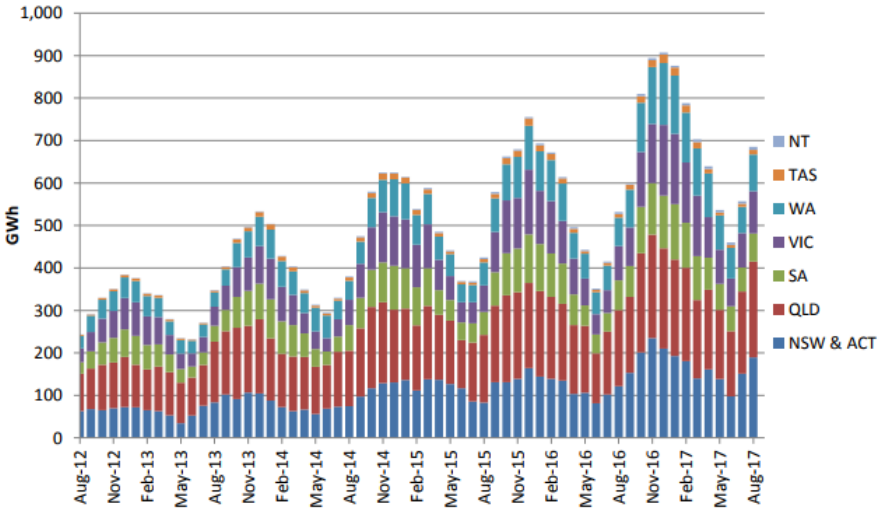
Positives:

1. **R**enewable energy resource that is available every day and can be used in remote locations
2. **S**ave on electricity bills during middle of the day
3. **E**asy to install and low maintenance cost

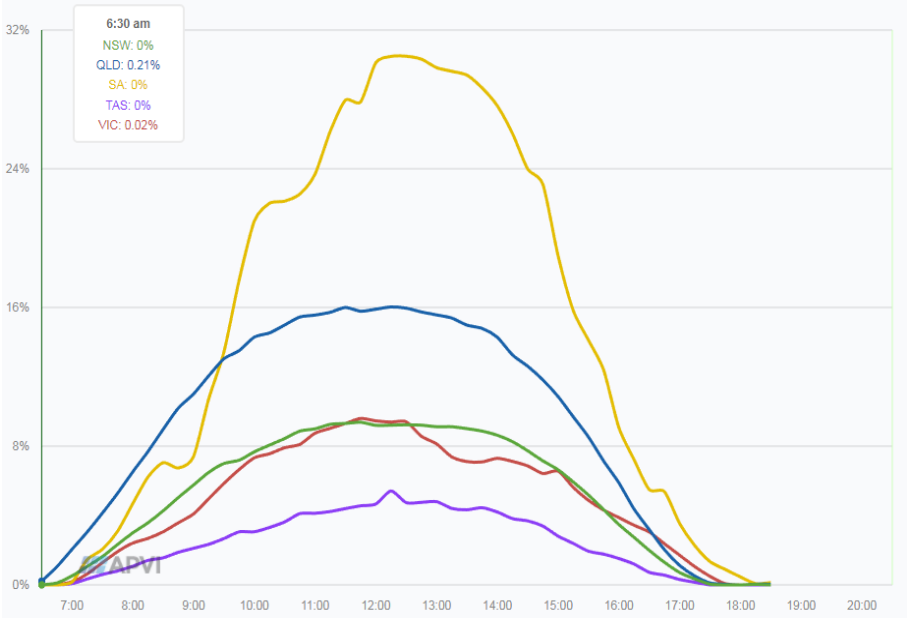
Negatives:

1. **H**igh initial capital cost
2. **N**ot 100% reliable due to intermittency and unpredictability
3. **A**ssociated with pollution during production of solar panels

Solar



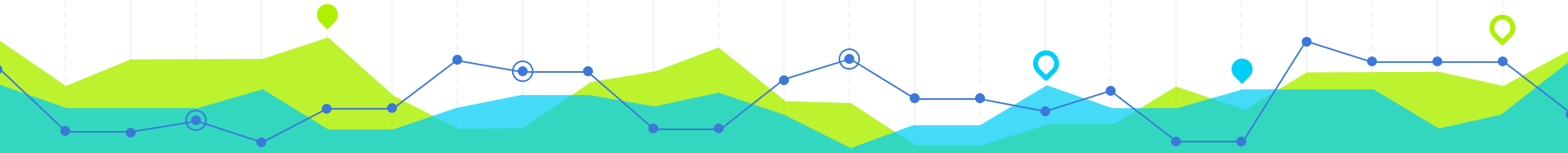
Residential PV Generation



State Contribution on 1st September 2017

Comparison of Renewable Energy Types

Characteristic	Solar with Storage	Wind	CC Gas Turbine	Pumped-Hydro	Biofuels
On-demand	Yes	No	Yes	Yes	Yes
Operating Cost	Low	Low	Medium-High	Medium	Medium-High
Fuel Cost	None	None	High	None	Medium
Limitations	Weather dependent	Weather dependent	High cost of fuel	Affected by drought	Availability of fuel
LCOE ($/MWh) 2020 Avg	138	92	83 + fuel cost (~$12/GJ)	161	No data

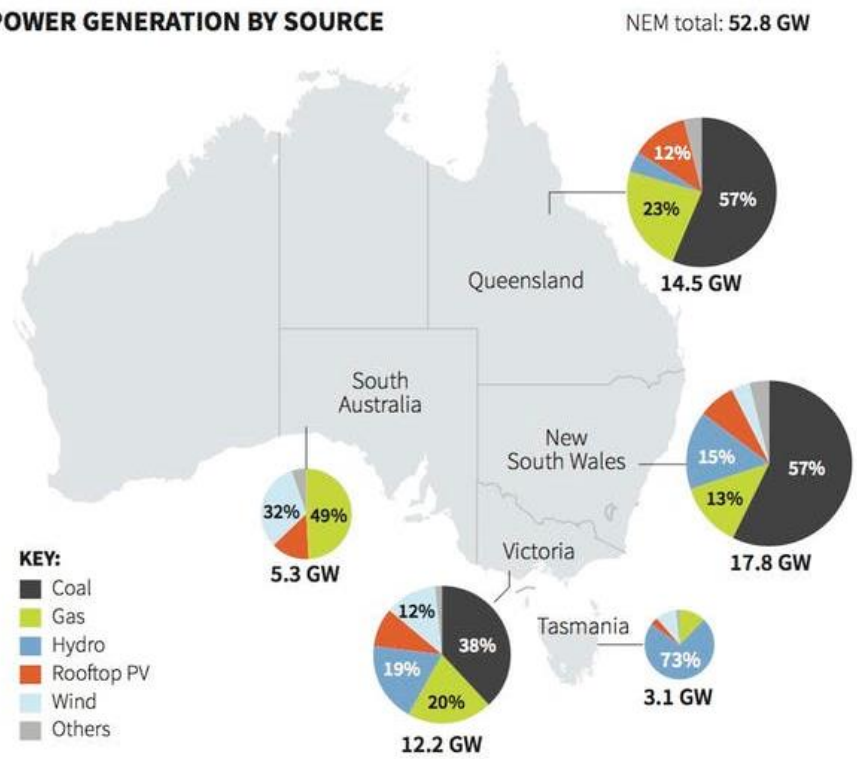


How to evaluate Regional Generation Requirements?

Australia's National Energy Market (NEM)

The Australian NEM is a wholesale electricity market providing electricity to retailers and wholesale customers in Queensland, NSW, Victoria, South Australia and Tasmania.

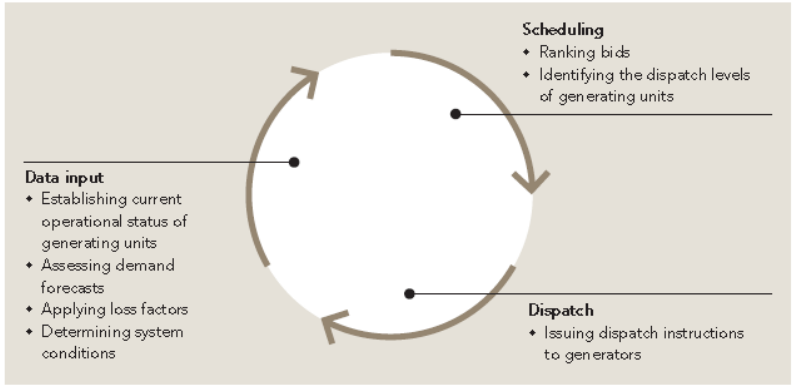
Exchange between electricity producers and electricity consumers is facilitated through a pool where the output from all generators is aggregated and scheduled to meet demand.



Australia's National Energy Market (NEM)

Generators 'bid' to supply the market with specific amounts of electricity at particular prices.
'**B**ids' are submitted every five minutes of every day.
From all 'bids', the generators required to produce electricity are selected.

THE GENERATOR DISPATCH CYCLE



Selected generators are dispatched into production.
All dispatched generators receive the 30 min averaged price for production during this period
In this way, the sale of power is matched to the available energy and performance of the generating unit.

Strategy for Regional Generator Analysis

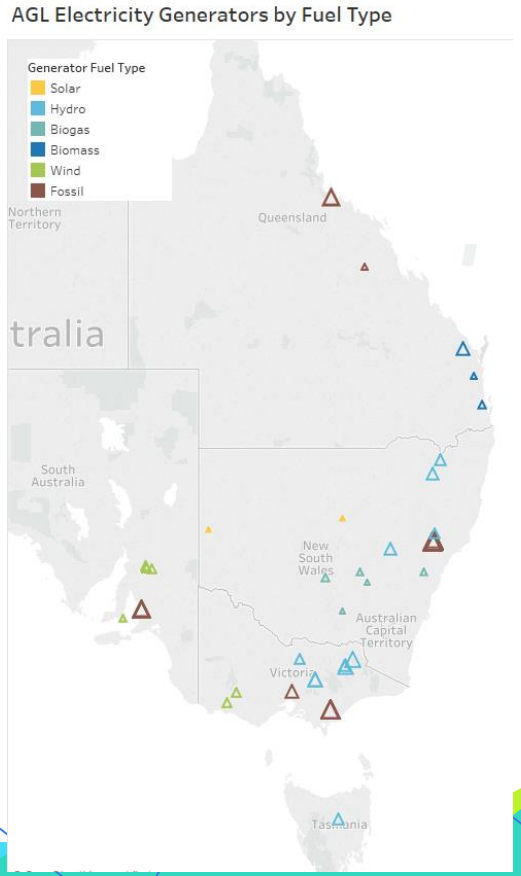
Electricity Generation solutions need to be designed to meet the needs of the regions.

New Generators should supplement or replace the most **Significant generators** in each Region in order to:

- Diversify
- Distribute

the electricity generation

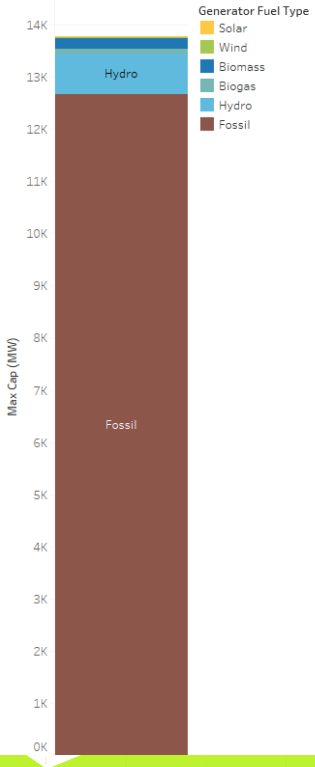
Significant generators = most significant indicators of the Dispatch Price (Regional Reference Price, RRP)



Regional Analysis

Queensland

QLD Gen Types



Electricity in QLD is generated from a wide range of fuel sources, including: coal, gas, oil, biomass, hydro, wind, geothermal and solar.

Queensland's resources sector creates a strong demand for electricity at mines, smelters and refineries

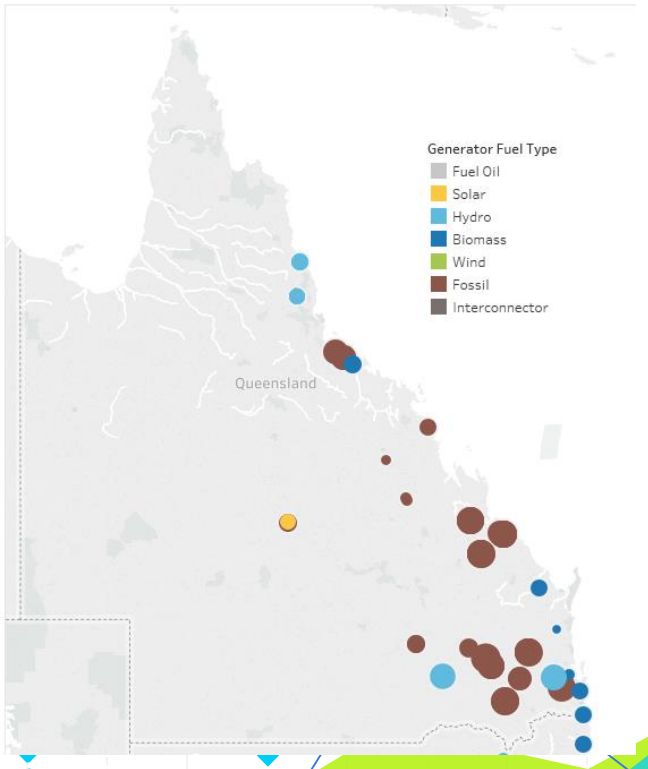
Queensland has high penetration of solar PV installations, but currently only one large operational solar farm.

The NEM interconnected grid does not extend to every city, town or community in Queensland. These areas rely on fossil-fuel generators operating outside the NEM to send out electricity into isolated networks

Maximum demand is expected to remain flat due to solar installations.

Queensland is more subject to extreme weather events (cyclones, flooding) than other regions.

Electricity Generators by Fuel Type



Queensland Analysis

S16/17 Peak occurred on January 18th

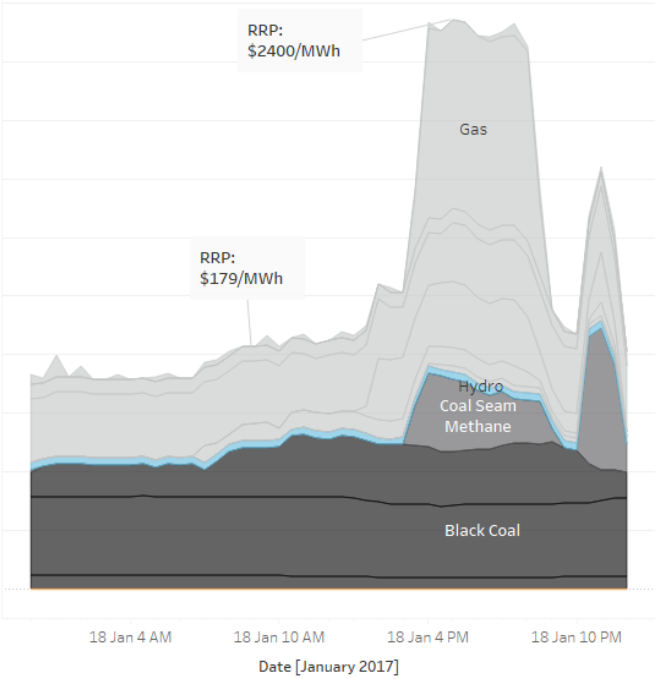
Main predictors of RRP in Jan ‘17 were:

Generator	Generator Type	AGL
Mackay Gas Turbine	Diesel	x
Barcaldine Power Station	Natural Gas	x
Rocky Point Cogeneration Plant	Biomass	x
German Creek Power Station	Waste Coal Mine Gas	x
Braemar 2 Power Station	Coal Seam Methane	x
Braemar 2 Power Station	Coal Seam Methane	x
Oakey Power Station	Natural Gas	x
Callide B Power Station	Black Coal	x
Gladstone Power Station	Black Coal	x
Barron Gorge Power Station	Hydro	x
Oakey Power Station	Natural Gas	x
Condamine Power Station A	Natural Gas	x
Wivenhoe Power Station	Hydro	x
Townsville Gas Turbine	Natural Gas	x
Callide B Power Station	Black Coal	x

Planned Power Generation projects:

Solar:	1200 MW
Wind:	675 MW
Biomass:	1.2 MW

Significant QLD Generators



Significant Generators:

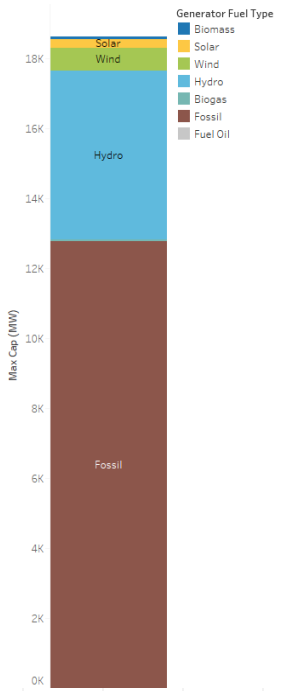
Black Coal provides base load.
Hydro also contributes to base load.
Gas Turbines and **C**oal Seam Methane provide Peaking Power.

Recommendations:

1. **S**olar Generation with Battery firming to provide Base Load power
2. **H**ydro generation for peak load generation
3. **B**io Renewables to supplement Gas as a fuel for peaking generation
4. **A**ddition of renewable generation to off-grid regions

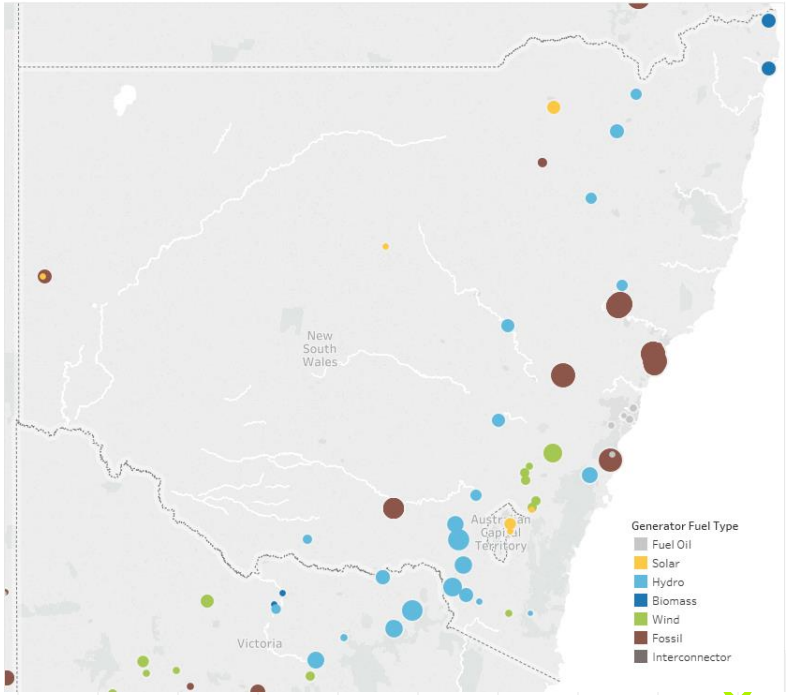
New South Wales

NSW Generation Types



Electricity in NSW is generated from a wide range of fuel sources.
NSW has interconnectors to both Victoria and Queensland
Maximum demand is expected to remain constant, offset by increases in installed PV capacity.
Maximum demand is currently summer peaking but is forecast to move to winter peaking due to solar installations.
Maximum demand is also expected to move later in the day (sunset) for the same reason.
Decommissioning of black coal generators will remove significant base load capacity.

Electricity Generators by Fuel Type



New South Wales Analysis

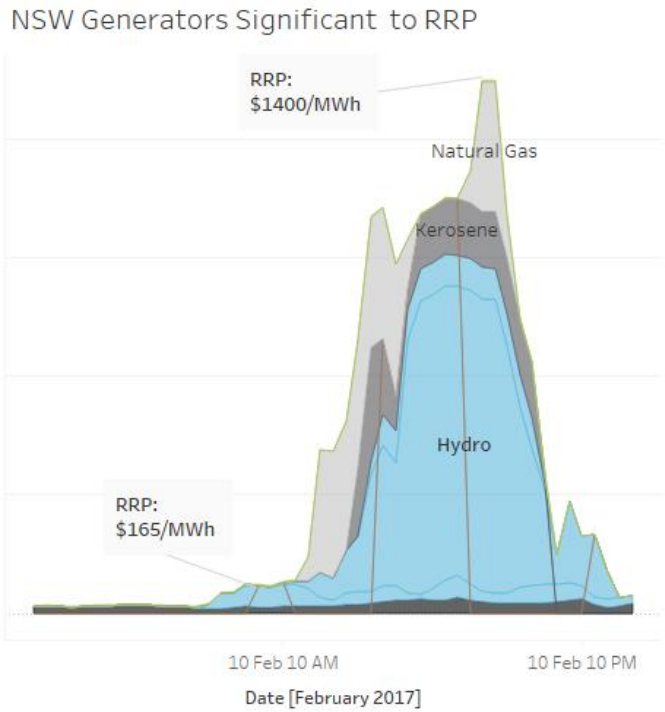
S16/17 Peak occurred on February 10th

Main predictors of RRP in Feb ‘17 were:

Generator	Generator Type	AGL
Hunter Valley Gas Turbine	Kerosene	√
Broken Hill Gas Turbines	Diesel	x
Colongra Power Station	Natural Gas	x
Guthega Power Station	Hydro	x
Tumut 3 Power Station	Hydro	x
Murray Power Station	Hydro	x
Interconnector	Interconnector	x
Boco Rock Wind Farm	Wind	x

Planned Power Generation projects:

Solar: 340 MW
Wind: 850 MW



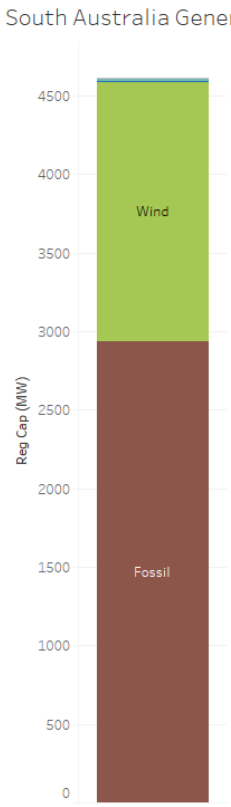
Significant Generators:

Gas & **K**erosene Turbines provide Peaking Power.
Hydro, **I**nterconnector and **W**ind provide Base load power

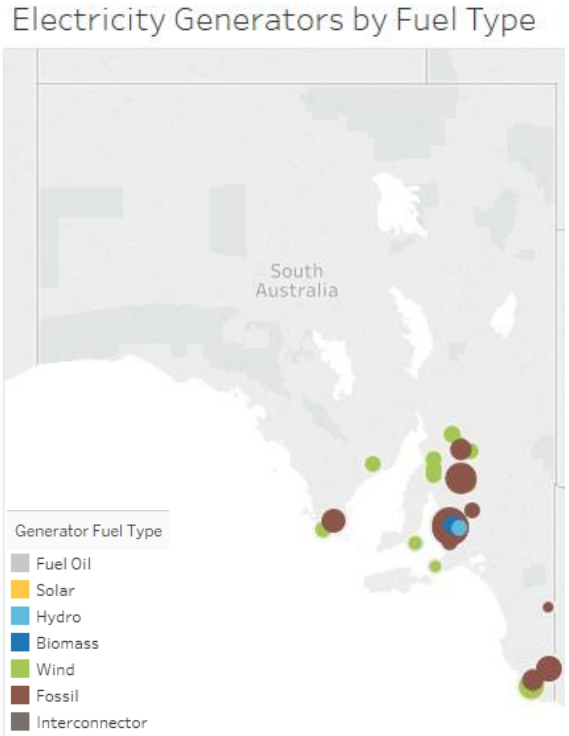
Recommendations:

1. Solar and Wind with Battery firming to provide Base Load power
2. Bio Renewables to supplement Gas as a fuel for peaking generation
3. Pumped Hydro to provide additional peaking generation

South Australia



Electricity in South Australia is generated in the most part from wind and natural gas. Small scale generators exist for Biogas and Hydro.
Diesel-fired power stations are used for peak demand and also used to service off-grid remote communities.
Maximum demand is expected to remain flat due to solar installations and increased energy efficiencies.
Maximum demand is expected to become negative in the middle of the day ie the state will become a net producer.
Barker Inlet Power Station (AGL), will replace two of the four Torrens Island A Natural Gas turbines.
Two Interconnectors connect SA to the eastern states.
Planned Battery Storage projects include 30 MW battery storage on Yorke Peninsula, west of Adelaide and 100MW storage battery adjacent to the Hornsdale wind farm.



South Australia Analysis

S16/17 Peak occurred on February 9th.

Main predictors of RRP were:

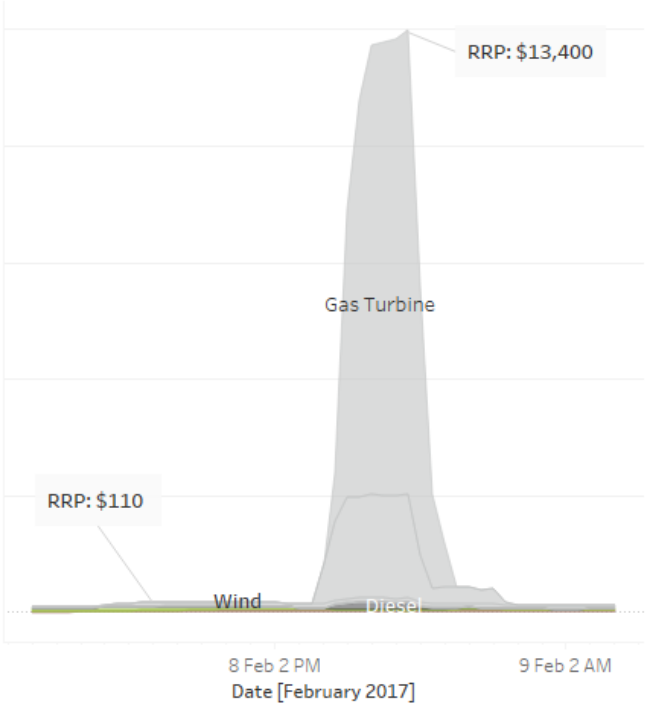
Generator	Generator Type	AGL
Dry Creek Gas Turbine Station	Natural Gas	x
Dry Creek Gas Turbine Station	Natural Gas	x
Port Lincoln Gas Turbine	Diesel	x
Snuggery Power Station	Diesel	x
Hornsdale Wind Farm 2	Wind	x
Hallett 2 Wind Farm	Wind	√
Lake Bonney Wind Farm	Wind	x
Torrens Island Power Station "A"	Fossil	√
Pelican Point Power Station	Fossil	x
V-S-MNSP1	Interconnector	x
V-SA	Interconnector	x
Osborne Power Station	Fossil	x

Planned Power Generation projects:

Solar: 480 MW

Wind: 427 MW

SA Significant Generator Profile



Significant Generators:

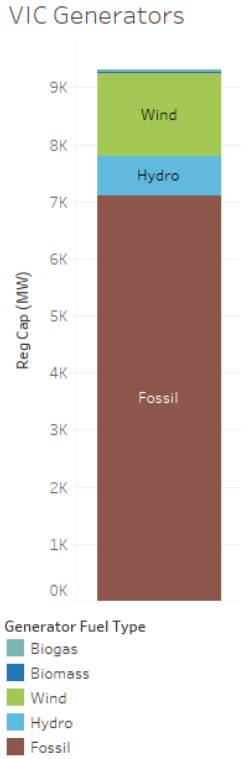
Wind and **I**nterconnector provide the Base load

Natural Gas and **D**iesel provide Peaking Power.

Recommendations:

1. **S**olar and Wind Generation with Battery firming to provide Base Load power
2. **B**io Renewables to supplement Gas as a fuel for peaking generation.

Victoria

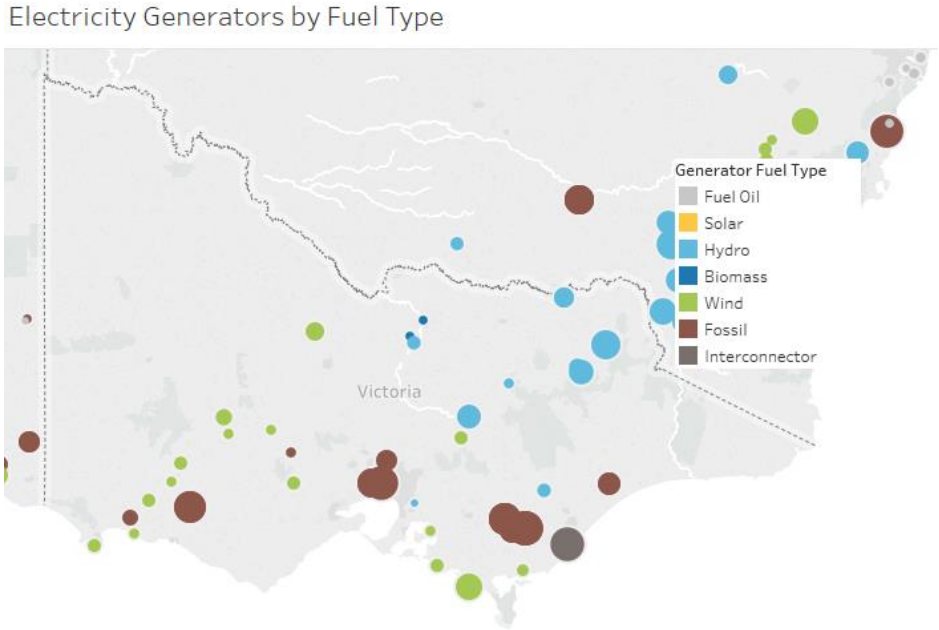


Electricity in Victoria is generated from coal, natural gas, hydro and wind.

Maximum demand in the short-term is expected to remain flat due to solar installations, with later increases due to increasing population and gas-to-electricity conversions.

Victoria is connected via interconnectors to NSW, SA and Tasmania.

Basslink, one Tasmania interconnector, is unregulated, deriving revenue by trading in the spot market.



Victoria Analysis

S16/17 Peak occurred on February 9th

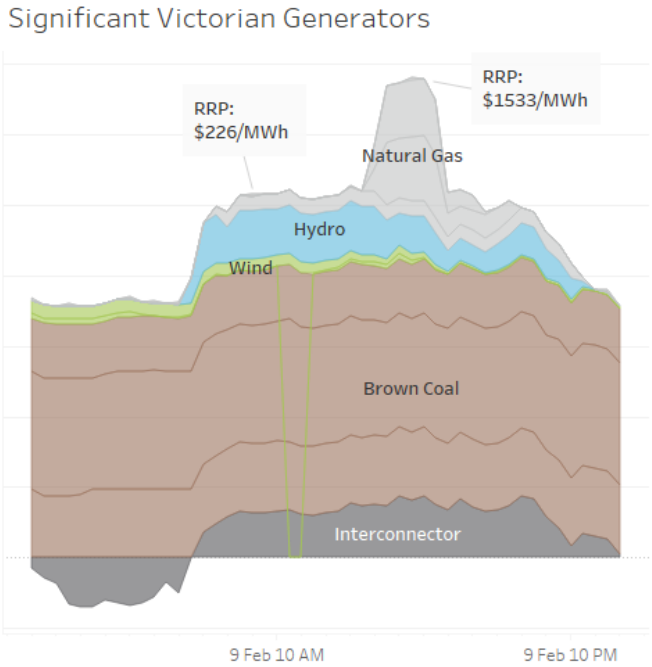
Main predictors of RRP were:

Generator	Generator Type	AGL
Jeeralang "A" Power Station	Natural Gas	x
Jeeralang "A" Power Station	Natural Gas	x
Jeeralang "B" Power Station	Natural Gas	x
Jeeralang "B" Power Station	Natural Gas	x
Mortons Lane Wind Farm	Wind	x
Loy Yang A Power Station	Brown Coal	√
Yallourn W Power Station	Brown Coal	x
Bogong / Mckay Power Station	Hydro	√
Interconnector	Interconnector	x
Loy Yang A Power Station	Brown Coal	√
Laverton North Power Station	Brown Coal	x
Mt Mercer Wind Farm	Wind	x

Planned Power Generation projects:

Solar: 71 MW

Wind: 900 MW



Significant Generators:

Brown Coal and Interconnector provide base load.

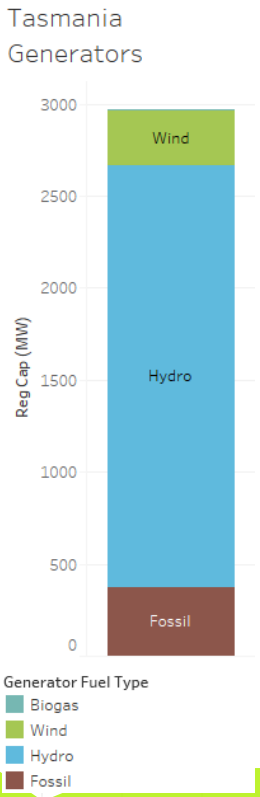
Hydro and **W**ind (when available) contribute to base load.

Natural Gas provides Peaking Power.

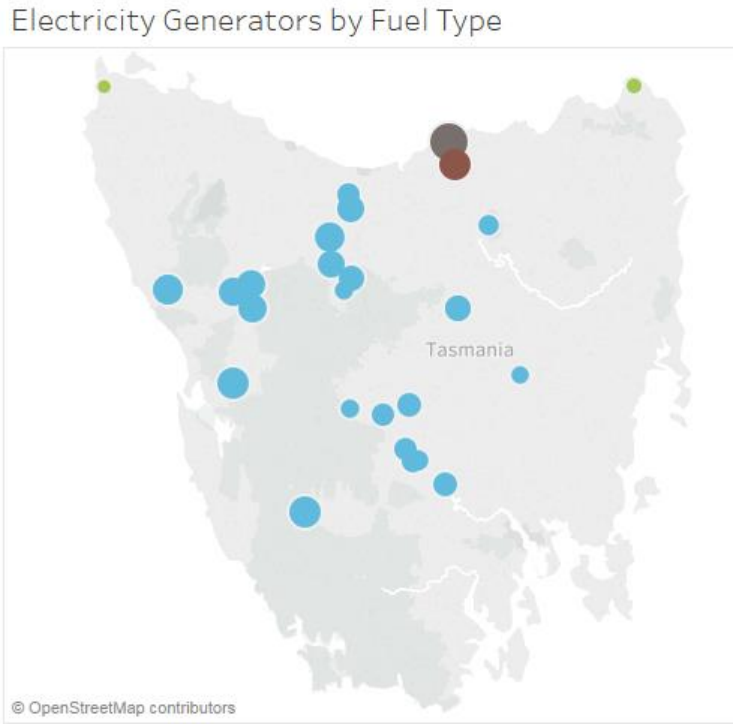
Recommendations:

1. **S**olar and Wind Generation with Battery firming to provide Base Load power
2. **B**io Renewables to supplement Gas as a fuel for peaking power.
3. **H**ydro reserved for peaking power

Tasmania



Electricity in Tasmania is generated from hydro, natural gas, and wind.
Hydro Tasmania, a State-owned company, operates and maintains an integrated system of 29 hydro power stations.
Natural gas is delivered from Victoria through an undersea pipeline across the Bass Strait from Victoria.
Interconnectors to Victoria are used to import or export electricity according to demand.
Tasmania is a winter-peaking system driven by heating load and is projected to have a slower solar uptake than other regions.
Maximum demand occurs in early evening.
In 2016, the Basslink Interconnector failed, requiring the state to rely on diesel generators and a gas-fired power station



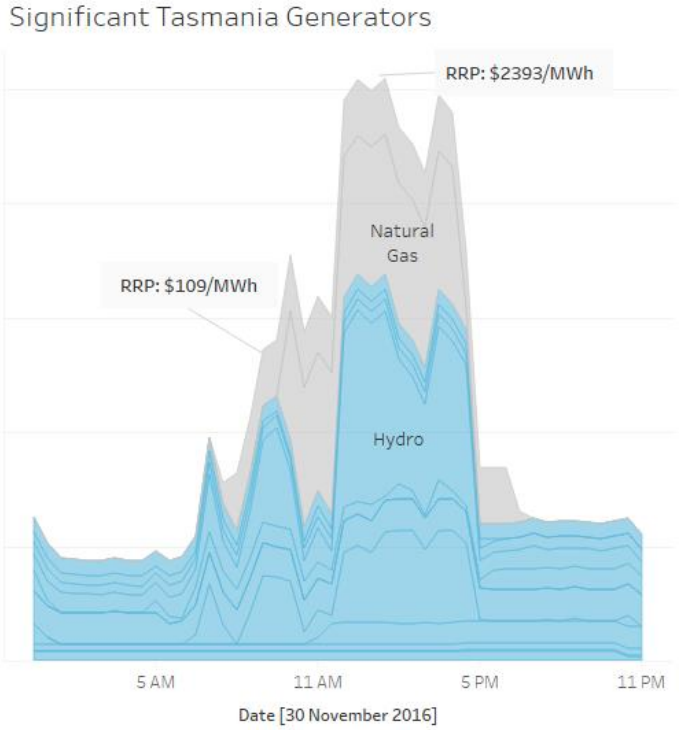
Tasmania Analysis

S16/17 Peak occurred on November 8th

Main predictors of RRP were:

Generator	Generator Type	AGL
Bell Bay Three Power Station	Gas Thermal	x
Tamar Valley Peaking Power Sta	Gas Turbine	x
Gordon Power Station	Hydroelectric	x
Rowallan Power Station	Hydroelectric	x
Poatina Power Station	Hydroelectric	x
Mackintosh Power Station	Hydroelectric	x
Tribute Power Station	Hydroelectric	x
Fisher Power Station	Hydroelectric	x
Trevallyn Power Station	Hydroelectric	x
Bastyan Power Station	Hydroelectric	x
Reece Power Station	Hydroelectric	x
Lake Echo Power Station	Hydroelectric	x
John Butters Power Station	Hydroelectric	x
Devils Gate Power Station	Hydroelectric	x
Tarraleah Power Station	Hydroelectric	x

There are no Planned Power Generation projects registered for Tasmania.



Significant Generators:

Hydro generation provides both Base Load and Peaking Power
Natural Gas provides Peaking Power when required.

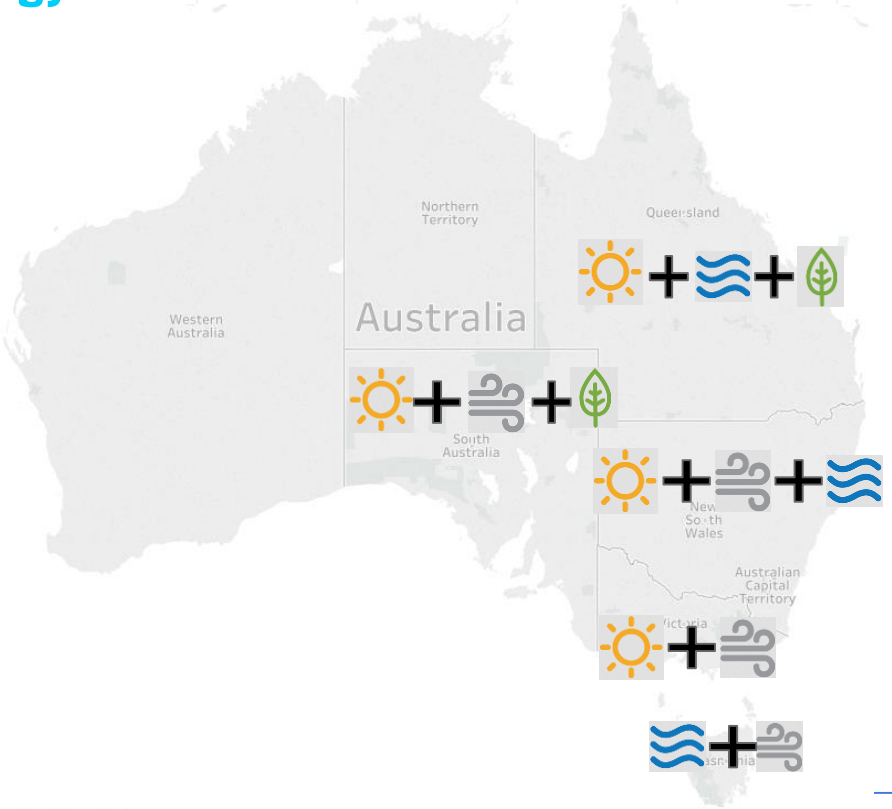
Recommendations:

1. **W**ind Generation with Battery firming for Base Load power
2. **B**iofuels to provide an alternative to Natural Gas

Conclusion

Conclusion : Future of Energy is Diverse and Distributed

-> Reduce Wholesale Cost by reducing the need for Gas generation through (Pumped)Hydro generation
-> Reduce Economic Cost by using lower cost Wind and Solar Generation
-> Address Societal Pressure by increasing proportion of Renewable generation
-> Reduce Customer Pressure by using Biofuels to supplement Fossil fuel generation



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Any questions?