Submission to the Climate Change Authority on

'Modelling the electricity sector and emissions reduction policies'

By
Peter Lang[1]

Thank you for the opportunity to provide feedback to the Climate Change Authority on 'Consultation Paper: Modelling illustrative electricity sector emissions reduction policies'.

I offer the following comments and recommendations:

1. If you exaggerate the cost of nuclear compared with other technologies, your study will be discredited.

2. The only proven viable way to replace most coal-fired electricity generation is with nuclear power (as France did, mostly between 1970 and 1990). The emissions intensity of France's electricity (0.07 t/MWh) is less than 10% of Australia's (0.9 t/MWh).

   Table 1: Emissions intensity of electricity, tonnes/MWh

Source	Data Date	Australia	France
IPCC, Table 3.5	2002	0.885	0.078
Econometrica	2011	0.992	0.071
IEA, p110	2011	0.823	0.061

   For comparison, emissions intensity of electricity in Germany is 0.672 t/MWh; i.e. nearly tern times higher than France. Furthermore, the cost of electricity is much lower in France than Germany. The contrast is stark and the evidence is clear – renewables have not demonstrated they are a viable way to reduce emissions significantly, but nuclear has been demonstrating just that for over 30 years.

3. I recommend you include several scenarios and sensitivity analyses using different current and projected future costs for nuclear power, e.g.:

   a. learning rates between 0% to 10% per doubling of global capacity (of small nuclear power plants, not including the large plants)

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b. starting capital cost per kW ranging from the high stated in the AETA 2013 report to the low demonstrated by the contract for the nuclear plants being built in UAE by a South Korean consortium; i.e. $3800/kW (in 2009 US$), plus adjustment factors for Australia-specific labour and other costs.

4. Include the full system costs for all options. The full system cost for renewables increases as renewable penetration increases: e.g. Nicholson and Brook, 2013, '*Counting the hidden cost of energy*' summarised from OECD/NEA, 2012, '*Nuclear Energy and Renewables: System Effects in Low0carbon Electricity Systems*'

5. Point out that there are no examples of an electricity grid for a large industrial economy (e.g. USA, Europe, Australia) with a high proportion of wind and solar power.

6. Include an allowance for the risk that renewables will not be capable of supplying more than a small proportion of electricity by 2050 and, therefore, are unlikely to make a substantial contribution to reducing global GHG emissions; e.g. Expected Monetary Value (EMV) of the risk that a large proportion of renewables will not be viable in 2050 = $54/tonne CO2[2].

7. Australia does not have viable energy storage capacity for renewables, so this is not a viable option.

8. The real cost of a recent large solar thermal plant in USA is $19/W average power ($2.2 billion for claimed 1 TWh per year). That's at least four times

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[2] **Risk renewable energy cannot achieve the claimed CO2 savings by 2050:**

Estimate the risk renewable energy technologies, that meet requirements, will not be available by 2050 to provide 50% of electricity economically.

Nuclear – already proven it can do it (e,g, France with about 75% for the past 30 years), so say there is a 5% probability nuclear will not be able to do so in 2050.

Renewables – have not demonstrated they can do the job, EROI suggests they cannot, many practitioners say they cannot; therefore, assume there is a 90% probability they will not be able to.

Consequence = Social Cost of Carbon of the emissions not avoided by the technologies. Assume the projected carbon price is equivalent to SCC. Weighted average carbon price of the ETS from 2011 to 2050 (from Australian Treasury 2013 projections) is $60/tonne. Average Australian emissions intensity (for delivered electricity) is about $1 t/MWh. Therefore, average carbon cost would be about $60/MWh.

Risk nuclear will not be able to do the job = $60/MWh x 5% = $3/MWh
Risk renewables will not be able to do the job = $60/MWh x 90% = $54/MWh

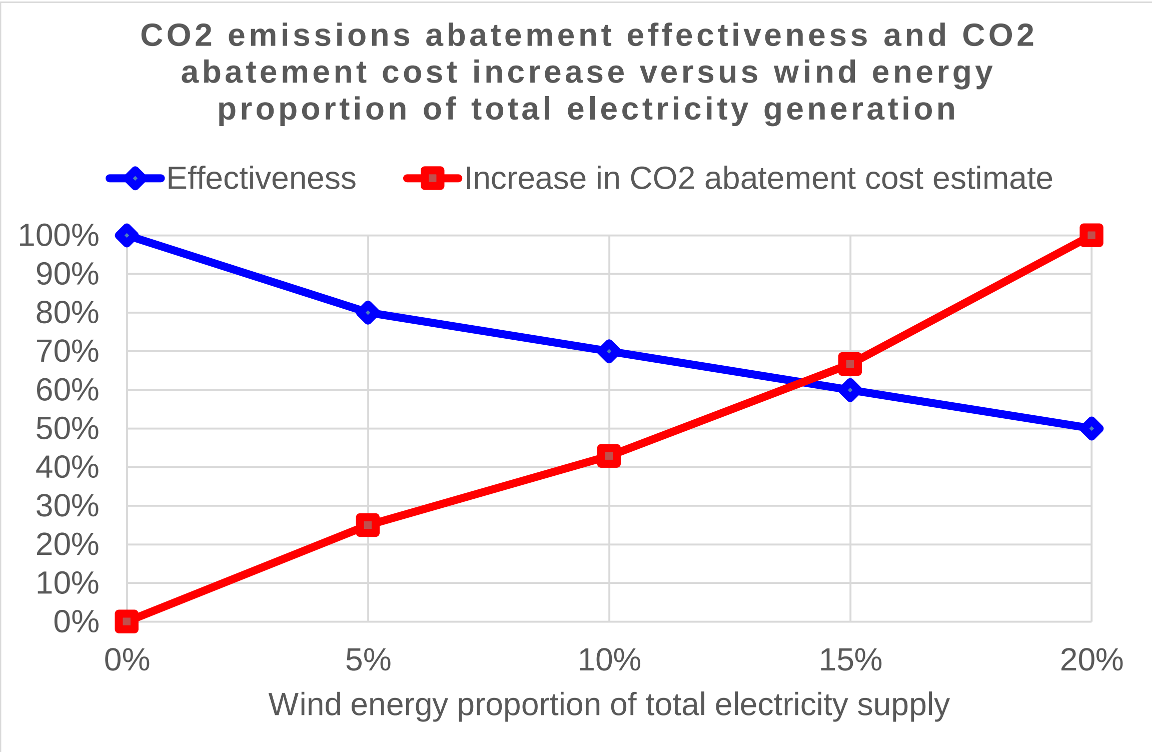
more expensive than nuclear, and even more when the full cost of the system to meet availability and reliability requirements is taken into account.

9. If your analysis relies on wind, solar, geothermal and biomass, it will be dismissed as irrational, impractical, unproven, and as another case of renewable energy advocacy by ideologues.

10. Take into account that intermittent renewables, like wind power, are not fully effective at avoiding CO2-e emissions. Their CO2 abatement effectiveness decreases as their penetration (proportion of electricity generation) increases. Wind power in the NEM in 2014 was just 78% effective at abating emissions. At 15% penetration, wind may be just 60% effective at abating emissions in the NEM. As penetration increases to higher levels their effectiveness would continue to decrease. The CO2 abatement cost increases in inverse proportion to the CO2 abatement effectiveness (Ref. Submission No. 259).

The chart below shows the relationship between:

- CO2 abatement effectiveness (vertical axis, blue),
- the percentage by which the CO2 abatement cost is underestimated if CO2 abatement effectiveness was not taken into account, (vertical axis, red) and
- the proportion of electricity generated by wind turbines (horizontal axis).



What this chart tells us:

At 15% wind energy proportion of total electricity generation (i.e. the likely situation in 2020 under the LRET), wind energy would be 60% effective at reducing emissions. What does this mean? Let's assume the emissions intensity of the grid in the absence of wind generation would be 1 t CO2/MWh. It the CO2 abatement effectiveness is

60%, therefore, 1 MWh of wind generation would avoid just 0.6 t CO_2/MWh, not the 1 t/MWh assumed in most analyses.

What is the impact of this on the estimates of CO_2 abatement cost?:

If the estimated CO_2 abatement cost is $60/t using the assumption CO_2 abatement effectiveness is 100%, the estimate would be $100/t if the CO_2 abatement effectiveness is 60% (i.e. $60/t divided by 60% = $100/t)

Therefore, the estimates that assume CO_2 abatement effectiveness is 100% understate the abatement cost by 67% (i.e. $100 / $60).

Nuclear power is likely to be the least cost way to make large GHG emissions cuts by 2050

By Peter Lang

The lowest cost way to reduce the emissions by 2050 is with a large proportion of electricity generated by nuclear power.

Here I use the CSIRO 'eFuture' calculator to compare two scenarios to supply electricity to meet the projected electricity demand on the National Electricity Market (NEM) in 2050 as well as cut CO2 emissions. The two scenarios are: 1) nuclear power not permitted and 2) nuclear power permitted. '*eFuture*' determines the generation mix that gives the least cost electricity for that scenario using the selected inputs. The scenarios compared here use the default inputs (central estimates) for each user selectable input. The two scenarios are compared on the basis of CO2 emissions intensity and wholesale cost of electricity.

CO2 emissions for nuclear 'not permitted' are 80 t/MWh versus 25 t/MWh with nuclear 'permitted'. That is, if nuclear is not permitted emissions would be 3.2 times higher than if nuclear is permitted.

Table 1 lists the *eFuture* projections of wholesale cost of electricity in 2050 with nuclear 'not permitted' and with nuclear 'permitted' (row 1) plus various estimates of the other cost items (not necessarily for 2050) in the remaining rows. The third column shows the ratio of 'No/Yes' (nuclear 'not permitted' / 'nuclear permitted'). Minor cost items that are commonly asked about are included. Costs are in $/MWh.

Table 1: Cost of electricity in Australia with nuclear permitted compared with nuclear not permitted. The first row is the projected wholesale cost of electricity generation in Australia in 2050; the other rows are for different times and countries.

Item	No nuclear	With Nuclear	No/Yes	Ref.
Wholesale cost in 2050	130	85	1.5	1
Accident insurance	0	0.1		2, 3
Decommissioning[3]	0.15	0.01		4, 8, 9
Waste management	0	1		5
System costs, 50% penetration	60	2		6, 7
Total LCOE for the system	190	88	2.1	

[3] See IEA, 2010, Tables 3.7a and 3.7d (at discount rate used in AETA, i.e. 10%), and p43: "Where no data on decommissioning costs was submitted, the following default values were used:
- Nuclear energy 15% of construction costs;
- All other technologies 5% of construction costs."

Footnote #8: "In the median case, for nuclear plants, at 5% discount rate, a cost of decommissioning equivalent to 15% of construction costs translates into 0.16 USD/MWh once discounted, representing 0.2% of the total LCOE. At 10%, that cost becomes 0.01 USD/MWh once discounted, and represents around 0.015% of the total LCOE"

Table 2: Grid-level system cost ($/MWh)s at differing penetration levels for a range of electricity generation technologies

Penetration Level	10%	30%	50%
Nuclear	2.4	2.1	1.8
Coal	0.9	0.9	0.9
Gas	0.5	0.5	0.5
Onshore Wind	18.4	31.8	45.2
Offshore Wind	28.3	36.8	45.3
Solar PV	36.4	55.6	74.8

Source: Columns 1 to 3 from Nicholson and Brook 'Counting the hidden costs of energy' summarised from OECD/NEA, 2012, 'Nuclear energy and Renewables: System Effects in Low-carbon Electricity Systems'. Column 4 is linear projection to 50% penetration.

Policy analysts also need to include in policy options analysis an estimate of the risk that renewables will not be able to deliver the benefits claimed by their proponents. We know nuclear can provide around 75% of electricity in an advanced industrial economy because France has been doing it for over 30 years. But renewables have not demonstrated they can or will be able to. Most practitioners think they will not. An estimate, in LCOE equivalent terms, of the risk that renewable and nuclear technologies will not be able to do the job in 2050 is: renewables $54/MWh, nuclear $3/MWh (see Box 1).

Box 1: Risk RE cannot achieve claimed CO2 savings by 2050

Estimate the risk renewable energy technologies, that meet requirements, will not be available by 2050 to provide 50% of electricity economically.

Nuclear – already proven it can do it (France for past 30 years), so say 5% probability it cannot in 2050.

Renewables – not demonstrated it can do the job, EROI suggests it cannot do the job, many practitioners say it cannot; therefore, assume 90% probability it cannot.

Consequence = Social Cost of Carbon (SCC) of the emissions not avoided by the technologies. Assume the projected carbon price is equivalent to SCC. Weighted average carbon price (from Australian Treasury 2013 projections) is $60/tonne. Average projected Australian emissions intensity (for delivered electricity) is about 1 t/MWh. Therefore, average carbon cost would be about $60/MWh.

Risk renewables will not be able to do the job = $60/MWh x 90% = $54/MWh
Risk nuclear will not be able to do the job = $60/MWh x 5% = $3/MWh

With the risk of failure included, the total system cost of electricity for the two options are:

Nuclear not permitted = $244/MWh
Nuclear permitted = $91/MWh

Therefore, the cost of electricity for the 'nuclear not-permitted' option is 2.7 x higher than the 'nuclear permitted' option. And emissions would be 3.2 times higher.

The risk that renewables will not be able to do the job is the major risk that those concerned about GHG emissions should be most concerned about, not the costs of nuclear waste disposal, decommissioning, accident insurance etc. all of which are negligible compared with the LCOE and the risk that renewables do not deliver the benefits claimed by their proponents.

References

1. CSIRO 'eFuture' scenario options calculator
2. US NRC, 2014, 'Backgrounder on Nuclear Insurance and Disaster Relief'
3. EIA, 'Nuclear electricity net generation' for year 2012
4. IEA, 2010, Projected Costs of Generating Electricity, 2010 Edition
5. OECD, 2013, 'The Economics of the Back End of the Nuclear Fuel Cycle', (Figure ES.1)
6. Nicholson and Brook, 2013, 'Counting the hidden costs of energy'
7. OECD/NEA, 2012, 'Nuclear energy and Renewables: System Effects in Low-carbon Electricity Systems'.
8. WNA, 2014, 'Decommissioning Nuclear Facilities' ("*0.1 to 0.2 cents/kWh*")
9. DECC 'Offshore Renewable Energy Installation Decommissioning'