Centre for Energy and Environmental Markets

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Technical, economic + commercial opportunities and challenges of a 100% renewably powered 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 (CO_2) emissions have reached historic highs. Under current policies, both energy demand and emissions are likely to double by 2050.

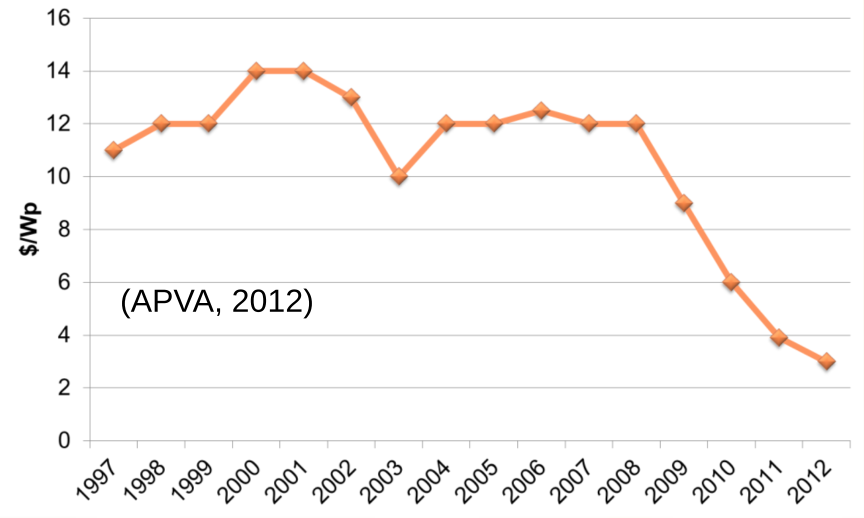
To turn the tide, common energy goals supported by predictable and consistent policies are needed across the world. But governments cannot do this alone; industry and citizens must be on board. The public needs to understand the challenges ahead, and give the necessary support and mandate for policy 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)

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,** Commercial feasibility? – can we establish commercial frame-works that drive appropriate deployment at speed and scale required

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100% renewables for the NEM?

A significant change from current mix with some hydro, modest wind

Note missing PV, other non-registered renewables

Figure 1.4
Registered capacity in regions, by fuel source, 2011

(AER, *2012*)

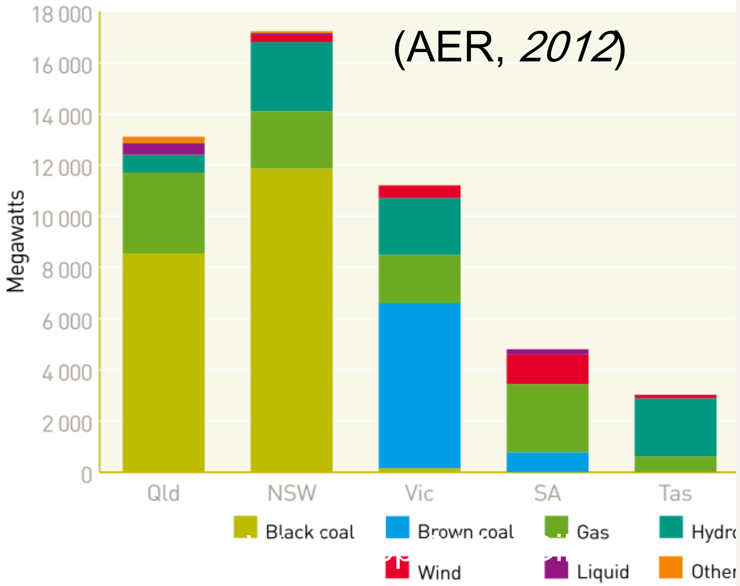
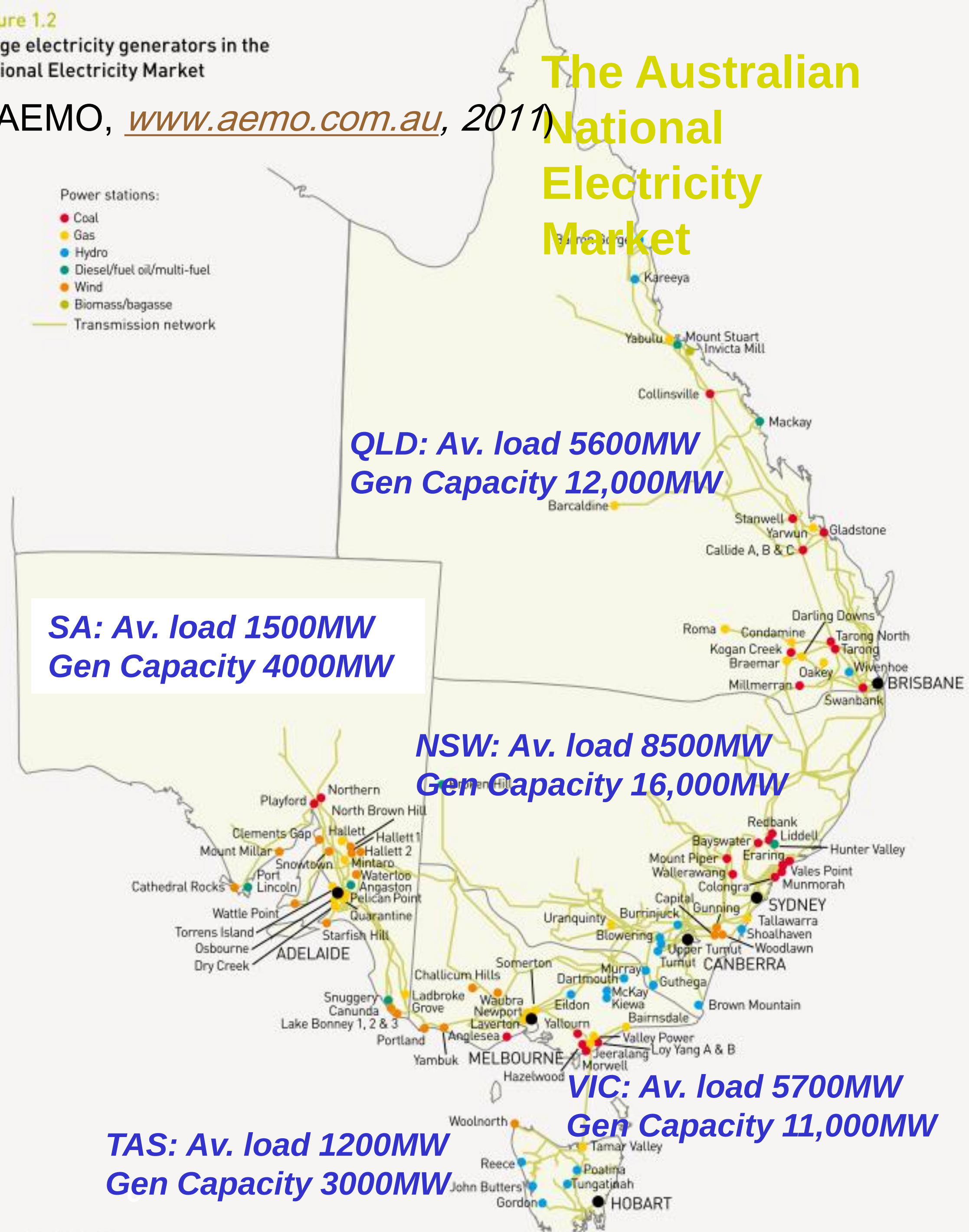


Figure 1.2
Large electricity generators in the National Electricity Market

(AEMO, www.aemo.com.au, *2011*)

The Australian National Electricity Market



QLD: Av. load 5600MW
Gen Capacity 12,000MW

SA: Av. load 1500MW
Gen Capacity 4000MW

NSW: Av. load 8500MW
Gen Capacity 16,000MW

VIC: Av. load 5700MW
Gen Capacity 11,000MW

TAS: Av. load 1200MW
Gen Capacity 3000MW

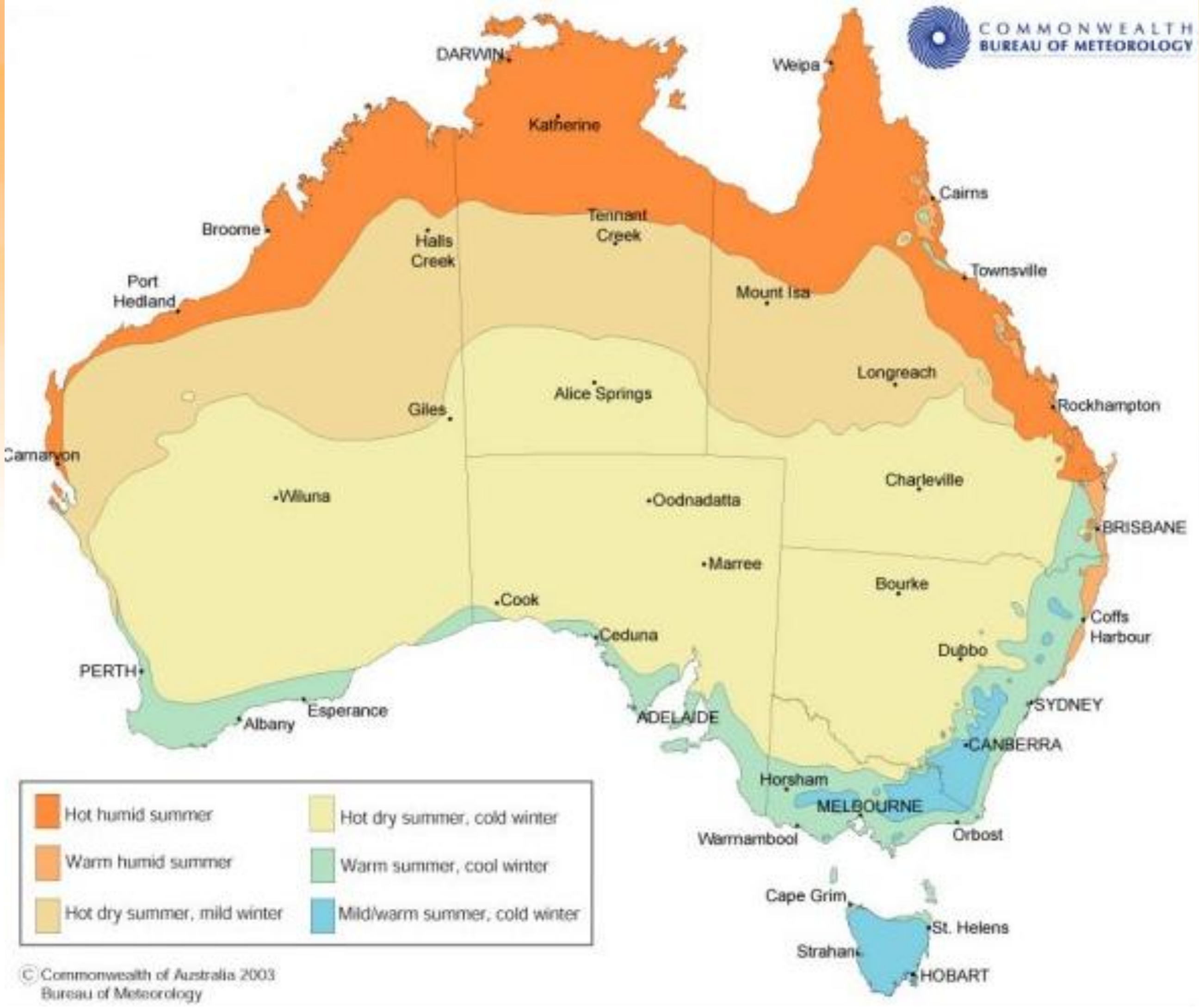
Sources: AEMO; AER

UNSW Modelling and simulation framework

- Consider only deployed renewable technologies with high Australian potential resource
  - On-shore wind, PV, CST, biogas turbines, existing hydro
- Hourly simulations of generation dispatch using regional weather observations to meet actual NEM demand over 2010 (8760 hours)
- Renewable generation mix and locations chosen by guided exploration
  - meet 0.002% Unserved Energy for entire year
  - moderate energy ‘spill’
  - moderate total biomass energy consumption
  - No additional hydro
- No consideration of costs, Tx requirements
- Implemented in Python – databases, dispatch (Elliston, 2010)

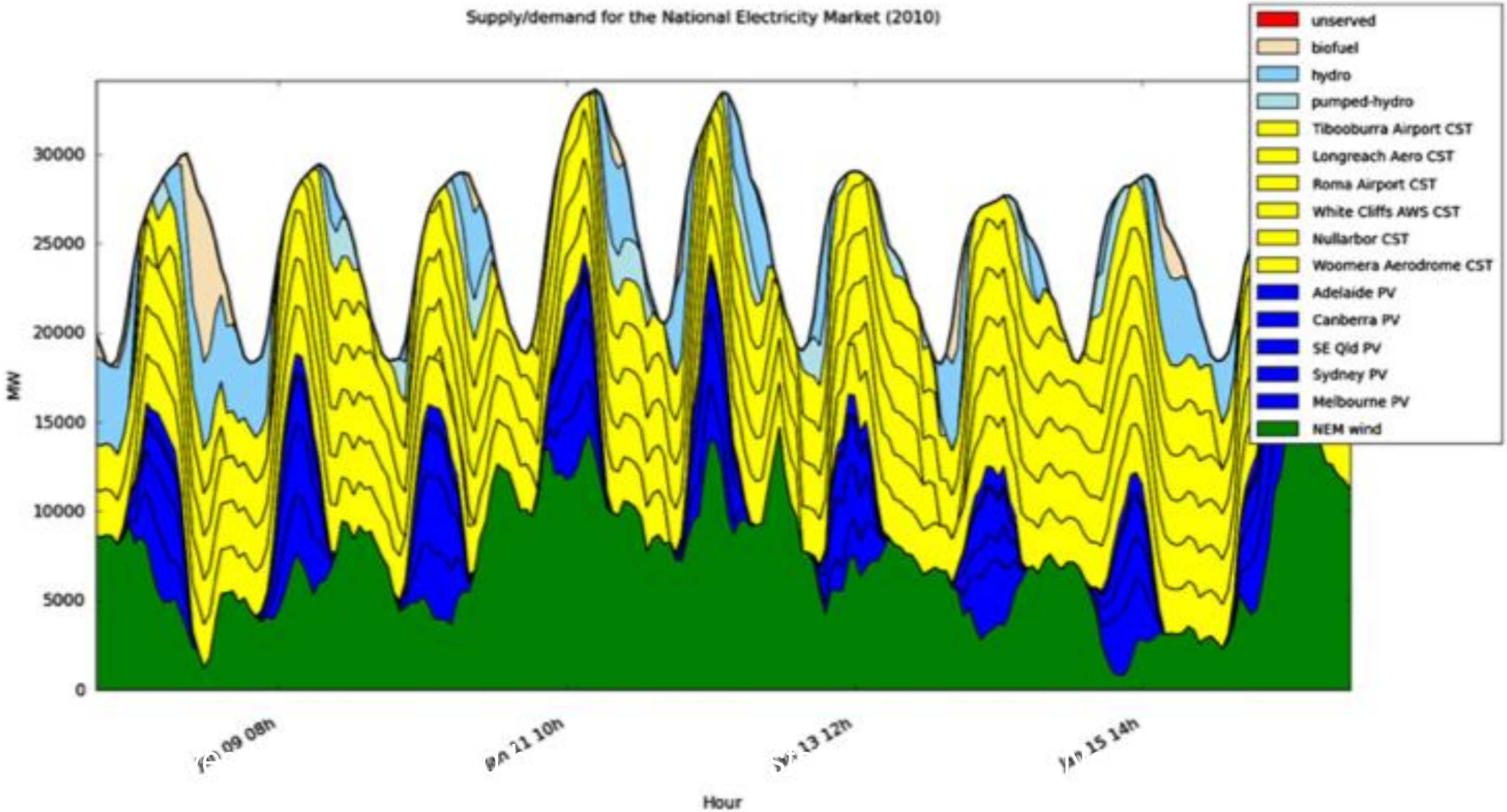
Elliston, Diesendorf and MacGill (2012) Simulations of Scenarios with 100% Renewable Electricity in the Australian National Electricity Market, **Energy Policy** (45)

Some new NEM regions to consider

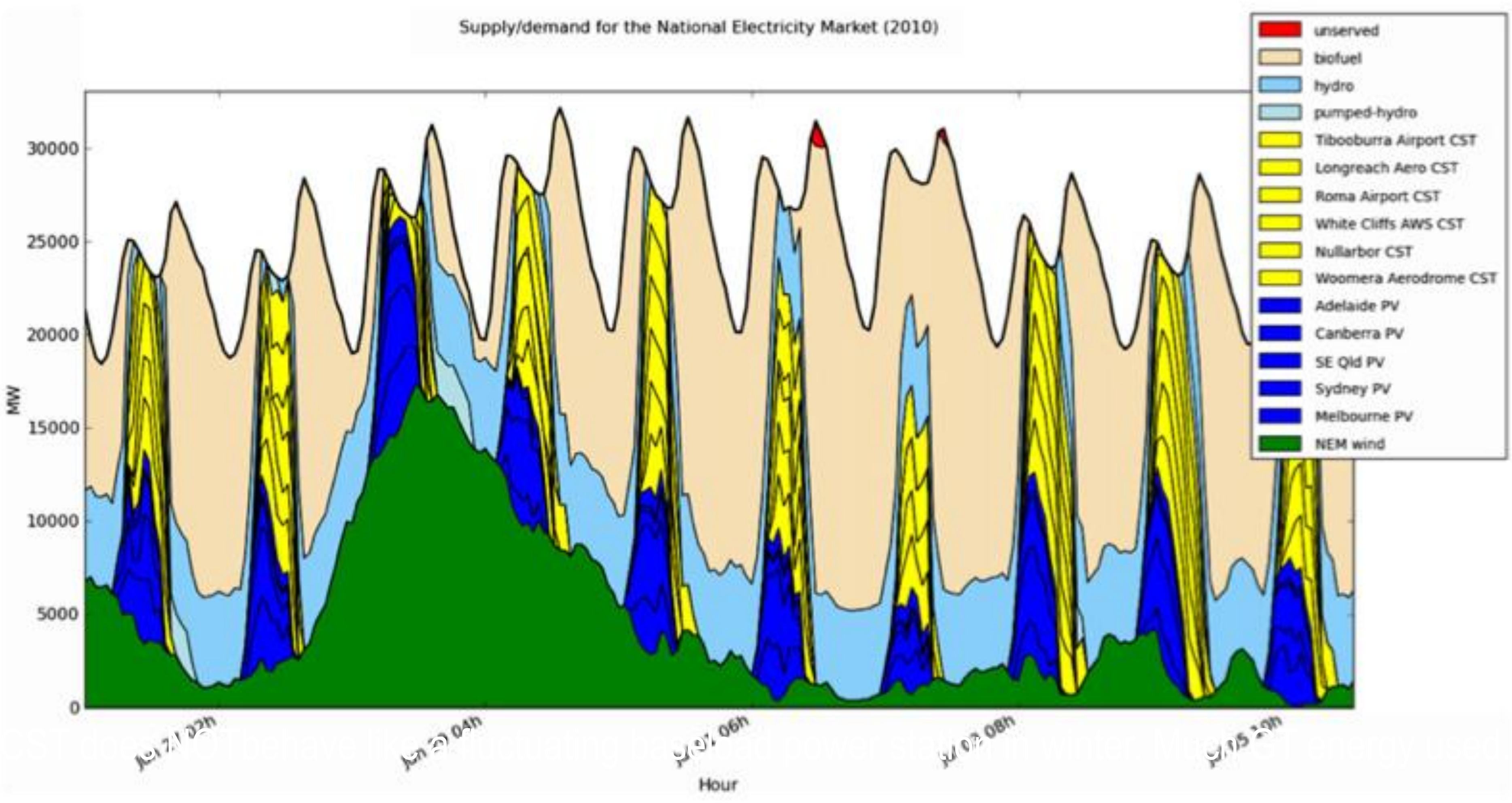


The diversity of Australian climate zones (Source: Bureau of Meteorology)

Supply and Demand for a Typical Week in Summer 2010 – Baseline Simulation



Supply and Demand for a Challenging Week in Winter 2010 – Baseline Simulation



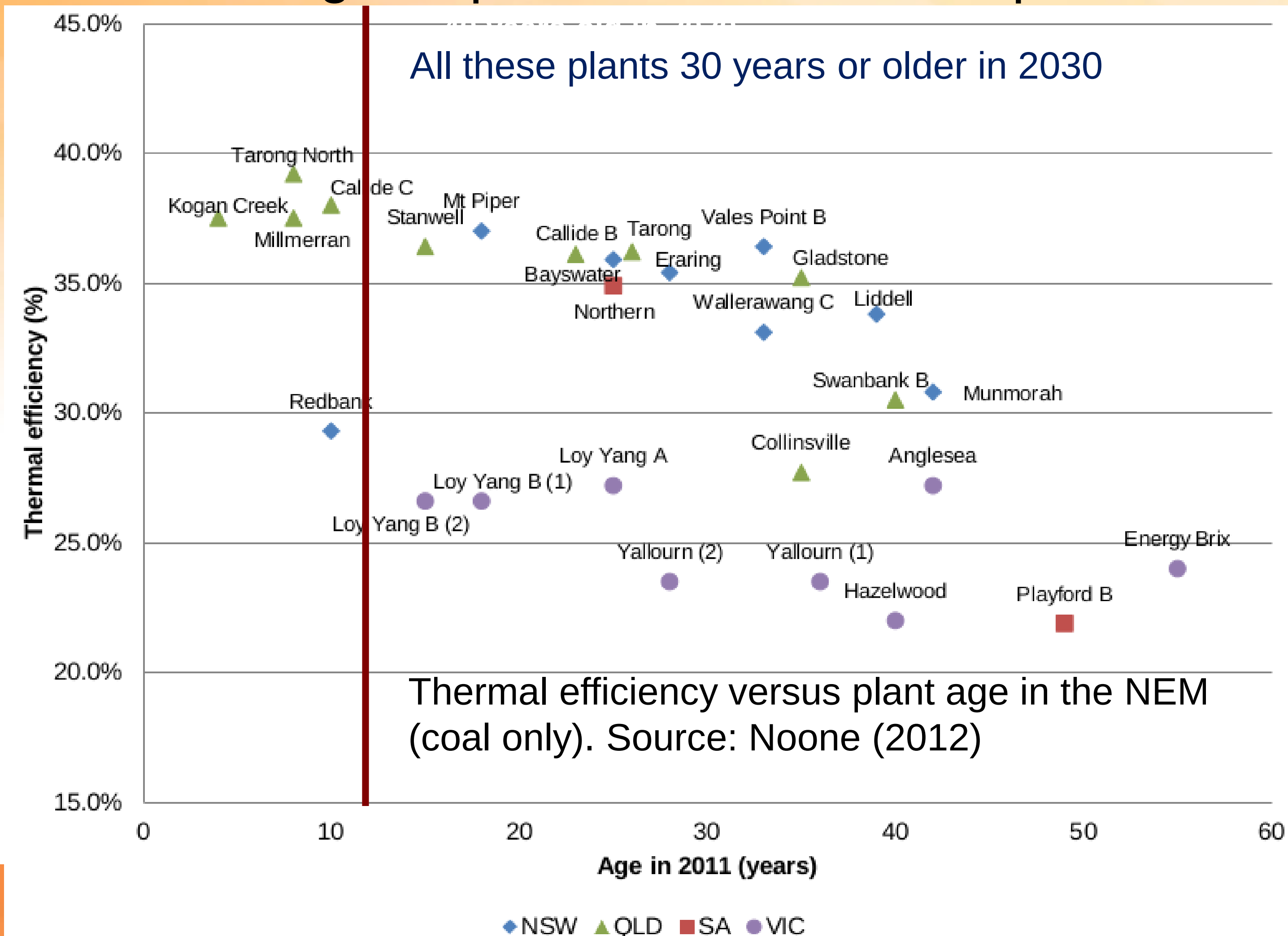
Work in progress: Simulation extensions and *Search*

- 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)

Possible Replacement scenario

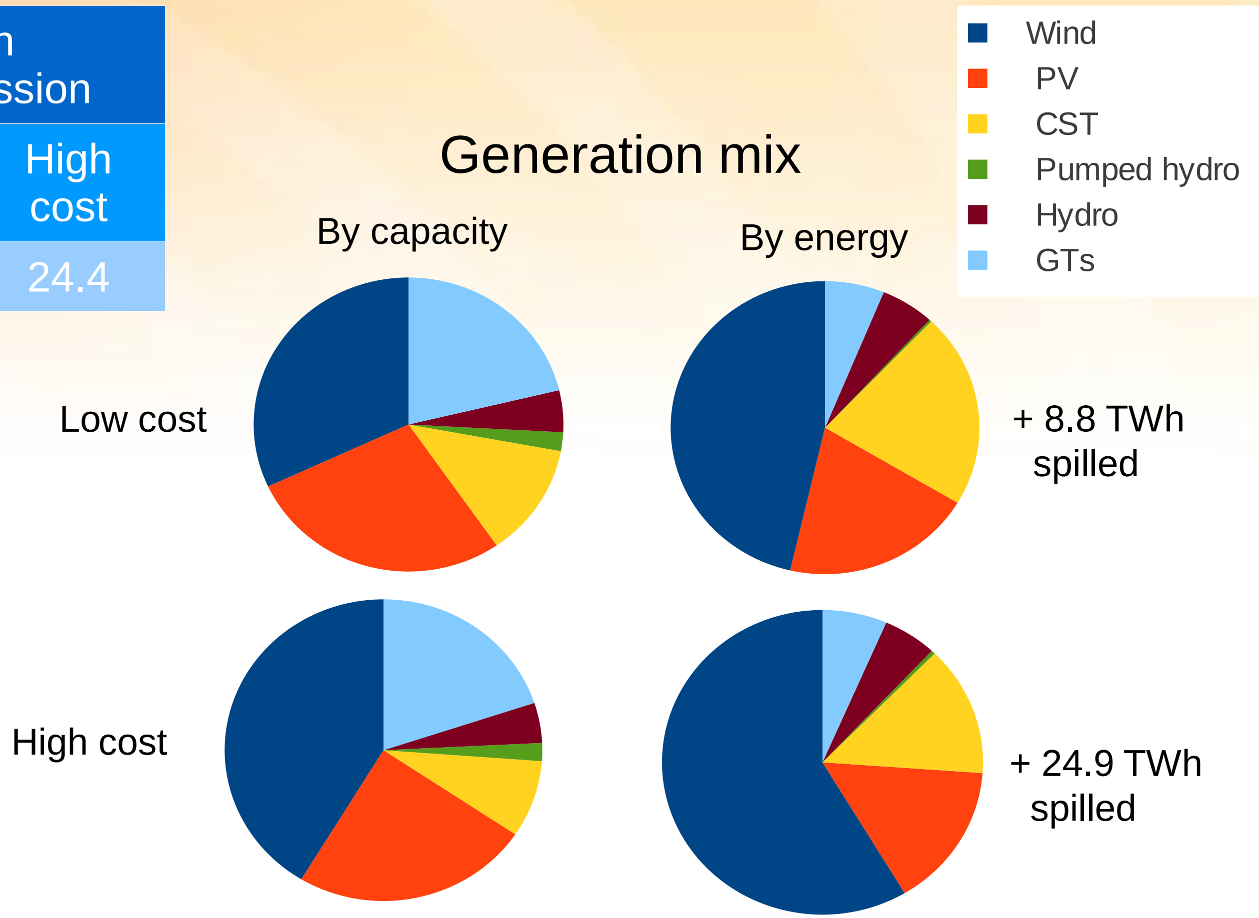
- Replace ageing plants but unchanged fuel types
  - Direct substitute
    - eg. supercritical black coal like-for-like
  - Some upgrading to best available
    - eg. subcritical brown coal to supercritical brown coal
  - Some miscellaneous cases
    - eg. steam turbines fired by natural gas to CCGT
- Calculate cost to meet 2010 demand
  - Re-calculate SRMC for every plant
  - Calculate 2010 operating costs using dispatch data
    - *Exclude plant if not dispatched in 2010*
- Assume carbon pricing would not alter generator dispatch
- *Note: emissions fall 20% from current NEM levels*

Preliminary findings (still under peer review)

A$b/yr for AETA *high* and *low* technology cost scenarios

Without transmission		With transmission	
Low cost	High cost	Low cost	High cost
19.6	22.1	21.2	24.4

At carbon prices of $50-100/tCO2 100% renewables costs can be lower cost than 'replacement' scenario



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*

Commercial? a question of policy: progress, much more required

CO_2 reduction share by 2020*	On track?	Technology	Status against 2DS objectives	Key policy priorities
		HELE coal power	Efficient coal technologies are being deployed, but almost 50% of new plants in 2010 used inefficient technology.	CO_2 emissions, pollution and coal efficiency policies required so that all new plants use best technology and coal demand slows.
		Nuclear power	Most countries have not changed their nuclear ambitions. However, 2025 capacity projections are 15% below pre-Fukushima expectations.	Transparent safety protocols and plans; address increasing public opposition to nuclear power.
36%		Renewable power	More mature renewables are nearing competitiveness in a broader set of circumstances. Progress in hydropower, onshore wind, bioenergy and solar PV are broadly on track with 2DS objectives.	Continued policy support needed to bring down costs to competitive levels and to prompt deployment to more countries with high natural resource potential is required.
			Less mature renewables (advanced geothermal, concentrated solar power [CSP], offshore wind) not making necessary progress.	Large-scale RD&D efforts to advance less mature technologies with high potential.
			No large-scale integrated projects in place	Announced CCS demonstration funds must

= Not on track; = Improvements but more effort needed; = On track but sustained support and deployment required to maintain progress.

IEA perspective on global clean energy progress, and policy needs towards protecting the climate (max 2 deg.C warming), (Energy Technology Perspectives, 2012)