Technical and Economic Feasibility of 100% renewable energy: *the Australian National Electricity Market*

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The challenge + opportunity for a clean energy future

We must seize the opportunity for a clean energy future.
Let me be straight: our ongoing failure to realise the full potential of clean energy technology is alarming. Midway through 2012, energy demand and prices are rising steadily, energy security concerns are at the forefront of the political agenda, and energy-related carbon dioxide (CO₂) emissions have reached historic highs. Under current policies, both energy demand and emissions are likely to double by 2050.

To turn the tide, common energy goals supported by predictable and consistent policies are needed across the world. But governments cannot do this alone; industry and citizens must be on board. The public needs to understand the challenges ahead, and give the necessary support and mandate for policy action and infrastructure development. Only decisive, effective and efficient policies can create the investment climate that is ultimately needed to put the world on a sustainable path.

The good news is that technology, together with changed behaviour, offers the prospect of reaching the international goal of limiting the long-term increase of the global mean temperature to 2°C. By reducing both energy demand and related greenhouse-gas (GHG) emissions, strategic application of clean energy technologies would deliver benefits of enhanced energy security and sustainable economic development, while also reducing human impact on the environment.

(IEA, Energy Technology Perspectives, 2012)
Taking a longer-term perspective, 100% renewables a question of when.. and how

- Our only technically feasible option

(Murphy, http://physics.ucsd.edu/do-the-math/, 2012)

Only real uncertainty with fossil fuels is how much might be left hence sharpness of this peak … Uranium too
Mitigation pathways: What exists is possible… although not always attractive

(Former) USSR emissions fell 50% in less than a decade through widespread economic collapse.
More thoughtful transition pathways

A 100% 2050 renewables goal … yet also shorter term targets to better drive action

DK Energy Agreement, March 22 2012

- With the Energy Agreement of March 22, we have succeeded in obtaining broad political commitment to an ambitious green transition for Denmark that focuses on energy savings throughout society and promotes renewable energy in all sectors.
- This agreement implies a 12% reduction of gross energy consumption in 2020 in comparison to 2006; a share of 35% renewable energy in 2020; and 50% wind energy in Danish electricity consumption in 2020.
- The agreement is important for delivering on the political goal that Denmark’s entire energy supply (electricity, heating, industry and transport) is covered by renewable energy in 2050.
Growing interest in future 100% renewable electricity

- Many drivers including
  - climate change (and given poor progress of other low carbon options)
  - energy security (most countries see fossil fuel $ as economic liabilities)
  - falling renewable technology costs

- Some key questions
  - Technical feasibility? – can 100% renewables mixes utilizing highly variable and somewhat unpredictable solar and wind reliably meet demand at all times and locations
  - If yes, Economic feasibility? – is 100% renewables economically worth doing given likely costs vs costs of inaction, other options
  - If yes, how do we get there

(Chart: IES Workshop on Rapid Climate Mitigation, APVA, 2012)
Technical feasibility: range of proven renewables

Figure 4.6  Near-term technology development priorities and CO$_2$ mitigation for power generation technologies

(IEA, Energy Technology Perspectives, 2010)

A range of renewable technologies more advanced that CCS, or Nuclear Gen IV
Technical feasibility: ‘what exists is possible’
winds a significant contributor in growing number of electricity industries

(LBL/DOE, *Wind Technologies Market Report, 2011*)

Source: Berkeley Lab estimates based on data from BTM Consult, EIA, and elsewhere
100% renewables for the NEM?
A significant change from current mix with some hydro, modest wind
Note missing PV, other non-registered renewables
Some new NEM regions to consider

The diversity of Australian climate zones
(Source: Bureau of Meteorology)

Considerable ‘integration’ value in having diverse climate regions across the NEM
Supply and Demand for a Typical Week in Summer 2010 – Baseline Simulation

(Elliston et al, Energy Policy, 2012)
Supply and Demand for a Challenging Week in Winter 2010 – Baseline Simulation

Work in progress: Simulation extensions and Search

- **Cost model** – using AETA (BREE, 2012)
  - 2030 projected annualised capital cost ($/kW/yr)
  - Fixed O&M ($/kW/yr) and Variable O&M ($/Mwh)
  - Optionally including ‘high level’ indicative transmission costs

- **Regional model**
  - Each “generator” assigned to a region
  - Dispatch algorithm is now region-aware
  - Tracks hourly energy exchanges between regions

- **Search algorithm**
  - genetic algorithm seeks mix of technologies and locations to minimise overall industry annualised (capital and operating) cost *(including cost of USE)*
A basis for cost comparisons?

Existing plants will eventually require replacement

Climate change requires an effective response

Thermal efficiency versus plant age in the NEM (coal only). Source: Noone (2012)
Preliminary findings (still under peer review)

A$\text{b/yr}$ for AETA high and low technology cost scenarios

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<tr>
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<th>Without transmission</th>
<th>With transmission</th>
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<tbody>
<tr>
<td>Low cost</td>
<td>19.6</td>
<td>21.2</td>
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<tr>
<td>High cost</td>
<td>22.1</td>
<td>24.4</td>
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Current NEM costs approx. $10b/year. At carbon prices of $50$-100/tCO2 100% renewables costs can be lower cost than ‘replacement’ scenario.

+ 8.8 TWh spilled
+ 24.9 TWh spilled

IED Workshop on Rapid Climate Mitigation
Qualifications, limitations and further work

- Preliminary findings only at this stage
- Simulation and Search limitations
  - 2010 only, hourly resolution and small number of generator sites due to limited data,
  - No modelling of plant or network failures for improved reliability assessments
  - Network model not complete, no constraints
  - Reference scenario not a likely future
- Further work
  - Improve temporal, spatial data resolution
  - Additional scenarios for comparison (eg, CCS, all gas, nuclear)
  - Compare, contrast, learn from and help inform other forthcoming modelling efforts including *AEMO 100% renewables scenario*
An extra $10b/year compares to ....

- In 2012 Australian Households will spend **$642 billion** on living costs including:
  - $11.7 billion a year on meat *versus* $2.4 billion a year on seafood
  - $14.1 billion a year on alcohol *versus* $1.1 billion a year on tea and coffee
  - $78.4 billion a year on cars *versus* $2.2 billion a year on public transport
  - $8.0 billion a year on beauty *versus* $2.0 billion a year on brains
  - $19.0 billion a year on recreational *versus* $8.3 billion a year on medical
  - $9.5 billion a year on gadgets *versus* $5.1 billion a year on fashion
  - $10.5 billion a year on personal care *versus* $0.78 billion a year on pet pampering

(www.moneysmart.gov.au)