“The sun doesn’t always shine, and the wind doesn’t always blow” – that’s a common refrain. So, how can Australia be powered on 100% renewables with the same levels of reliability that we enjoy today? A lot of the solution lies not in the technology, but in changing our mindset about ‘baseload’ power.

At a glance...

• ‘Baseload’ power is a concept rather than a physical requirement of a reliable energy system. The majority of Australia’s ‘baseload’ energy comes from high polluting coal-fired generators of which 75% are already beyond their intended operating life.

• To enjoy clean air and reduce carbon pollution Australia will need to shift to 100% renewable energy by 2035. This is possible, affordable and desirable.

• The concept of ‘baseload’ power becomes redundant under a 100% renewable energy grid. Current technology could allow Australians to keep the lights on 24/7 using only renewable energy. Emerging battery storage can make this process smoother and cheaper.

• Major figureheads of international energy companies within some of Australia’s largest trading partners acknowledge there will be no need for ‘baseload’ power as we know it today. Achieving 100% renewable energy is already a reality in some countries.

• With key market reforms in place to manage the energy transition, Australians can comfortably let go of the mindset of ‘baseload’ and have confidence in a modern, reliable, renewable energy sector powering our future.

Acknowledgement

This report was prepared by WWF-Australia. Original report authors: Adrian Enright. This report includes added contributions from industry experts. It does not necessarily reflect the formal position of the participating organisation.
TODAY’S BASELOAD...

Australia’s electricity is principally derived from coal and gas, followed by renewable energy (Figure 1). Coal and gas are often referred to as baseload power; that is, they can provide power 24 hours a day 7 days a week, and at the moment provides the minimum power demand. However, coal-fired stations in Australia generally operate at a higher level than is needed to satisfy the minimum level demanded so as to meet most of the intermediate and some peak load. This results in excess energy being produced, which is inefficient.

What most don’t understand is that baseload power is a concept rather than a physical requirement for a reliable energy system. The term baseload is a description of the minimum level of demand over some timeframe. However, coal-power stations can’t ramp up and down quickly, and were built to be most efficient when running almost full-tilt all the time. The reality is that electricity usage is variable, demand changes throughout the day and night, and Australia doesn’t need baseload power generation.

There is a clear environmental and economic motivation to immediately shift towards renewable energy in Australia. Renewable energy is now cheaper to build than new coal and gas, and the impacts on our air quality and health from burning fossil fuels is now better understood. Shifting towards clean, renewable technologies will also help Australia play its role in cutting carbon pollution and avoiding dangerous levels of global warming.

Numerous studies have shown that achieving 100% renewable electricity by 2035 is possible with existing technology. Other studies show that it’s desirable among the majority of the Australian population. Other studies show that 100% renewable energy can be cheaper. The recent ‘Home Grown Power Plan’ (2016) models that between now and 2050, the shift to renewables and increased energy efficiency could deliver enough fuel-cost savings to cover 110% of the bill for building 100% renewable power. Australia could save, on average $9 billion a year on power sector fuel costs.

For these benefits to materialise, the electricity grid needs to become more flexible by phasing out ageing, high polluting coal burning generators and replacing this capacity with modern, renewable technology.

This renewable capacity is already starting to gather pace. For example, around five million Australians live under solar rooftops and have installed more generating capacity (over 4GW) than Australia’s largest coal burning generator, Loy Yang. However, the bulk of our power supply still comes from ageing (Table 1) and highly polluting sources. In particular, around 75% of our existing coal generator fleet is passed its design life. In 2014, almost 30% of the nation’s coal-fired electricity was more than 40 years old. This will rise to 45% by 2020 and 65% by 2030. Australia also ranks in the top ten global emitters of CO2 from burning fossil fuels for power. This places Australia in a rather unique position as a world leader in household solar uptake, but global energy laggard in terms of our ageing, high polluting baseload power capacity.

* Assuming a design life for thermal plant is 25-30 years as per Nelson et. al. 2014.
Despite evidence to show 100% renewable electricity is doable, some residual questions remain; how will Australians keep the lights on as we make this transition? What will happen to what we now know as our reliable baseload supply?

Table 1: Australia’s oldest operating power stations (Climate Council, 2014)

<table>
<thead>
<tr>
<th>State</th>
<th>MW</th>
<th>Fuel</th>
<th>Commissioned</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAZELWOOD</td>
<td>VIC</td>
<td>1600</td>
<td>Lignite</td>
</tr>
<tr>
<td>CALLIDE</td>
<td>QLD</td>
<td>1720</td>
<td>Black Coal</td>
</tr>
<tr>
<td>LIDDELL</td>
<td>NSW</td>
<td>2000</td>
<td>Black Coal</td>
</tr>
<tr>
<td>MUNMORAH</td>
<td>NSW</td>
<td>600</td>
<td>Black Coal</td>
</tr>
<tr>
<td>PLAFORD</td>
<td>SA</td>
<td>240</td>
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</tr>
<tr>
<td>MUJA</td>
<td>WA</td>
<td>974</td>
<td>Black Coal</td>
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</table>
Figure 2 illustrates what our power system currently looks like, versus what it could look like under 100% renewable electricity.

The present system (on the left) includes a large capacity of baseload generation that operates most of the time, with peaking and intermediate plants ramping up and down to meet peaks in demand. In a renewable system (on the right), the variable renewables (e.g. wind and solar) will provide the bulk of the energy, and dispatchable renewables (e.g. concentrated solar power with thermal storage) will ramp up as required to fill the gap and meet the demand. In this modern, clean electricity supply market, we maintain the reliability needed to keep the lights on by shifting from ‘baseload and peaking’ supply to a ‘variable and dispatch’ model.

Modelling by the Centre for Energy and Environmental Markets (CEEM) has demonstrated that variable renewables act primarily to displace baseload generation in the system, and partner ideally with larger amounts of intermediate and peaking plants (such as hydro and biogas turbines).

Some may question that this reliance on variable renewables introduces unreliability into the electricity market. However, even with a very basic understanding of weather forecasting we have a good idea of when the sun will shine and when the wind will blow to a level of certainty required to ensure renewable energy replaces what we used to know as ‘baseload’. More sophisticated wind and solar radiation forecasting systems are also being developed by major scientific bodies, such as the National Oceanic and Atmospheric Administration (NOAA) and alongside major corporate organisations, including IBM. Such technologies will only strengthen the confidence in the reliability of a 100% renewable electricity system.

Other renewable energy that is stored either in batteries (see section ‘Do we need to rely on batteries?’) or as pumped hydro for example can be used to fill in the gaps where required*. Pumped hydro in particular has reliable capacity to deliver energy on demand and is a very well proven technology. For example, the companies operating the Snowy Mountains and Tasmanian Hydro power stations have refined their output strategies to make the most of the wholesale spot market so are already adept at being highly responsive to demand and are much more nimble than coal-fired power stations that can take hours or days to increase capacity. Furthermore, there are increasingly sophisticated demand management systems and pricing strategies that can provide even greater assurances around reliability.

* Recognising that hydroelectricity must be considered against other environmental impacts including changes to flow regime of rivers and the knock-on impacts this can have on biodiversity.
ISN’T NUCLEAR A BETTER WAY TO GO?

Nuclear energy is also often touted as a replacement baseload power solution for Australia. However, apart from not being needed under a renewable ‘variable and dispatch’ model, the costs of establishing, operating and cleaning up nuclear power plants does not stack up next to the mix of renewable options in Australia.

International experience shows that over 150 nuclear power stations globally currently lie idle either because they’re too expensive to run or because of concerns about their safety or age. Governments and industry are left facing a bill in the order of $1 trillion worth of liabilities from these retiring plants.
DO WE NEED TO RELY ON BATTERIES?

Modelling to date consistently suggests that battery energy storage is not required to reliably operate a 100% renewable electricity system. It is estimated that Australia has enough solar and wind capacity alone to power the country 500 times over. This capacity is also significantly geographically dispersed which means there is sufficient and consistent renewable capacity available across the country. This also allows for system flexibility and affordability without any need for batteries.

However, as the price of battery technology continues to fall, it may become cost effective to install some battery storage. This will be particularly useful where batteries can defer investment in distribution networks.

Battery storage can be located at the centralised wind and solar power production site to smooth the variable generation output as it is fed into the grid. It can also store excess renewable production for later.

Smoothing renewable energy production is important for maintaining system reliability (and avoiding ‘blackouts’) and managing voltage concerns by preventing the very short-term fluctuating nature of variable renewable energy before feeding it into the grid.

Battery storage will also likely play a significant role in household and other decentralised systems by allowing people to store energy generated throughout the day and either use this at night, or sell excess energy back to the grid. Such systems will require supporting policies to ensure the owners of decentralised systems are appropriately compensated for the energy they produce.

The fall in battery price technology

The dramatic fall in prices of battery storage systems have helped put the role of batteries in a modern electricity system (Figure 3) front and centre. This has translated into optimistic forecasts around the uptake of battery storage technology globally (Figure 4).

Back home in Australia, household battery costs fell by a third in six months in 2015. US inverter maker Enphase has predicted that battery storage costs and prices will halve by 2020.

Figure 3: Lithium-ion cost curve and estimates (Bloomberg New Energy Finance, EIA: Energy Information Administration)

Figure 4: Worldwide forecast of battery storage capacity (MW) and annual revenue (USD) for utility-scale applications (Bloomberg New Energy Finance, EIA: Energy Information Administration)
The Institute of Sustainable Futures has modelled that with more renewables and storage, peak period electricity prices will halve in Australia over the next 20 years⁶⁶. This is in part driven by the fact that once the renewable energy capacity is built, the cost of producing each additional unit of electricity is close to zero. This then makes the relative cost of coal-fired generation expensive because it has to mine and then burn coal to operate.

There will likely be short-term adjustment costs in making the transition to more renewables. However, the size of this will ultimately depend on the appropriate transition of the network and when this is done. The longer the necessary transition is delayed, the costlier it will become⁶⁷.
A shift towards 100% renewable electricity will require a shift in Australia’s mindset away from a reliance on baseload power to one of a modern ‘variable and dispatch’ model. In making this shift, Australia will be in good company.

Take China for example. In February 2016, the chairman of State Grid (China’s biggest network owner), Mr Liu Zhena played down the role of coal as a critical source of ‘baseload’ power. “The only hurdle to overcome is ‘mindset’,” Liu said. “There’s no technical challenge at all.”

In Germany, 50 Hertz, the company responsible for more than one-third of Germany’s electricity grid, says there is no issue absorbing high levels of variable renewable energy such as wind and solar, and grids could absorb up to 70% penetration without the need for storage.

“It’s about the mindset,” says Boris Schucht, the CEO of 50 Hertz. “10 to 15 years ago when I was a young engineer, nobody believed that integrating more than 5% variable renewable energy in an industrial state such as Germany was possible.” However, in the region Schucht operates in, 46% of the power supply comes from wind and solar. Next year it will be more than 50%.

Meanwhile in the UK, Steve Holliday, CEO of National Grid who operates the transmission network in the UK, gave his take on what modern baseload energy may mean, saying; “The idea of baseload power is already outdated. I think you should look at this the other way around. From a consumer’s point of view, baseload is what I am producing myself. The solar on my rooftop, my heat pump – that’s the baseload.”

Furthermore, in May 2016, Portugal was powered by 100% renewable energy for four days straight. The country’s boom in wind and solar resources has positioned it to become a net exporter of renewable energy to neighbouring countries. Denmark has had similar experiences recently where it has produced in excess of 100% of its demand from wind energy, allowing it to export the excess renewable energy to Norway, Germany and Sweden.

In Australia, 100% renewable energy has already become a reality in given periods. For example, South Australia has achieved 100% renewables across whole working days. On particular days the output from renewable energy in the state has outstripped demand. The ACT will soon rely on 100% renewable energy. Under recent announcements, the nation’s capital will achieve 100% renewable energy by 2020 using a mix of wind and solar, as well as large existing hydroelectricity capacity.

To support this transition further, it is vital that Australia urgently review its energy market frameworks to integrate them with climate change policies.
SO, WHERE TO FROM HERE?

The transition to 100% renewable electricity by 2035 is inevitable, affordable and necessary to put the brakes on Australia’s carbon pollution from electricity generation. To achieve this, however, Australia needs to put in place the structures to manage the transition to the new energy paradigm. These changes will facilitate the shift towards more renewable capacity being built and will instil confidence among Australian households of the overwhelming opportunity to tap into our inexhaustible renewable potential. As a first step, key market reforms are necessary. This will allow the mindset of baseload to become a concept of our 20th century history rather than letting it hold us back well into the 21st.
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To stop the degradation of the planet’s natural environment and to build a future in which humans live in harmony with nature.

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WWF-Australia National Office
Level 1, 1 Smail Street
Ultimo NSW 2007
GPO Box 528
Sydney NSW 2001

Tel: 61 2 8228 6800
Freecall: 1800 032 551
Fax: 61 2 9281 1060
Email: enquiries@wwf.org.au