SUBMISSION TO THE AUSTRALIAN GOVERNMENT'S RENEWABLE ENERGY TARGET REVIEW, AUGUST 2012

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Foreword

I make this Submission in good faith and in a personal capacity only. I am not employed by, nor do I represent, any vested interest commercial or otherwise. I am a chemical engineer, holding degrees in applied science, chemical engineering and business administration, plus post-graduate qualifications in environmental and energy studies. I am a Fellow of the Institution of Chemical Engineers and a Chartered Scientist of the UK Science Council. My interest in the Renewable Energy Target Review derives from over 30 years practical experience in the oil, coal, petrochemicals, electricity, transport infrastructure and related fields, plus my own personal study of global trends in greenhouse science and energy policy and supply.

Australia is joining a number of other countries (1) in setting aspirational targets for the generation of a portion of its electricity needs from primary energy sources that can be classified as 'renewable'. This is a worthy objective as far as it goes, but its application and limitations must be properly understood. This, plus some observations about matters raised in the RET Issues Paper, will be the basis of my Submission.

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1. Key assumptions

(a) The Climate Change Authority is considering only the fuels listed on P. 29 and 30 of its Renewable Energy Target (RET) Issues Paper (1) for electricity generation, and not any other potential clean energy source for the future such as nuclear fission.

(b) The target date for 20% renewable energy/power generation is 2020, eight years from now.

(c) Both major political parties have committed to a target reduction of 160 Mt /yr of greenhouse gases (GHG) from the alternative expected business-as-usual result across the whole Australian economy by 2020. This equates to a 5% reduction below year 2000 GHG levels.

(d) While 20% by 2020 is the nominated target, the prime objective of the RET is, or should be, to bring about a sizeable long-term reduction in GHG emissions from the generation of electricity.

(e) The community's standard of living is to be maintained, as reflected in the capability of any new renewable energy/power system to deliver the same quantity and quality of electricity as might be displaced from fossil fuel burning.

2. The difference between energy and power is important

While it is common usage to speak of 'energy policy', 'renewable 'energy' and so on, the real issue of concern is about 'power', i.e. the rate at which energy is used. Power relates to energy as the rate of changing energy from one form to another. This brings in the notions of time, cost, efficiency, availability and convenience in use.

Power is what we need to run our refrigerators, television sets, air-conditioning, lifts, trains, lighting, cars, trucks, machines, computers, mobile phones…. and so on. Any form of primary energy (e.g. sunlight, coal, oil, gas, wind, biomass, chemical energy, wave) has to be converted into useable power for our convenient use, instantly on demand, always available, and at a cost we are prepared to pay. Power should be generated from that source of primary energy which is best able to meet these requirements, reliably, every time.

In the first instance, any power producing system, fossil fuel, renewable, or otherwise, should be evaluated against **six basic criteria,** viz. ---

- **energy density**, i.e. the amount of energy that is contained in a given unit of volume or mass of the chosen energy source, for example measured in joules /litre or /kg.
- **power density**, i.e. the amount of power that can be generated from a chosen energy source in a given unit of volume or area, for example measured in watts /sq metre.
- **scale**, i.e. the ability of the power generating system to deliver the required quantum of power, reliably, to many potential consumers at acceptable economic and environmental cost.
- **cost,** i.e. the unit cost of the power as actually delivered to the final user, for example measured in cents /kilowatt hour (kWhr). In this regard, it is necessary to distinguish between **installed power capacity** and **power actually delivered**, which can be significantly different, especially in intermittent renewable energy systems such as wind and solar (see 'capacity factor' below).
- **emissions intensity,** i.e. the GHG released by the power generating system when in use, for example measured in Kg /kWhr.
- **capacity factor,** i.e. a number which indicates the amount of time an energy/power conversion system will produce power at 100% of its rated maximum power output.

Only by informed consideration of these criteria can a proper decision be made about the desirability of a particular energy/power conversion system. Unfortunately, there is a tendency in some quarters to regard any form of renewable energy as best to replace fossil fuel because it is 'free'. This is misguided, and can result in costly or ineffective results. There is no substitute for careful analysis, and dealing with the numbers as they fall.

3. Where is the life cycle analysis (LCA) ?

It cannot be assumed that simply because a form of energy supply is 'renewable', and therefore produces no GHG at the point of use (e.g. wind, solar, wave), or is deemed to have any such GHG produced at the point of use offset by the CO_2 absorbed in its growth (e.g. biomass), it will always be a better choice, all things considered, than using an existing or alternative fuel. This can only be determined by a full life-cycle-analysis (LCA) of the production and use of both fuels, to see if there is a net GHG reduction benefit or a net positive energy benefit overall.

While acknowledging the advantages of renewable energy, the Intergovernmental Panel on Climate Change (IPCC) (2) outlines some of the important issues that should also be considered where applicable, e.g. governance of land use and zoning, choice of biomass production systems, water availability, site-specific conditions, effects on terrestrial carbon stocks, biodiversity, and specific challenges for grid integration.

Efficient use of resources is another consideration. For example, a study in the United States (3) found that, when compared on a like-for-like actual generation basis, wind power used 9.6 times more concrete and 11.5 times more steel than a nuclear power plant. The Midford Wind Corridor electricity generating plant in Utah comprises 139 turbines spread across 10,400 ha (104 sq km) of land, with an installed capacity of only 300 MW. Assuming a capacity factor at best of 40% (i.e. a net 120 MW of electricity actually generated), this renewable energy/power generation system represents an extravagant use of resources at high cost to visual and social amenity.

Common sense would suggest that any LCA analysis for comparative purposes must always be questioned as to assumptions made and possible manipulation towards biased outcomes. None of this is to belie the fact that renewable fuels can, and should, play a part in Australia's future energy portfolio, but their place should evolve from robust analysis rather than wishful thinking.

4. Analysis of the LRET challenge, and its effect on GHG reduction in line with Government and Opposition policy

From the Issues Paper (1) ---

total electricity generated in Australia, 2009 – 10	=	239,650 GWhr	(100%)
electricity generated from renewables	=	19,711 GWhr	(8.2%)
generated from renewable hydro resources	=	12,522 GWhr	(5.2%)
generated from 'other' renewables	=	7,189 GWhr	(3.0%)

For simplicity, this analysis will be based entirely on 2009–10 figures, i.e. <u>assume no growth in electricity</u> <u>demand to 2020</u>, and look only at the Large Scale Renewable Energy Target (LRET) of <u>41,000 GWhr /yr by 2020</u>.

This assumes that the 3.0% of 'other' renewable generation shown above is attributed to the small-scale target scheme (SRET), and will not be considered here. As stated in the Issues Paper (1), the 5.2% hydro contribution is classed as large-scale generation, is already in place, and will not be counted as LRET for this analysis.

According to the CSIRO (4), electricity generation accounts for around 35% of GHG emissions in Australia. Given its focus in the LRET scheme, and the relative difficulty (at present) of significantly reducing GHG in other areas of economic activity, a reasonable proposition might be that large-scale electricity generation should aim to achieve a reduction equivalent to, say, <u>50% of Australia's total targeted GHG reduction by 2020</u>, i.e. (50% x 160) = 80 Mt /yr.

4.1 Effect on GHG reduction

What if we attempted to achieve this by replacing 41,000 GWhr of electricity generated by black-coal-fired power stations, with 41,000 GWhr of electricity generated from renewable energy?

target additional LRET generation needed by 2020	=	41,000 GWhr /yr
average black coal emissions intensity (4)	=	900 $KgCO_{2e}$ /MWhr
total emissions generated if from black coal	=	$((41{,}000 \times 10^{9}) \times (900 \times 10^{-6}))$
	=	36.9 Mt CO_{2e} /yr

If this is replaced completely by renewable energy/power generation, the GHG saving would be offset to some extent by the applicable LCA effects as mentioned in Point 3 above.

In the absence of knowing exactly what these technologies or their specific LCA effects might be, an estimate can be taken from the Report of the Intergovernmental Panel on Climate Change, 2011, *Renewable Energy Sources and Climate Change Mitigation -- Summary for Policy Makers* (2). A middle-of-the-road estimate of 30 $KgCO_{2e}$ /MWhr is chosen (it is not clear if this includes an allowance for back-up fossil fuel or back-up nuclear power, so this effect will be ignored here).

LCA emissions from replacement renewable energy/power system	=	$((41,000 \times 10^9) \times (30 \times 10^{-6}))$
	=	0.845 Mt CO_{2e} /yr
net GHG reduction	=	(36.9 -- 0.845)
	=	**36.0 Mt CO_{2e} /yr**

Given that a typical 1 x GW black-coal fired power station, with an average capacity factor of 75%, produces about 6 Mt CO_{2e} /yr, this means that it would be necessary to close down up to 6 (36 / 6) such power stations, or their equivalent, to be replaced by one or more renewable energy/power systems capable of generating the same amount and quality of electricity.

Since most hydro resources in this country are already fully exploited for LRET generation, this would mean that the 'other' renewable energy contribution to electricity generation, as shown in Point 4 above, would have to increase by almost **six** times (41,000 / 7,189) over the eight year period to 2020.

This could well happen from an investment point of view, but even if it did, this analysis shows it is likely to achieve only **45% (36 / 80) of the desired result in emission reduction terms**. This would leave the remaining **124 MTCO_{2e} (160 -- 36)** to be achieved in other areas of the economy (such as transport, industrial processes, agriculture, and land use changes), or by successful application of CO_2 capture and storage (CCS) on a reasonably large scale, or be offset through international GHG emissions trading. As previously noted, this result does not reflect any growth in electricity demand over the eight year period.

4.2 Reconciliation with Bloomberg

The above result is based on shutting down 6 typical 1 x GW black-coal-fired power stations with an average capacity factor of 75%, or their equivalent. Renewable energy/power systems, such as pV solar, concentrated solar without storage, or wind, typically have capacity factors in the 30 to 40% range at best. If a capacity factor for the replacement renewable system(s) of **35%** is assumed, it means that **investment sufficient to replace up to 13 ((6 x (75 /35)) notional 1 x GW black-coal-fired power stations would be necessary.**

This would appear to be higher than the estimate by Bloomberg New Energy Finance quoted in the Issues Paper (1) that around **11 GW** of additional renewable generation capacity, costing in the order of **$19.5 billion**, would be needed to reach the 41,000 GWhr target. This difference can be explained by the difference in assumed **capacity factors,** viz. ---

Bloomberg :	$((11 \times 10^9) \times (8,760) \times Y)$	=	$(41,000 \times 10^9)$
	Y	=	$((41,000 / (11 \times 8,760))$
Therefore**, Bloomberg capacity factor**		=	**42.5%**

Without knowing exactly what mix of renewable energy/power system technologies will be used, this capacity factor seems high. The Issues Paper notes that the Australian Energy Market Commission expects most of this additional renewable energy capacity to be in the form of wind and biomass (1). By way of example, the Electric Reliability Council of Texas USA, from hard experience in that windy State, pegs wind's capacity factor for electricity generation into the grid at only 8.7% (3). All things considered, a more realistic estimate for the analysis here might be **35%**, as stated above.

This conclusion is reinforced by Bloomberg's estimate of the cost per installed kilowatt for the assumed bundle of renewable energy/power systems to generate the 41,000 GWhr of electricity. It is assumed here that this is an 'overnight' cost, i.e. an instantaneous expenditure without interest or other cash costs during delay or construction. Hence ---

investment cost per installed kilowatt = $((19.5 \times 10^9) / 11 \times 10^9))$
= **$1773 /kw**

This is on the low side for modern large-scale electricity generation, which seems to suggest a reliance on basic wind and biomass, with no allowance for fossil fuel backup, possible additional transmission lines, or associated energy storage. While a similar calculation for, say,(nuclear), (concentrated solar power + energy storage), (enhanced geothermal), or (coal + CCS), would undoubtedly show higher numbers, a simple comparison along these lines would be misleading. Because of their differing characteristics as to initial and ongoing investment, plant life, capacity factors, cost of fuel, O&M, thermal efficiencies, and costs of decommissioning, there is no substitute for a detailed comparison using internally consistent assumptions about these key variables. Any electricity generating investment at scale is an important addition to long-term infrastructure, and must be assessed accordingly. Short-term options, because they appear inexpensive at the beginning but with poor long-term operating characteristics, must be avoided.

The only true way to do this is to make a calculation of the **Levelised Cost of Electricity (LCOE)** for each of the options to be considered. This then allows a proper comparison between options, both as to the long-term LCOE itself, and, by comparison of each option with the LCOE of the existing fossil fuel generation to be replaced, the **cost of the $CO2_e$ abatement** for each option as well. This method is strongly recommended, and is well set out in a 2010 Study using information and data from the Electric Power Research Institute (EPRI) and the National Renewable Energy Laboratory in the USA (5). After careful analysis of six long-term clean energy/power generating options versus existing coal-fired power, the Study concluded ---

> *The nuclear option reduces CO2 emissions the most, is the only option that can be built quickly enough to make the deep emissions cuts required, and is the least cost of the options that can cut emissions sustainably. Solar thermal and wind power are the highest cost of the options considered. The cost of avoiding emissions is lowest with nuclear, and highest with solar and wind power.*

5. Comments on LRET questions raised in the Issues Paper

The detailed questions raised in the Issues Paper (1) are pertinent, but to answer them properly requires a detailed knowledge of the current electricity generation business, and its interaction with existing Government policies, subsidies for renewable fuels, and penalties for non-compliance. At present, I am not in a position to make such comments other than some general observations.

Observation 1 : As shown in the analysis above, the LRET target could probably be met in GWhr terms by 2020, but this would require policy certainty, prompt regulatory and planning approvals, and massive private sector investment, all over a relatively short period. The currently fractious nature of Australian politics, with its attendant uncertainty about future climate change policy, is not encouraging in this regard.

An unfortunate side effect is likely to be the continued investment in wind power generation which is seen by financiers as quick, easy to implement, and promising reliable returns underwritten by compulsion. If the LRET is to remain in place alongside the carbon tax, it is essential for the Climate Change Authority to take a critical look at wind power proposals by applying the six criteria outlined in Point 2 above. Their variable and intermittent output, low capacity factor, visual ugliness, and adverse community and health effects, make large wind turbines across the landscape a poor choice to make any significant inroads into GHG reduction.

Observation 2 : The Clean Energy Finance Corporation (CEFC) is being set up to administer a fund of $10 billion, half of which is earmarked for investment in renewable energy/power projects. There seems to be no reason to exclude projects which might also qualify under the LRET scheme from consideration by the CEFC. This would effectively make the Government a potential equity investor in such projects. It is therefore especially important for the CFEC to rigorously apply the **six criteria and LCA** outlined above to any renewable energy/power generation proposals, so as to avoid uneconomic or environmentally ineffective investment of public monies.

It is important for all Agencies to remember that the real purpose of any such investment, public or private, is to result in the maximum possible sustainable reduction in GHG emissions at the lowest possible long-term marginal cost, The electricity generation and transport sectors offer the most promising opportunities for reduction. Coordination of policy between Agencies is essential so as to avoid dysfunctional outcomes.

Observation 3 : It is instructive to note the results of Treasury modeling (6) carried out for the introduction of the carbon tax, as used in the Australian Government's Draft Energy White Paper, 2011 (8). This showed that, even after allowing for an heroic expansion of renewables capacity to a practicable maximum of 42 GW plus significant application of CCS, some 53% (47 GW) of Australia's electricity generation by 2050 will still have to come from fossil fuels in the absence of nuclear power generation. Of necessity, this will result in the large ongoing purchase of overseas 'offset' credits by Australian businesses in order to meet the country's long-term target of an 80% GHG reduction below year 2000 levels by 2050. Under original Treasury modeling, this was estimated to cost $716 billion (in 2010 dollars) (7), all of which money would go offshore for no productive return. Given recent changes to the floor price (28/8/12) this quantum will change, but the question can still be asked -- is this the best result we can get for Australia ?

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6. Conclusion

Having a large-scale renewable energy target of 41,000 GWhr /yr for electricity generation in Australia is not unreasonable, but forcing it by 2020 is likely to result in low-grade technologies like wind and the burning of biomass. A longer-term view, focusing on better technology outcomes, should be taken.

In this context, it is hard to escape the conclusion that, if Australia is serious about the potentially devastating effects of long-term climate change, it needs to put nuclear power generation on the table for assessment along with all other low-carbon alternatives.

To be realistic, modern research and development of large-scale nuclear power generating systems requires heavy commitment of financial and human resources, and is best done in the USA, UK, Europe and China where nuclear power has been in use for decades. That said, current Australian Government policy of not even thinking about how to access nuclear power is short-sighted, and likely to leave us stranded with outdated technologies when the tide in favour of fossil fuels recedes. Renewables have a place, but objective analysis will show they can't do the whole electric power job on the scale required to combat climate change while maintaining our economic growth and standard of living.

Perhaps the best known climate scientist in the world, Dr. James Hansen of NASA's Goddard Space Institute in the USA, had this to say recently (9)…. ***"Many well-meaning people proceed under the illusion that 'soft' renewable energies will replace fossil fuels if the Government tries harder and provides more subsidies. It will be a tragedy if environmentalists allow the illusion of 'soft' energies to postpone demand for a real solution of the energy, climate and national security problem. Nuclear power already has the best safety record of any energy technology, and the newest nuclear plants have great improvements."***

It is time for the nuclear option for Australia to be reviewed. Current Government policy needs to change, and a bipartisan political approach taken, to enable this to happen.

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