THE UNIVERSITY OF MELBOURNE

ENERGY Research Institute

A research collaboration

# Frequently asked questions

# Zero Carbon Australia Stationary Energy Plan

beyond ZERO emissions

## Questions



*Note: these are intended only as a brief answer to FAQ's. For most questions, there is further detailed information and references in the full Report, but this cannot be fully reproduced in the FAQ due to the space it would take up! Therefore, if you would like further information, please read the relevant section of the Stationary Energy Report.*

Q

## What is the basis for the costs in the Plan? Can it really get that cheap?

A

**Yes, the cost of renewable energy is continuously declining—the costs in the ZCA Plan are based on the best available real-world industry data taking into account known cost reduction potentials from industry scale-up.**

*Want to know more?*

The technology costs in the Zero Carbon Plan are based on what could occur if a large-scale rollout of renewable energy goes ahead. Policy certainty can create an ongoing pipeline of projects which helps the industry establish efficient manufacturing practices and supply chains, as well as economies of scale of construction. Therefore the costs of wind and solar thermal start from the cost of today's projects, but take into account future cost reductions.

The process by which renewable energy is continuing to get cheaper has already been observed around the world, with the continuing learning curves observed in the relatively mature markets of wind (10% historic learning rate per cumulative doubling of capacity) and solar PV (20% historic learning rate) being leading examples.

It should also be pointed out that most of the extra costs of grid connection are covered separately in the ZCA Plan with the use of dedicated transmission lines. The high-voltage power lines and substations are costed separately under the Transmission Upgrades section in Part 5. In many of today's smaller renewable energy projects, the costs of grid connection are included in the overall project costs.

**Wind Power** – the cost of wind farms in Europe is already cheaper than they are in Australia, as their industry is larger, more mature and has access to efficient manufacturing and supply chains. Furthermore, the introduction of cheaper wind turbines from Chinese manufacturing is also expected to lower the costs of projects, currently by around 25%. Goldwind, a leading Chinese wind company, is planning on producing 6MW permanent magnet direct-drive turbines by 2012, similar in size and scale to the Enercon E-126 turbines recommended in the ZCA SE Plan. The E-126 is already operational at commercial on-shore wind farms in Belgium and Germany, originally rated at 6 MW, it has now been found to actually be capable of producing 7.5 MW at peak output.

**Chinese-made permanent magnet direct-drive wind turbines.**

http://greenenergyreporter.com/wp-content/uploads/2011/02/Goldwind-Pipestone-turbines.jpg

See Appendix 3B, p146 for more details.

Enercon GmbH 2010, *E-126/7.5MW*, http://www.enercon.de/en-en/66.htm, Accessed 17 Dec 2010

Energy China Forum 2010, *China's Goldwind plans to start production of 6MW turbines*, http://www.energychinaforum.com/news/39323.shtml, Accessed 20 Dec 2010

**Solar Thermal Power** – The factors by which concentrating solar thermal power (CST) will be able to reduce costs are well-understood, and have been studied, documented and quantified by reports from the U.S. Department of Energy's Sandia National Laboratories, National Renewable Energy Laboratories, Sargent & Lundy Consulting LLC, ESTELA with A.T. Kearney & Associates, EPRI, Boston Consulting Group, the European NEEDS project, Goldman Sachs, and the International Energy Agency, in varying degrees of detail.

The main factors are:

- Economies of scale from larger projects. Currently, most existing CST plants are in the range of 50MW or less. There are no technical limitations to scaling up to 200-250MW per unit, which are significantly cheaper on a per-MW basis. Using an already hired and trained workforce to build the larger tower, turbine block, tanks, piping systems and all the components double the size is less than double the price – this is true for any construction project. Having sister projects in the same location one after the next also aids this process.
- Mass-manufacture of components. A major part of the capital cost of a CST power plant is in the mirror field. The heliostats are manufactured en masse in facilities similar to car factories, and once the production line and workforce is set up, producing hundreds of thousands of components per year is cheaper per unit than just a few thousand. As an industry grows it creates a steady and high demand allowing factories to reach higher, more efficient utilisation. This process is what makes most consumer goods in the world cheap today.
- Learning from experience. Unleashing the potential of world-leading engineering and construction firms onto a market is able to create more efficient ways of building the technology through learning experience during the project development and construction. For example, leading Spanish engineering firm SENER, who have decades of experience in the conventional fossil and nuclear power sectors, have recently entered the CST industry. SENER has developed a new type of parabolic trough assembly which can be manufactured five times faster than the previous technology —from this single innovation on a type of CST technology that has been around commercially for over 20 years.

The costs of CST in the ZCA Plan are based on today's initially higher costs, for SolarReserve's power towers, but taking into account future cost reductions allowing conservatively for high costs in the initial years. The Sargent & Lundy report that is mainly referenced is to this date still considered the gold standard of the solar thermal industry, with the most extensive analysis and transparent methodology. ZCA is in constant contact with the industry and research institutions to further develop CST cost estimates for future work.

See sections 3.1.3, 3.1.9, and Appendix 3A for more details.



**PS20 concentrating solar thermal power tower near Sevilla, Spain.**

Q

## Can renewable energy really supply 100% of demand reliably? Is 17 hours storage enough? What if there are several cloudy days in a row?

A

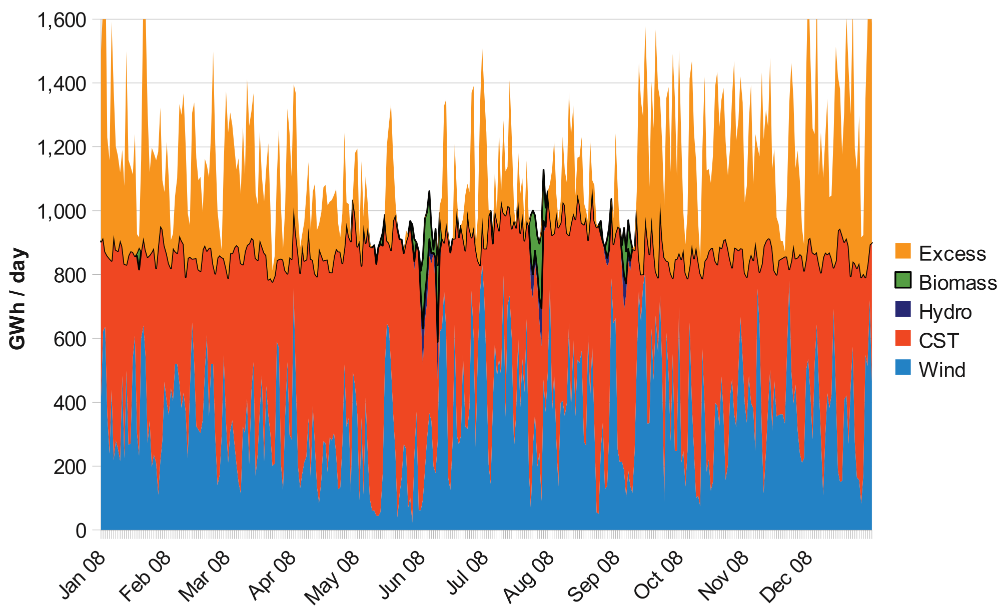
**Part 4 of the Plan has the detailed modelling that was carried out on the ZCA generation mix. Using real-world solar, wind and demand data, it has shown that the chosen mix is capable of meeting Australia's electricity demand, 24 hours a day, 365 days a year.**

*Want to know more?*

The inputs into this model were:

- Demand data from the actual National Electricity Market, scaled up to represent the higher electricity demand in 2020. This is publicly available from AEMO.
- Actual solar insolation data from at or near each of the 12 solar locations chosen for the Plan.
- Wind data from existing wind farms in South-Eastern Australia, publicly available from AEMO and shown in graphic form on http://windfarmperformance.info/. This was initially the best available wind data, however due to its limited geographical diversity (mainly South Australia and Victoria) and that only some sites had a full two years worth of operational data; it is not truly representative of the wind power envisaged under the ZCA Stationary Energy Plan. More wind farms spread over a more geographically diverse area would have lower maximum peaks and higher minimum output per unit of capacity installed.

The modelling has been carried out on half-hourly timescales using this data. Many people ask questions such as "what if there are several cloudy days in a row over the solar thermal plants?", or "won't there be some times when there is no wind blowing?". Cloud cover over one solar thermal site is not an issue, as there is extra capacity at other sites that can provide power. When the wind is blowing, more salt can be held back in the tanks for later use. The key design periods are the extended coincidence of low wind and cloud cover over a number of sites at the same time. The modelling shows that this only occurs on a few occasions per year, and the biomass backup of the CST plants is sufficient to meet this shortfall.




**ZCA2020 solar/wind/demand electricity modelling results for 2008 data.**

Q

## Why only wind power and concentrating solar thermal? What about other zero emission energy technologies?

A

**The ZCA Plan only looked at commercially available technologies that will produce zero greenhouse gas emissions during operation that can be built in Australia within the timeframe considered. Should other technologies that meet this criteria become available at a comparable cost, they will strengthen the reliability and affordability of the system.**

*Want to know more?*

A key parameter of the ZCA Project is to only consider technologies that are already commercially available, that is, companies are already building and offering the technology, and it is scaleable to meet a large proportion of Australia's energy needs.

Currently, wave and geothermal power are not yet being offered at commercial scale – they are still in the development and testing phases. In particular with geothermal, Australia's 'hot dry rocks' resource from radioactive granite is fundamentally different to the more volcanic types of geothermal already operational in places like Iceland, New Zealand, the Philippines etc. Offshore wind is unlikely to be necessary in Australia due to our vast onshore wind resources, though it clearly has an important role in places like Europe. The higher and stronger windspeeds available do not yet offset the extra capital costs of offshore installation. Should more renewable energy technologies such as these and others become commercially available in the next few years at a comparable or cheaper cost, they would be included in our modelling. The ZCA scenario, which is only one possible scenario of many, shows that a 100% renewable grid can be achieved even with existing technologies, so the addition of different technologies will likely improve the reliability and affordability of a 100% renewable energy system.

Nuclear power was not considered primarily due to the timeframe requirements for designing and building the infrastructure, not only the actual construction period but taking into account the lack of any legislative framework for nuclear power in Australia.

Even in Western countries that have existing nuclear power programs it can take 10-15 years to complete a single reactor, impacting considerably on the economics. The only recent nuclear power plant that is being constructed in a Western country, the Olkiluoto 3 plant in Finland, is several years behind schedule and billions of dollars over budget. Industry representatives such as Ziggy Switkowski have commented that it would take at least 15 years before a reactor could be built in Australia, even if the current government policies prohibiting its development were overturned. Whilst any transformation of the Australian energy system on the scale proposed by the ZCA2020 Plan will necessarily require significant changes to policy and prioritisation of planning, it is not expected that nuclear power could significantly contribute to emissions reductions in the scale and timeframe considered here, whereas the renewable technologies specified have been scaled up rapidly in recent years. It is also noted that despite considerable development and safety reviews, there are no successful Generation III+ plants operating in the world. While countries like China are pursuing nuclear power, most of their plants are older Generation II designs, no longer considered in the West due to their lower safety precautions. It is noted that industry leading nuclear power company AREVA is diversifying into wind and solar thermal power, with their recent acquisitions of Multibrid (wind) and Ausra (solar thermal) being a core part of their growth strategy.

Carbon capture and sequestration (CCS) does also not yet meet the parameter of being a commercially available technology, nor is it expected to be a zero-emissions technology if it is shown to be technically workable ($CO_2$ capture systems on fossil power plants are not expected to capture 100% of emissions). It remains to be shown that CCS is a scaleable and affordable technology given the lack of geological storage in some key coal power producing areas. It is not expected that CCS will be meet the ZCA parameters in the necessary timeframe.

There is large potential for rooftop solar PV, balanced by centralised solar thermal plants with cheap storage. Future work of the ZCA Project will test lifting the initial assumption of 10% of Australia's energy from rooftop solar up to 20-30%.

Solar PV is a mature, commercial technology for producing electricity from solar power. However as it is relatively modular to install, and storing the electricity is relatively expensive, it is better suited to distributed generation on rooftops and commercial/industrial buildings. Centralised generation is best suited to solar plants with storage, which can continuously provide the firming power for variable wind and PV. For the ZCA Stationary Energy Plan, rooftop solar was treated as a form of energy efficiency, with an initial estimate that 10% of Australia's energy could come from rooftop solar PV and hot water, at all scales. In the Zero Carbon Australia Buildings Plan, the potential for onsite renewable generation from solar hot water and PV will be further quantified, and may be increased to 20-30% of Australia's energy generated from rooftop solar. Once these numbers are known in more detail, they will be fed back into an update of the Stationary Energy Plan.

ABC, Mar 17 2009, "Aussies will accept nuclear power, conference told", http://www.abc.net.au/news/stories/2009/03/17/2518340.htm

Project Business Research Group, 2010, "Case 3 Olkiluoto Nuclear Power Plant", http://crgp.stanford.edu/events/presentations/CRGP_Alto_2010/Case_1/Olkiluoto_3_case_workshop_1.pdf, Aalto University, Finland

**Commercial-scale rooftop solar PV array.**

Q

## Part 2 of the ZCA Stationary Energy Plan describes how Australia's energy use can go from almost 4000PJ/yr to less than 2000 – how can this be done without decreasing our quality of life?

A

**Most of the energy we consume is wasted due to inefficient motors, heaters and other conversion technology. The ZCA Plan will reduce this waste and leave us using a level of energy per capita comparable to other modern industrialised economies.**

*Want to know more?*

Not all energy is equal. A key parameter of the ZCA Plan is to deliver the same if not better quality of energy services as today, but doing so more efficiently. The major reductions in energy use come from both increased efficiency of current services, but also the step-change efficiency achievable through electrification of services currently supplied through fossil energy. While we put a lot of fossil fuel energy into our cars, heaters and machinery, they are inefficient conversion devices. Electrical devices can deliver the same if not better services with less energy. Electric vehicles are four to five times more efficient than petroleum vehicles, and using rail where ever possible uses even less energy per passenger or tonne of freight again. Heat pumps can deliver quality heating with a third or less of the equivalent fossil energy requirements. Australia uses significantly more energy and electricity per capita than other rich industrialised countries like Germany, Japan, Spain, or the UK. Even taking into account differences in geography and industries, there is significant scope to improve the efficiency of Australia's energy use, especially as our historically low energy prices have offered little previous incentive for valuing energy efficiency.

This is outlined in more detail in Part 2.3 and Appendix 1, and will be further developed in the separate Buildings, Transport and Industrial Processes ZCA reports.

Q

## Isn't wind too variable? Won't it always require backup?

A

**No. Wind turbines dispersed across a large geographical region will mean that some wind power is always being generated.**

*Want to know more?*

A study from the US National Renewable Energy Laboratories which modelled several scenarios of wind turbines dispersed across the eastern half of the U.S.A. found that at least 16%, and as high as over 30% of the rated capacity was available with the same reliability as conventional baseload power (99.97% reliability on a Loss Of Load Probability analysis), depending upon the transmission interconnections. As wind turbines usually run at around 30-35% capacity on an annual average basis, this means approximately half of the electricity coming from wind power is 'baseload'.

However, the half-hourly modelling in Part 4 has in fact not used this 16% as a floor, it is more conservative. It is based on data from existing wind farms in South-Eastern Australia (SA, VIC & southern NSW) scaled up to represent the 50,000 MW of proposed capacity under ZCA2020. As more wind data from other states (QLD, WA and northern NSW) becomes available, this will likely smooth the wind output in the model, meaning lower peaks and higher troughs. At this stage, using this more limited data means that there are times when output dips below 16%.

Corbus, D. et al 2010, *Eastern Wind Integration and Transmission Study*, National Renewable Energy Laboratory, pp202-203, http://www.nrel.gov/wind/systemsintegration/ewits.html, Accessed 24 Jan 2010

Q

## What about the extra investments that need to be made in efficiency and electrification?

A

**These will be costed in detail in the Buildings, Transport and Industrial Processes Plans. Initial investments in efficiency are offset by the energy bills saved over their lifetime, which result in fast paybacks.**

*Want to know more?*

The ZCA Stationary Energy Plan has costed the large-scale renewable energy infrastructure and transmission. It has not costed the investments that will be made in retrofitting buildings, installing onsite renewable energy, switching gas and oil services to electricity, rolling out new rail infrastructure etc. These will be covered in the separate Buildings, Transport and Industrial Processes Plans.

However, these investments must be compared against the fossil energy bill that they will avoid. Oil prices are rising, as are gas and coal prices – the modelling in Section 7 shows that under Business-As-Usual, Australians will collectively be paying hundreds of billions of dollars on conventional fossil energy over the next few decades. This money that would otherwise be spent on oil and gas can be considered a 'budget' or 'fund' that can be better spent investing in efficiency and electrification.

Overall, it is expected that the full suite of Zero Carbon Plans will save households and businesses money. Once it is built, the renewable energy infrastructure will have a constant and known price of electricity, hedging Australians against volatile and rising fossil energy prices.

Q

## How will an electric transport system work? What about long-distance transport? Don't electric vehicles have a poor range?

A

**All the technology required to run a fully renewable power transport system exists today – electric rail, electric vehicles and biofuel hybrids. This will be fully detailed and costed in the ZCA Transport Plan.**

*Want to know more?*

The full requirements of a zero carbon passenger and freight transport system will be detailed extensively in the Transport report. However the basic concepts can be explained quickly:

- Long distance passenger and freight movements are largely replaced with new electrified rail services, extending the regional network and using 350+km/h High Speed Rail for high volume corridors.
- Intracity movements will also undergo a significant mode shift to upgraded heavy metro rail and light rail networks in major settlements, including some shifting of freight from intercity distribution hubs closer to point-of-demand.
- Electric vehicles can be used just like today's vehicles for tasks that cannot be met with electric rail. This includes final point-to-point delivery of freight using electric trucks; currently commercially available models are up to 12 tonnes gross with up to 240km range. Electric cars are quiet, clean and cheaper to run than a petrol car, with ranges of 160km and greater sufficient to cover the vast majority of journeys.
- There is scope for some small use of biofuels (that do not compete with food sources) for services that cannot be electrified, along with rapid recharging, battery-swapping or other options for the few times when electric vehicles travel further than their battery range in a single journey. This is limited by the amount of biofuel that can be produced sustainably without food production competition.

Q

## What about the local environmental impacts? Land, water use etc?

A

**The net local and global environmental impacts of renewable energy are small, and lower than the conventional fossil alternatives.**

*Want to know more?*

Along with the greenhouse gas carbon dioxide, coal and gas power plants release locally detrimental emissions such as SOx, NOx and P10 particulates causing respiratory illnesses, and toxic substances such as mercury and arsenic. The mining is often done on otherwise prime agricultural land.

There are next to no toxic materials used in solar thermal plants and wind farms. Direct-drive wind turbines don't even use lubrication oil as they have no gearboxes. The nitrate salts used for storing solar thermal energy, are relatively harmless and otherwise widely used in agriculture as fertiliser.

Wind turbines do not use any water, and the solar thermal plants specified in the ZCA Plan would use air-cooling, requiring 90% less water than a conventional thermal power plant using water-cooling. The water used in the steam cycle is continuously condensed and recycled, requiring only an occasional top-up. Water is also used in high-pressure waterjets for mirror washing, usually on a cycle of one wash every few weeks. This water use is minimal, and an initial assessment of water availability at the ZCA solar sites indicates that the solar thermal water use is small compared to existing water consumption and availability. More detailed studies would need to be conducted, and there are options for using dust-repellent mirror coating films to further reduce wash water requirements in particularly water-sensitive areas.

Wind turbines have a very small footprint and can be co-located on farmland that is continued to be used for agricultural purposes. Solar thermal plants do require land for the mirror arrays. However, solar thermal plants are well-suited to be placed in regional areas where there are large amounts of farmland becoming degraded and of low-value for continued agricultural use. Using this land for producing renewable energy would be a higher-value use than marginal farm production. Analysis in section 3.1.7 (p57) indicates that land use competition is not expected to be a significant issue for solar thermal power in Australia, given the relatively small land requirements for CST, all twelve sites would require 0.035% of Australia's total landmass.

The ZCA Plan does certainly not propose placing renewable energy infrastructure in areas of high environmental conservation value, e.g. National Parks.

**Enercon 7.5MW permanent magnet direct-drive wind turbines in operation, Estinnes Wind Park, Belgium.**

Q

## Could you get it done in ten years? Wind farms and transmission lines currently take several years just to get through the planning & permitting stages?

A

**Australia has the industrial capability to perform such a fast transition, as our existing construction & manufacturing capacity dwarfs the requirements of the Plan. Fast-track permitting and prioritisation policies for renewable energy already exist in other countries and can be replicated here.**

*Want to know more?*

The scale of the task of rebuilding Australia's electricity infrastructure within ten years is well within the capability of Australia's industrial capacity. Our construction and manufacturing sectors make up close to 20% of the total workforce, and historical data shows that the speed at which the Australian construction industry was growing from 2003-2008 was 50,000 new construction jobs ***per year***. The ZCA Stationary Energy Plan would require on average 14,000 new construction jobs per year during the growth phase. We have already shown that given the right incentives, we can ramp up industrial activity very rapidly. Other indicators documented in Part 6 also support this.

To achieve this growth, will require putting in place the correct financial incentives and policy. In the U.S., for example, fast-tracked permitting has allowed solar plants like SolarReserve's Rice and Crescent Dunes tower projects to receive permitting in only one year from original application. Germany's EEG (Renewable Energy Sources Act) requires that the grid operator provide transmission connections for new renewable energy power plants.

The ZCA Plan is proposing a departure from business-as-usual bureaucracy, and would require leadership that is not currently present in the Australian decision-making sphere. The Stationary Energy Plan highlights that the current limitations in progressing renewable energy in Australia are not technology, capacity or money.

Q

## What about people working in traditional fossil fuel industries?

A

**The renewable energy industry would create more than enough jobs to replace those in the existing fossil fuel industry.**

*Want to know more?*

Many of them would have directly transferable skills, for example in thermal power generation, metalworking and mechanical maintenance. There are approximately 20,000 people employed in supplying fossil fuel energy to the domestic market, less than 0.2% of the Australian workforce. The Stationary Energy Plan would create up to 40,000 jobs in operations and maintenance of renewable energy, and 30,000 jobs in manufacturing some components onshore, some of which could be located near areas such as the Hunter and Latrobe valleys, which currently have a high concentration of jobs in coal.