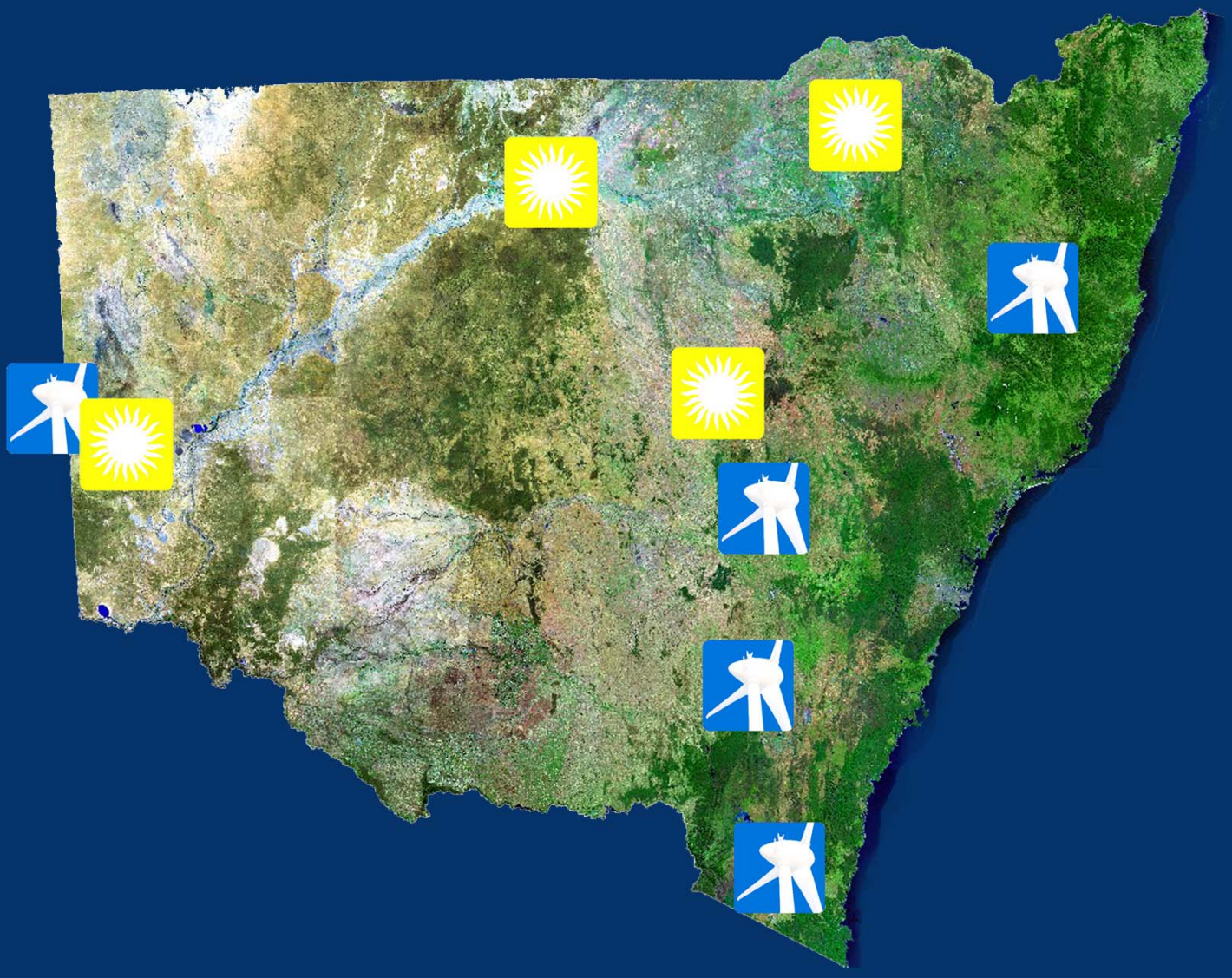
Australian Sustainable Energy

Zero Carbon Australia Stationary Energy Plan

NSW elements- first 3 years



beyond ZERO emissions

Beyond Zero Emissions' Zero Carbon Australia 2020 Stationary Energy Plan *('The Plan') is a 200 page technical study which demonstrates the feasibility of Australia moving to 100% renewable energy within ten years.*
This briefing paper aims to familiarise NSW politicians with the NSW aspects of the Plan, particularly for the first three years of implementation. It mostly excludes interstate considerations.

Prepared for Beyond Zero Emissions by Derek Bolton, Adam Lucas, Bronwyn Maelzer & Zane Alcorn Feb 2011

BZE Research Team at the Launch of ZCA2020 stationary energy

About Beyond Zero Emissions (BZE)

Beyond Zero Emissions is an independent, not-for-profit research and education organization dedicated to developing and implementing climate change solutions that will rapidly reduce greenhouse gas (GHG) emissions and give our society and global ecosystems a chance of surviving into the future. BZE is not aligned to or affiliated with any political party.

The Necessity of Early Action

Most climate scientists now agree that 350 parts per million (ppm) is the upper limit of a safe long-term level of CO2 in the atmosphere. We have already reached 390 ppm of CO2 and 445 ppm of CO2e (CO2 plus equivalent emissions from other GHGs such as methane and nitrous oxide).

Leading economists advise that the sooner governments act to cut emissions, the lower will be the social, environmental and economic costs of mitigation. Current government commitments which equate to a 5% reduction of GHG emissions by 2020 (potentially including overseas offsets) will not achieve the required atmospheric levels of CO2, and do not reflect Australia's historic or current per capita emissions profile. German Chancellor Angela Merkel's senior climate change advisor, Professor Hans Joachim Schellnhuber, has argued that countries with the highest per capita emissions, such as the United States and Australia, should be aiming for 100% emission reductions over the next ten years if we are to avert dangerous 'tipping points' in the earth's climate system.

Because the stationary energy sector is by far the largest contributor to Australia's GHG emissions, BZE's primary focus over the last few years has been to determine the right mix of energy efficiency measures and commercially proven renewable energy technology which will enable Australia to attain a zero emission energy sector within ten years. BZE's *ZCA2020 Stationary Energy Plan* (the Plan) is the result.

Benefits to the Australian economy of the *ZCA2020 Stationary Energy Plan*

- provides a clear and fully-costed technology roadmap to a carbon-free electricity sector, the foundation for a carbon-free economy;
- places an upper limit on rising electricity prices by de-coupling electricity generation from volatile fossil fuel prices and their inevitable on-going cost increases;
- reduces the impact of any carbon price on NSW businesses and residents by providing emission-free electricity;
- protects trade-exposed industries by enabling them to run on emission-free electricity;
- enables the creation of a dynamic new manufacturing industry based on renewable energy technology, generating thousands of new jobs and the potential to export Australian knowledge and expertise in a new, rapidly-expanding international market.

BZE's Vision for a Zero Emission Stationary Energy Sector

The Plan provides a detailed blueprint for transforming all present electricity demand to zero carbon sources. It also takes into account increased demand from a growing economy, and the total replacement of other fossil fuels (mainly oil for transport, and gas and coal for industrial use), combined with stringent but achievable energy efficiency measures.

With the imminent threat of Peak Oil and the inevitability of radical increases in the cost of transport fuels, displacing the need for oil imports will save Australia $65 billion a year by 2015.[1] By 2040, the Plan is projected to save over $1,000 billion (Net Present Cost, 2010 dollars), compared with business-as-usual. This is roughly equivalent to Australia's current annual GDP.

The Five Elements

CST+ and Wind

The co-implementation of windfarms and concentrated solar thermal power stations with molten salt thermal storage (CST+) is central to the Plan. Both technologies are commercially proven and economically affordable. CST+ has the advantage of providing reliable baseload electricity, 24 hours a day, seven days a week. The total installed capacity proposed under the Plan is 112GW, requiring a doubling of Australia's current electricity generating capacity in order to achieve a transfer of transport energy needs from fossil fuels to renewables.

Wind energy is relatively cheap when compared with conventional fossil fuel sources, but its

[1] Source: Goldman Sachs energy analyst, Arjun Murti.

availability is highly variable. If too much wind energy is added to conventional grids it displaces cheap baseload (coal) power, but increases the need for expensive dispatchible gas-powered turbines. CST+ is as dispatchable as gas. Under the Plan, during those periods when the windfarms are able to achieve maximum electricity production they can meet the entire demand, allowing the CST+ units to build up their thermal reserves. The CST+ units can continuously deliver electricity for up to 17 hours without sunlight.

Biomass

Despite the geographic diversity and overnight storage capacity of the proposed CST+ sites, temporary shortfalls will occur from time to time, mostly in the winter. To cover these shortfalls, it is proposed that stockpiled biomass sourced from wheat crop stubble is burnt to heat the molten salt. Since this shares generating equipment with the CST+ sites, there is minimal infrastructure investment required.

The biomass provisions in the Plan are only needed to completely eliminate reliance on conventional dispatchable sources as backup. Because the proposed biomass infrastructure may not be required in the final version of the Plan, and can be developed in a few years, it is not given further consideration in this briefing paper.

National Grid

The grid upgrades proposed in the Plan are to some extent already needed, independently of the proposed wind and solar capacity. Conversely, some of the proposed wind and solar units could be accommodated within existing grid connections.

Efficiency

If Australia is to attain a zero emission economy, major energy efficiency improvements are necessary. The Plan's proposed efficiency measures are not only feasible but highly cost-effective. Experience in other jurisdictions indicates that 3-4 year returns on investment are quite achievable.

Wind

ZCA2020 proposes 23 windfarm sites across Australia, five of which would be located in NSW. Most of these windfarms would have a peak output of 2GW (two of those in SA would go to 3MW) for a total of 48GW, 10GW of which would be located in NSW. The expected cost is $2.2/W (of capacity) for the early installations, falling to $1.25/W (2010 dollars) by 2016. This is not inclusive of transmission requirements, which are costed separately under the Plan as part of the grid upgrade requirements and can be more cost-effective when spread across many wind farms in a geographical region.

Enercon E-126 Wind Turbine in Georgsfeld, Germany. SOURCE: JFZ-WIKIMEDIA COMMONS

Firm Power

For the national network, the 'firm' power (capacity factor) is estimated conservatively at 15%, i.e., the average capacity of this technology to deliver electricity throughout the year at its maximum rating. If NSW wind generating capacity was isolated from the national grid, there would be less diversity, so the firm power may only be 9-10%.

NSW Sites

The five proposed sites for locating windfarms in NSW are Cooma, Crookwell, Orange, Silverton and Walcha. At present, more than 4000MW of wind capacity has been approved or is pending approval for installation in NSW, as can be seen in the table below. Most of these sites are close to (or identical with) the sites proposed under *ZCA2020*.

Region	**Land value $/ha**[2]	**Existing grid**[3]	**Nearby existing windfarm applications**[4] *(may not be complete)*		
			Location	**MW**	**DGRs Issued**
Cooma	700	132 x 2	Boco Rock (50k S)	270	Approved
			Berridale (30k W)	26	Approved
Crookwell	3100	330 x 1	Rugby (50k W)	290	26/11/10
			Collector (65k S)	160	15/10/10
			Arkstone (60k N)	100-180	6/5/10
			Crookwell 1	4.8	Installed
			Crookwell 2	92	Approved
			Crookwell 3	50-100	7/4/10
			Gullen Range (50k S)	~150	Approved
			Cullerin Range (50k S)	30	Approved
Orange	5700	330 x 2	White Rock (60k E)	~250	15/10/10
			Carcoar (20k S)	80-100	19/1/09
Silverton (nr Broken Hill)	13	220 x 1	Silverton	1000	Approved
Walcha	3800	330 x 1			
Current total wind generation (MW) installed, approved or proposed in NSW[5]					
Installed					188
Approved					1945
Proposed					2074-2749
Total					4207-4882

Table 1: ZCA2020 Windfarm sites for NSW

Given the existing windfarm approvals and applications for approval, a doubling of this capacity over the ten year period to 2020 is more than feasible.

Equipment and Land Impact

Each site would consist of 7.5MW Enercon E-126 turbines, with a hub height of 138 metres. Such

2 http://www.lands.nsw.gov.au/valuation/nsw_land_values
3 http://www.industry.nsw.gov.au/energy/files/sustain_renew_wind_atlas_poster.pdf
4 http://majorprojects.planning.nsw.gov.au/page/project-sectors/transport--communications--energy---water/generation-of-electricity-or-heat-or-co-generation/
5 http://www.industry.nsw.gov.au/energy/electricity/generation

large turbines need to be spread out to achieve their rated capacity. However, most of the land area on which they are located remains useful for farming, and has proven a valuable source of revenue for farmers in Germany, Denmark and other EU countries.

Best sites

Because detailed data on wind speeds at the specified locations is only available to proponents on a commercial basis, this briefing does not prioritise windfarm sites on that basis.

The full consequences of existing windfarm developments across NSW nevertheless merit closer study. Because geographic diversity of windfarm locations in different wind regimes throughout the State is necessary to maintain a high capacity factor for the grid, further investigation of this issue utilizing detailed wind mapping data will be required.

Modularity

Once a windfarm site has been acquired and grid access established, wind turbines can be installed piecemeal, requiring little in the way of shared infrastructure. The early installations can therefore be chosen largely on the basis of existing grid access and capacity.

Lead-time

Optimal siting and layout of a windfarm can involve considerable research and analysis. CSIRO's Wind Resource Assessment Guide indicates a timeframe of nearly two years.[6] It is likely that existing developers have portfolios of assessed sites ready to roll, and this may well enable the early installation of the proposed windfarms on a faster schedule.

CST+

ZCA2020 proposes that twelve CST+ sites would be built across Australia, four of which would be located in NSW. Each would have a peak output of 3.5GW and a construction cost of $13 billion, making the total capacity in NSW 14GW. This takes into account an expected decline in costs per MW as experience in manufacturing and construction is gained, and the units become larger, starting at 75MW and building to 217MW. The earliest installed units are expected to cost $10.50/W (of capacity), falling to $3.40 (2010 AUDs) in the second half of the transition decade after 9,000 MW of capacity have been installed.

Torresol Gemasolar Solar Thermal Power Tower, Spain
SOURCE: TORRESOL

The mean output will vary according to season and location.

Equipment and Land impact

A 217MW unit consists of:

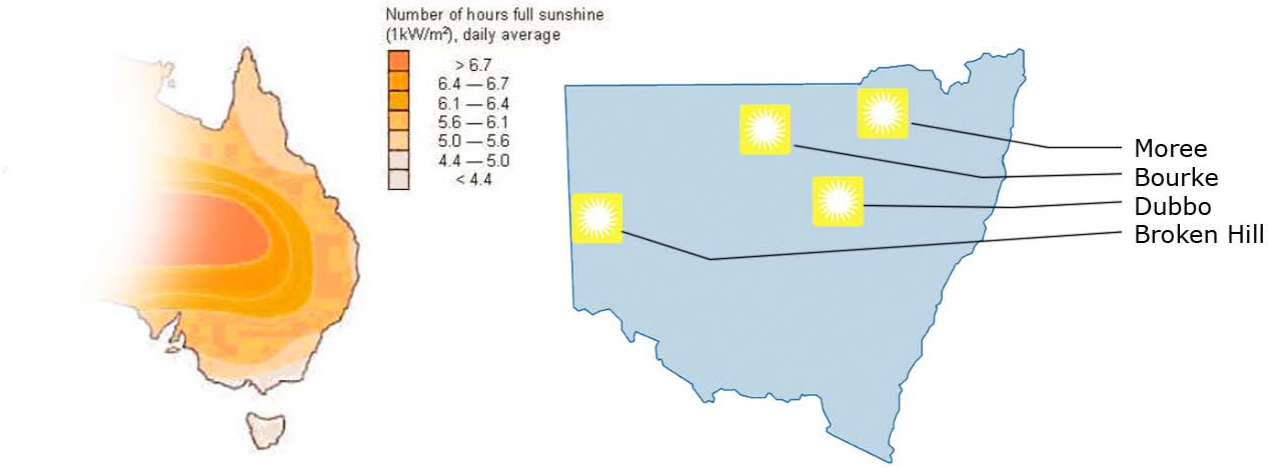
- a ‘central’ 280m tower supporting a molten salt receiver at the top of the tower;
- 17,900 x 148 m^2 flat tracking mirrors across a 14 km^2 circle for a total 2.65 km^2 of mirror

6 http://www.csiro.au/files/files/pis7.pdf

surface;

- a 245MW supercritical reheat steam turbine;
- two-tank molten salt storage, capable of driving the turbine at full output for 17 hours in darkness;
- air cooling with 15 x 9 m diameter fans.

It should be noted that the mirrors only occupy about 25% of the 14 km^2 land footprint at each site, permitting other land use between them. Because the mirrors will shade most of this area,



appropriate alternative uses for that land would need to be developed.

NSW Sites

The insolation and plug-in costs for the four NSW CST+ sites are detailed below in Table 2. (This data is sourced from Tables 3.6 and 5.1 of the Plan)

Table 2: Insolation at ZCA2020 CST+ sites for NSW

	kWh/sq m/day, monthly averages												*kWh/sq*	*Grid plug-in*				
	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*m/year*	*Type*	*To*	*km*	*MW*	*AUDM*
Bourke	9.5	7.7	9.1	9	8.1	5.5	6.4	7.1	8	9.6	6.9	9.8	2945	HVDC	Mt Piper	567	4000	2293
Broken Hill	10.2	9.3	9.4	7.9	7.1	5.5	5.9	6.7	8.2	9.3	7.7	9.3	2934	HVDC	Mildura	262	4000	1936
Dubbo	9.5	6.9	8.6	6.9	7.4	4.7	5.7	5.1	7.6	8.5	6.7	9.7	2660	HVAC	Mt Piper	249	3000	1220
Moree	10.3	7.6	7.8	5.6	6.7	6.2	4.5	6.3	5.7	7.3	8	10.9	2646	HVAC	Armidale	364	6000	2980

The estimated total cost for the four CST+ sites is $52 billion, and an additional $8.43 billion for the grid upgrade. Once again, it should be borne in mind that these costs include replacement of fossil fuels for most transport, heating and industrial needs in NSW. The price tag for NSW of a little over $60 billion over ten years is less than the amount that Australia will be paying annually for imported oil within five years.

Grid Issues

It should be noted that the proposed grid upgrade from Broken Hill is to Mildura, which would not deliver power to NSW through the existing grid. The Plan's proposal is predicated on any one of three Mildura links cited elsewhere in Table 5.1 of the Plan: $2.5 billion to Mt Piper, $4.5 billion to Melbourne, $2 billion to Port Augusta. However, a 300MW windfarm at nearby Silverton is going ahead. It is approved to expand to 1000MW, which will require a grid upgrade. Because of the synergistic relationship between CST+ and wind, the Broken Hill CST+ site can be developed at

matching power outputs with little in the way of extra grid costs.

Grid Upgrades

As discussed elsewhere in this document, most of the grid upgrades required in the first three years of construction will be with respect to the Dubbo and Bourke CST+ sites. Allowance has also been made for two wind sites to benefit from grid upgrades during that time. Further upgrades may be cost-effective to improve distribution of existing supply.

Prioritisation

Seasons

A critical issue in the choice of CST+ and wind sites across Australia is meeting the demand throughout each season. Comparing potential outputs from the proposed wind and solar sites with demand, the crunch is in the winter period, June through August. The Plan has therefore recommended site locations which would maximise the proposed national grid's power output in winter, while simultaneously drawing on Australia's geographic diversity in terms of its wind generating capacity and divergent time zones for sunlight. However, because this is less of an issue during the initial roll-out, the early sites may be chosen more for lowest average cost per MW.

The Bourke and Broken Hill regions each average about 10% more insolation than those around Moree and Dubbo. While Dubbo has the lowest grid connection cost, the difference amounts to only 6% of total site cost.

Grid

A complete analysis of the grid upgrade requirements would involve consideration of the additional flows in the grid and determining the average distance the added power has to travel. HVDC line losses are typically 3% per 1000km. If we assume Mount Piper as the 'destination' for power generated in the far west of NSW, this would appear to tip the balance in favour of Bourke over Broken Hill for initial construction.

Ramp Up

Over the full ten year period envisaged by the Plan, NSW would have 20% of the total wind power capacity and 30% of the total CST+ capacity.

The Plan calls for windfarm installations nationwide to begin at 1250MW p.a., ramping up to 6000MW p.a. nationally, or 210MW p.a. and 1200MW p.a., respectively, for NSW.

For CST+, the early sites may take two to three years to come on-stream, but it is anticipated that construction time will eventually fall to 18 months. The rate of construction needs to reach a peak of over 6000MW p.a. nationally, or 2000MW p.a. in NSW.

The early CST+ units are modest in size in order to gain experience in construction and operation. Their location is therefore driven as much by cheap grid connection and convenient access as by mean power output. As time progresses, the emphasis shifts.

CST									*$m in 6 months starting*					
Site	*Unit*	*MW*	*start*	*dur'n*	*end*	*online*	*$/W*	*$m*	*0*	*6*	*12*	*18*	*24*	*30*
Dubbo	1	75	0	30	30	27	10.5	790	158	158	158	158	158	0
	2	100	6	27	33	30.3	10.5	1050	0	233	233	233	233	233
	3	150	12	24	36	33.6	10	1500	0	0	375	375	375	375
	4	220	18	24	42	39.6	9	1980	0	0	0	495	495	495
	5	220	24	21	45	42.9	7	1540	0	0	0	0	440	440
	6	220	30	21	51	48.9	6.1	1340	0	0	0	0	0	383
BH	1	75	0	30	30	27	10.5	790	158	158	158	158	158	0
	2	100	6	27	33	30.3	10.5	1050	0	233	233	233	233	233
	3	150	12	24	36	33.6	10	1500	0	0	375	375	375	375
	4	220	18	24	42	39.6	9	1980	0	0	0	495	495	495
	5	220	24	21	45	42.9	7	1540	0	0	0	0	440	440
	6	220	30	21	51	48.9	7	1540	0	0	0	0	0	440
Bourke	1	100	6	27	33	30.3	10.5	1050	0	233	233	233	233	233
	2	220	18	24	42	39.6	9	1980	0	0	0	495	495	495
	3	220	24	21	45	42.9	7	1540	0	0	0	0	440	440
	4	440	30	21	51	48.9	6.1	2680	0	0	0	0	0	766
Dubbo	grid		12	6	18			1220	0	0	1220	0	0	0
Bourke	grid		18	12	30			2300	0	0	0	1150	1150	0
				Totals		6 month			316	1015	2985	4400	5720	5843
						Cumulative			316	1331	4316	8716	14436	20279

Wind								*$m in 6 months starting*					
Site	*MW*	*start*	*dur'n*	*end*	*online*	*$/W*	*$m*	*0*	*6*	*12*	*18*	*24*	*30*
W	50	12	12	24	12	2.2	110	0	0	55	55	0	0
	130	18	12	30	18	1.9	250	0	0	0	125	125	0
	440	24	12	36	24	1.9	840	0	0	0	0	420	420
	660	30	12	42	30	1.8	1190	0	0	0	0	0	595
X	50	12	12	24	12	2.2	110	0	0	55	55	0	0
	130	18	12	30	18	1.9	250	0	0	0	125	125	0
	440	24	12	36	24	1.9	840	0	0	0	0	420	420
	440	30	12	42	30	1.8	790	0	0	0	0	0	395
Y	50	12	12	24	12	2.2	110	0	0	55	55	0	0
	130	18	12	30	18	1.9	250	0	0	0	125	125	0
Z	50	12	12	24	12	2.2	110	0	0	55	55	0	0
	130	18	12	30	18	1.9	250	0	0	0	125	125	0
W	grid	18	6	24			900	0	0	0	900	0	0
X	grid	24	6	30			900	0	0	0	0	900	0
			Totals		6 month			0	0	165	1565	2240	1830
					Cumulative			0	0	165	1730	3970	5800

CST+Wind								
	Totals	6 month	316	1015	3150	5965	7960	7673
		Cumulative	316	1331	4481	10446	18406	26079

Table 3: NSW Expenditures, 6 x 6 months (excluding land, access, planning & consultancy)

Policy Settings

Based on overseas experience, there is strong evidence that an advanced renewable energy feed-in tariff, combined with direct government investment and/or government loan guarantees, provide the best mix of policy levers to drive a rapid transition to a decarbonised electricity market. This is true whether or not a carbon price can be agreed upon in the short to medium term. Energy efficiency and demand management measures are best supported by a reformed energy market in which electricity retailers become energy service providers, as is the case in California, for example.

Costs, Output and Jobs

Table 3 above shows the expenditures required (2010 AUDM) and the timeframes for construction. Table 4 below shows the number of job years during the first three years of implementation of the Plan in NSW. The two tables are informed by the following assumptions:

- a constant expenditure rate for each multi-period item;
- the CST plants will start to provide power at 90% of construction time; the remaining 10% is presumed to consist of adding heliostats (while an earlier production start might be appropriate, this would render the constant expenditure rate calculations incorrect; a finer breakdown of the costs and construction phases would therefore be useful);
- the wind farms provide increasing power linearly from the start to the end of construction;
- detailed planning for the first wind installations can be squeezed into 12 months; these being only 50MW, optimisation is less important than for the later installations, with some fine-tuning possible during construction;
- the existing approved wind farm at Silverton necessitates grid upgrades; it is here assumed that a corresponding level of CST+ could be provided at Broken Hill without further grid upgrades: the first 300MW of Silverton will be online within two years, and the next 700MW within three;
- of the five wind sites:
    - no development at Silverton would be necessary in the first three years, as that site is already being adequately developed under existing approved plans;
    - three can be found which can handle 180MW with no major grid upgrade (X, Y and Z in the tables);
    - the remaining site, W, can handle 50MW with no major grid upgrade.

The time periods are in months except where stated.

Jobs

The Plan estimates 80,000 jobs nationally in installation during the construction phase, with 45,000 continuing indefinitely in operation and maintenance. To the extent that the wind turbines and heliostat mirrors are to be manufactured here, another 30,000 jobs could potentially be created.

It is estimated that a total of 20,000 jobs would be displaced from the mining and combustion of coal and gas were the Plan to be implemented.

The fraction of manufacturing jobs that would be retained in NSW depends largely on state and

federal policy settings. The sooner the works begin, the higher the likely percentage of jobs created in NSW. The bottom line of the table assumes that 50% of the manufacturing jobs would be created in NSW.

Employment provided from the construction of grid upgrades is not included here.

CST Jobs	*yrs / MW*	*Six month period* *0*	*6*	*12*	*18*	*24*	*30*
M'facture	0.4	20	80	140	270	420	600
Install	6.5	390	1250	2240	4380	6840	9720
O&M	0.7	0	0	0	0	0	110
Wind Jobs	*yrs / MW*	*Six month period* *0*	*6*	*12*	*18*	*24*	*30*
M'facture	3.7	0	0	560	2480	5180	7330
Install	1.2	0	0	180	800	1680	2380
O&M	0.3	0	0	0	20	100	230
NSW Jobs, assuming 50% of manufacture in NSW							
M'facture		10	40	350	1375	2800	3965
Install		390	1250	2420	5180	8520	12100
O&M		0	0	0	20	100	340
Total		400	1290	2770	6575	11420	16405

Table 4: Jobs in CST and Wind

Energy Efficiency

Australia's per capita use of electricity is 50% higher than that of Germany, and the gap is widening. Within the *ZCA2020* publication framework, details of the proposed energy efficiency measures that could be taken in Australia are due in the volumes on transport, buildings and industry. However, there are many existing reports which detail measures that can and should be taken.

While the NSW Government does have several schemes that are currently in place,[7] most are purely voluntary, offering subsidised assessments and training, some of it means-tested. Only two go beyond that:

- Energy Savings Scheme – a good policy with weak targets, reaching only 4% in 2014
- Public Sector Policy

Other avenues worth considering include:

- *Construction of an Intelligent Grid*[8]
- *Regularly improved & upgraded building standards (home and office)*
  The national standard is mostly a voluntary code. NSW lags behind several other states,[9] and even further behind some European countries, US states and Canadian provinces.

7 http://www.environment.nsw.gov.au/climatechange/energyefficiencystrategy.htm
8 http://igrid.net.au/
9 http://www.greenlivingpedia.org/Building_energy_efficiency_standards#State_standards_for_building_energy_efficiency

- *Ending or re-engineering subsidies to industry*
  Subsidizing the electricity used by energy intensive industries distorts the market and weakens the incentive to improve efficiency.[10] If subsidies are to be paid, the formula should relate to the energy required to make the product under best practice, not the energy actually used.
- *Improved energy labeling on motor vehicles, equipment and products in general.*

Future-proofing the economy with renewable energy

ZCA2020 offers a road map for a resilient economic future for NSW. The construction of a massively upgraded and extended energy grid fed by renewable energy completely avoids the State's economic exposure to fuel supply shocks, and in particular the increasing volatility of global oil, coal and gas prices. It will also ensure that those energy and carbon intensive industries operating in NSW can boast that they are amongst the lowest emitting industries in the world, as all of their energy will be supplied from renewable sources.

While Australia continues to enjoy healthy export revenue streams from coal and gas exports, as we have already seen in Western Australia, once the infrastructure is in place to liquefy gas for export, domestic wholesale prices will increasingly converge with global prices. Likewise, domestic thermal coal prices will be increasingly subject to price spikes as demand from Asian markets continues to grow and supply is disrupted by increasingly frequent and severe weather events as the result of human-induced climate change. A recent proposal by the NSW Labor Government to build and operate a coal mine at Cobbora to supply below-market-cost coal to coal-fired power generators may cushion those generators from such shocks in the short term, but will increase NSW's greenhouse gas emissions, expose NSW taxpayers to significant market risk, and do little or nothing to reduce the energy intensity of NSW's economy.

ZCA2020 offers NSW a strong pathway to sustainable growth. It will generate prosperity and employment for many rural and regional communities, deal decisively with NSW's greenhouse gas emissions problem, and place NSW at the forefront of the clean technology revolution which is proceeding apace throughout Europe, Asia and the Americas.

Contacts & further information

Dr Adam Lucas, Science & Technology Studies Program, University of Wollongong
Email: adam@beyondzeroemissions.org
Mobile: 0411 199 213

Pablo Brait
Beyond Zero Emissions – Melbourne office
Email: pablo@beyondzeroemissions.org
Phone: 03 8383 2232

The complete *ZCA2020* report can be downloaded at: www.beyondzeroemissions.org

10 http://adl.brs.gov.au/data/warehouse/pe_abarebrs99000480/PR11569.pdf