Comparing the costs of 100% renewable electricity with lower carbon fossil fuel scenarios in Australia

Never Stand Still | Engineering

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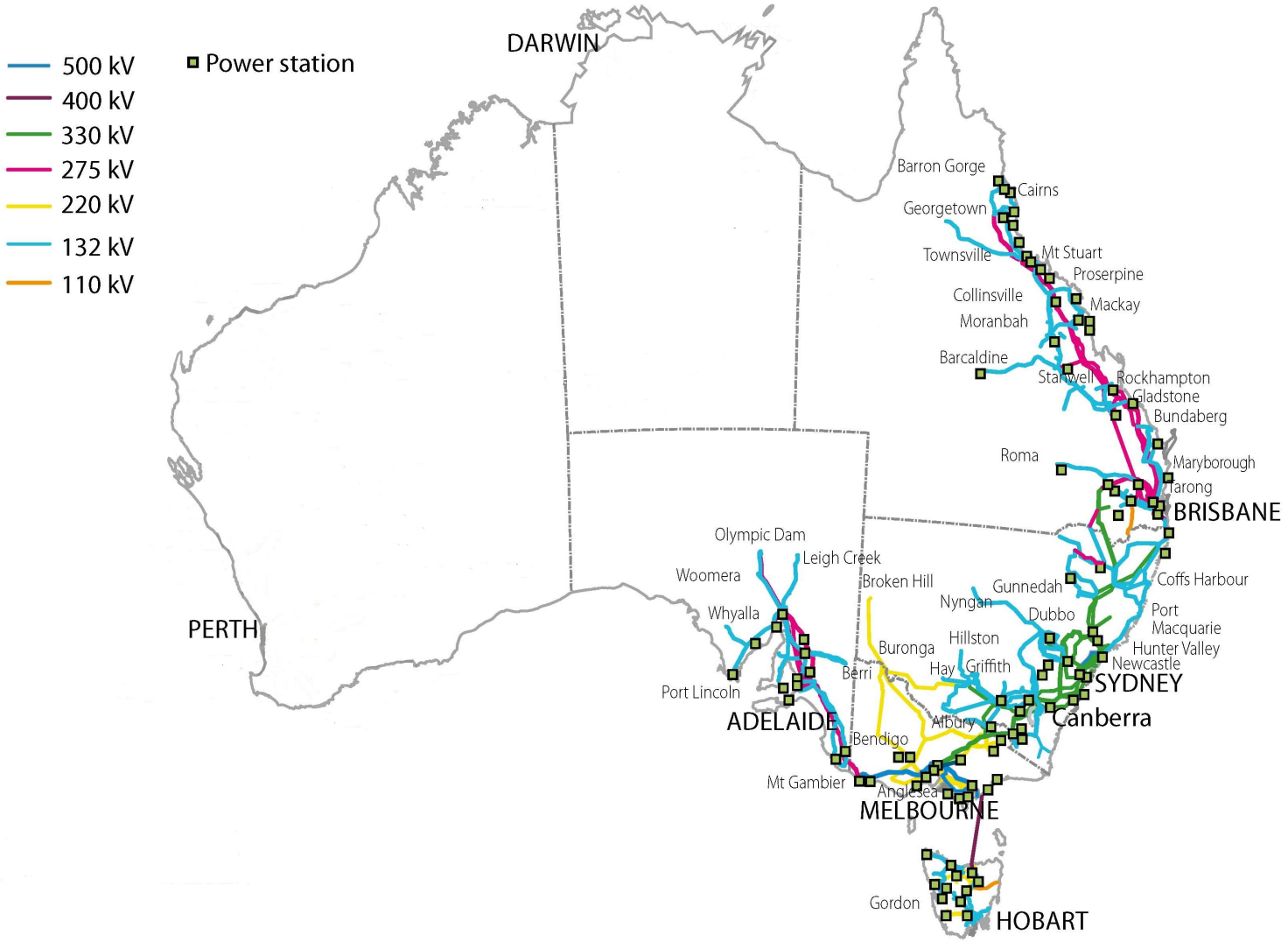
Outline

- Setting the scene
  - Long-lived assets, uncertainty in policies, costs & tech.
- NEM background
- Previous work on 100% renewables in Australia
- Status of carbon capture and storage (CCS)
- Three “lower” carbon fossil fuel scenarios
- Results
- Conclusions

Setting the scene

- Carbon budget vanishing quickly
  - IEA: “If action to reduce CO2 emissions is not taken before 2017, all the allowable CO2 emissions would be locked-in by energy infrastructure existing at that time”
- Electricity is a big emitter in Australia
  - Electricity produces around 1/3rd of emissions
  - Yet many low carbon generation options
  - Some options not commercially available
    - eg. enhanced geothermal systems, wave power, CCS
- Mitigation policy is really risk management
  - Limited time, some options are risky

National Electricity Market

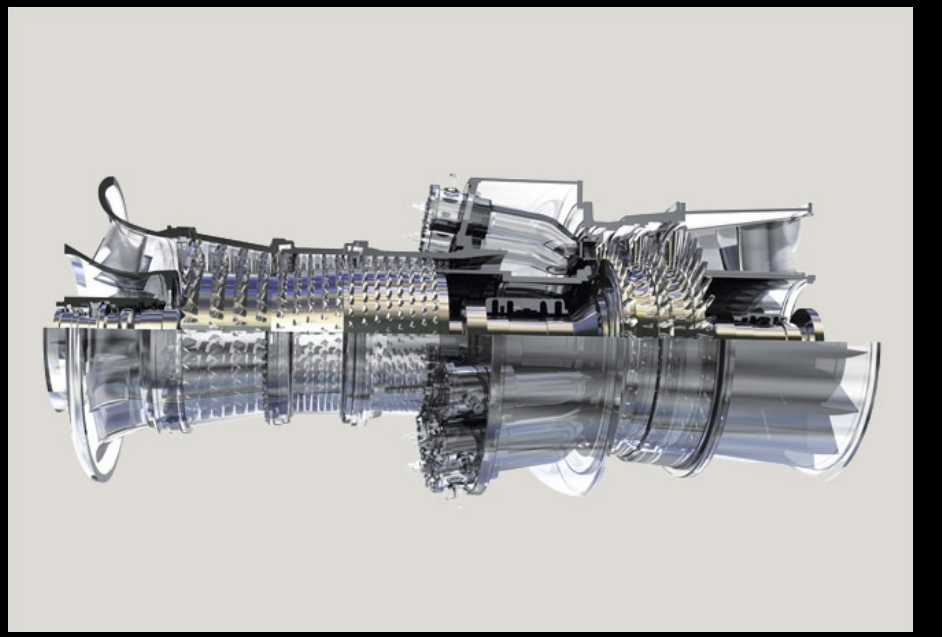


National Electricity Market

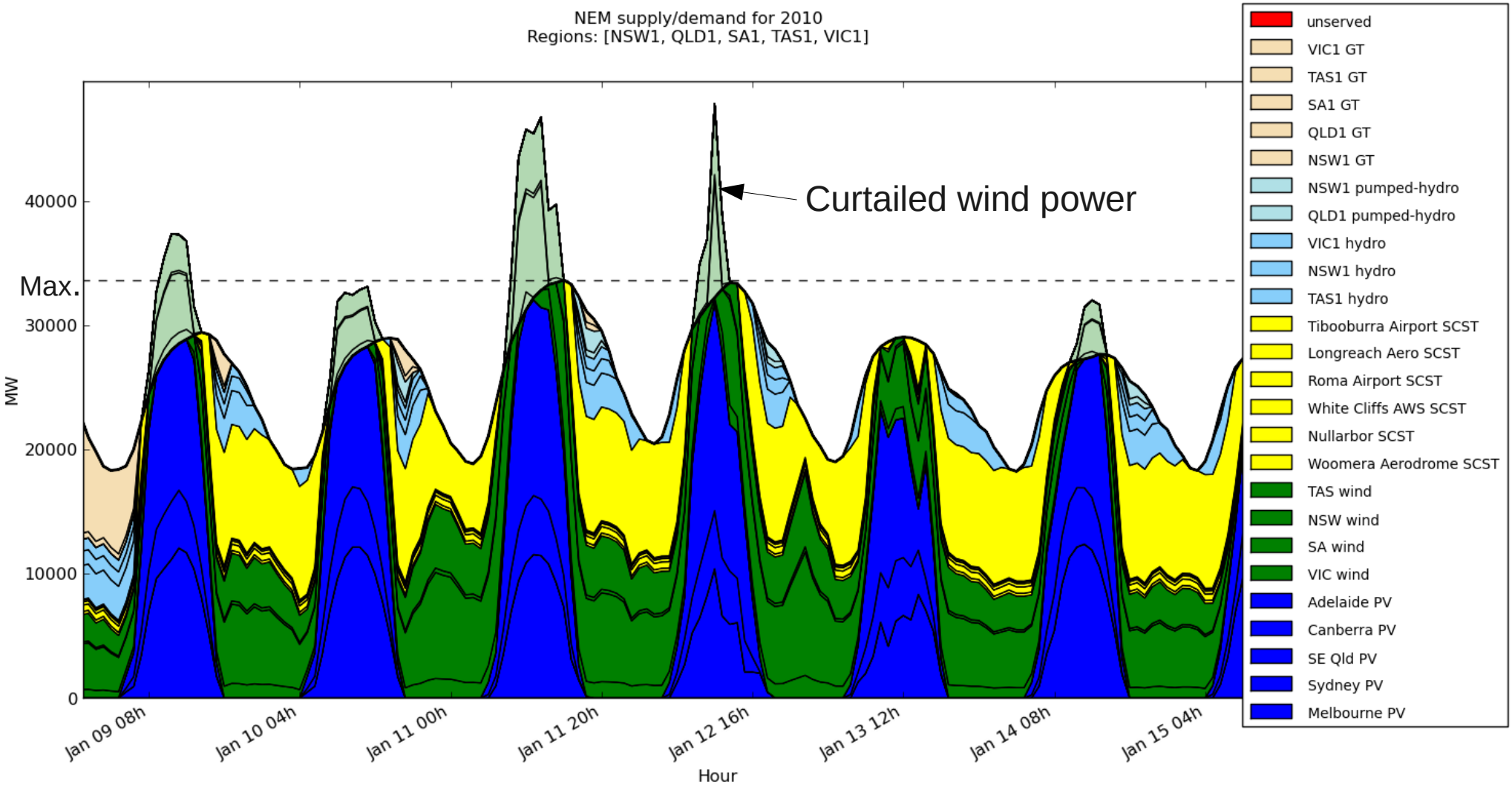
- Peak demand 35 GW
- Annual energy ~185 TWh
- Fuel mix: 75% coal, ~13% gas, ~12% renewables (hydro, wind, PV)
- 41 TWh (“20%”) renewable electricity target by 2020
- No large-scale solar PV
- No large-scale CSP (44 MW Liddell plant)
- Carbon pricing legislation to be repealed
  - $23 to $25 per tonne since July 2012

Previous work on 100% RE

- Beyond Zero Emissions (2010)
  - *Zero Carbon Australia Stationary Energy Plan*
- UNSW (2010 -)
  - Two papers published in Energy Policy
  - One under review
- AEMO 100% Renewables Study
  - No reference scenario



Hourly balancing mid-Jan 2010



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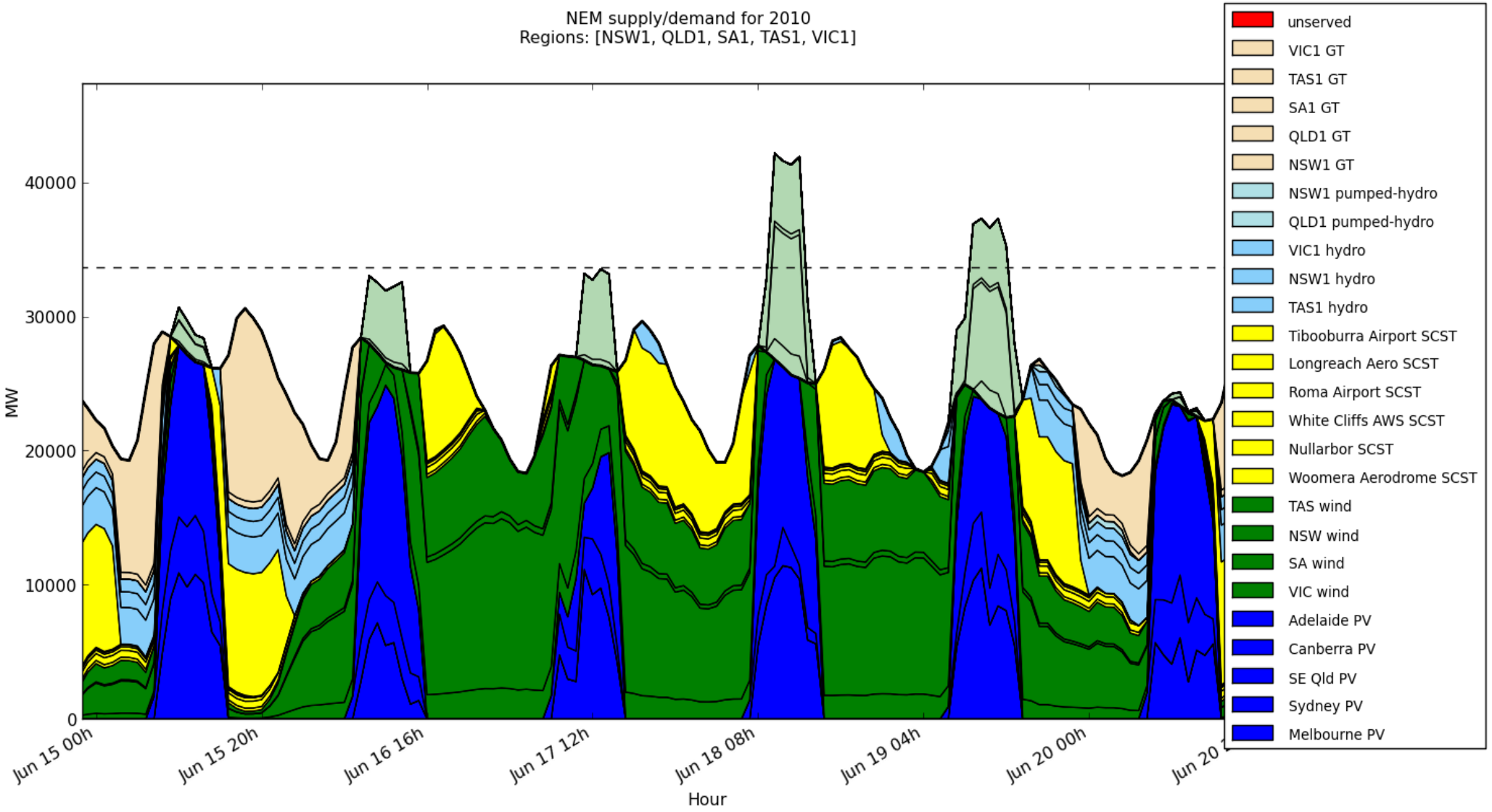
Hourly balancing mid-June 2010



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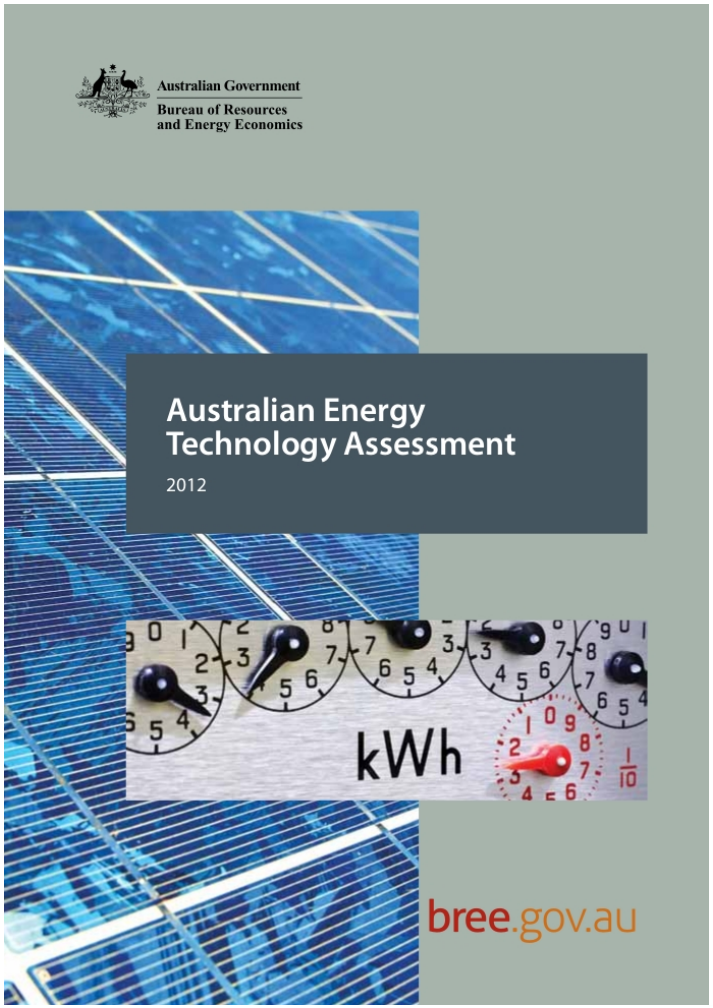
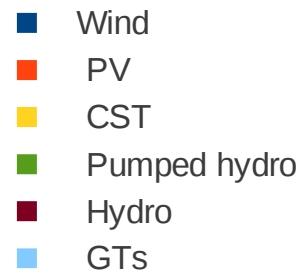
Technology cost data



Source: Bureau of Resource and Energy Economics (2012)

Generation mix

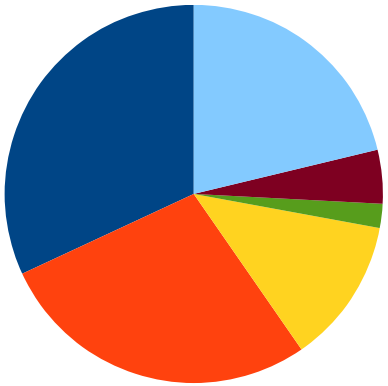
5% discount rate

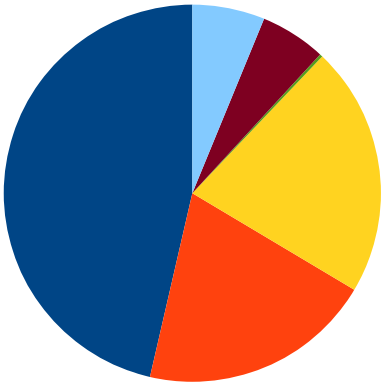


By capacity

By energy

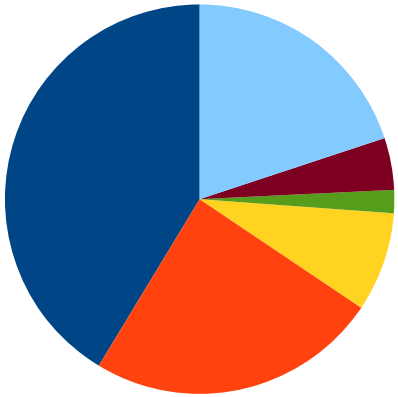
Low cost

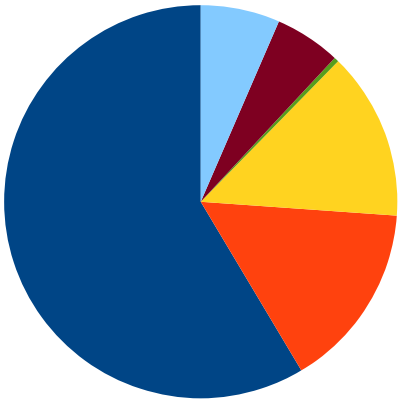




+ 8.8 TWh spilled (~4%)

High cost





+ 24.9 TWh spilled (~12%)

CST 13.3 GW, PV 29.6 GW (< Germany)

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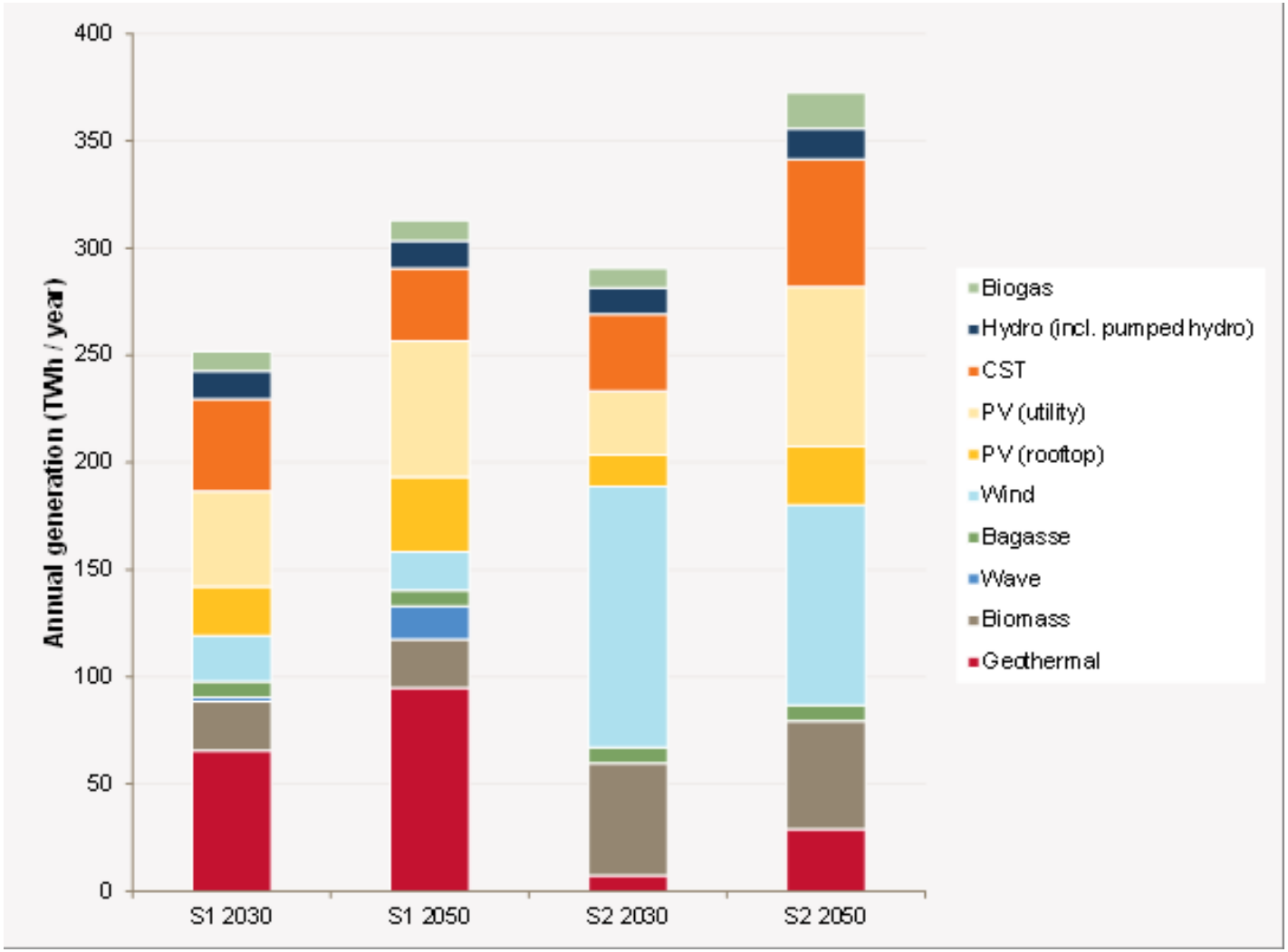
What are the likely costs?

	Generation only		Including transmission	
Discount rate	Low cost	High cost	Low cost	High cost
5%	$96	$108	$104	$119
10%	$135	$154	$153	$173

Average cost of energy (2012 $ per MWh)

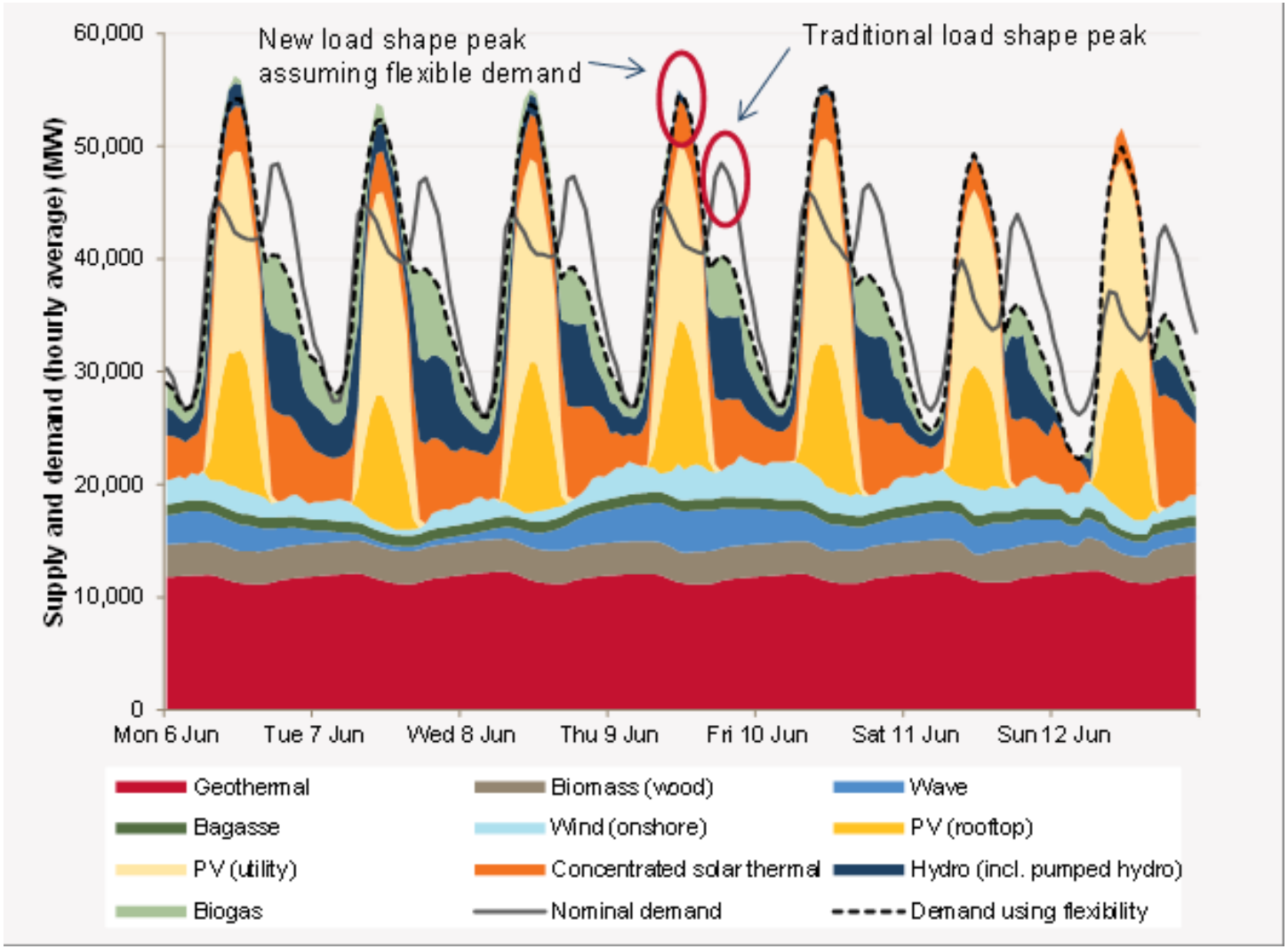
Hinkley Point C strike price: ~ $155 per MWh (2012 £)

AEMO 100% Renewables Study



Energy generation by technology

Sample balancing plot (AEMO)



Status of CCS

- 13 large-scale CCS demo projects world-wide
  - Operating or under construction
- Mostly capturing gas processing emissions
- IEA expected 260 Mt/y by now
  - 65 Mt/y being captured
- IEA: “CCS must be developed and demonstrated rapidly if it is to be deployed after 2020 at a sufficient scale to achieve the 2DS”
- Australian Government reducing funding

Status of CCS

Scenario 1: Coal with CCS

Saskpower Boundary Dam CCS plant under construction (Canada)

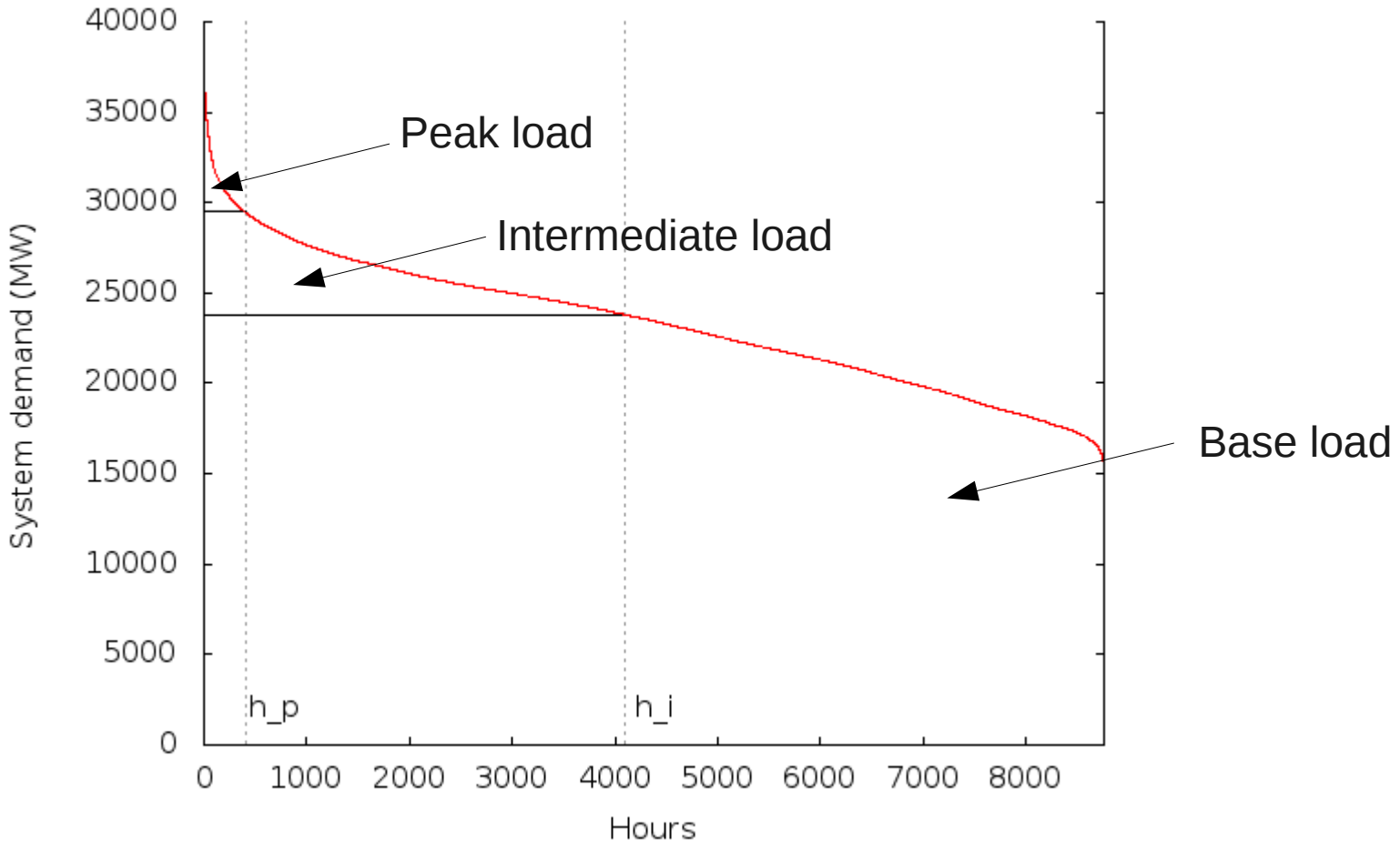
Scenario 2: CCGT

Marchwood 842 MW 2-on-1 CCGT (Hampshire, UK)

Scenario 3: CCGT with CCS

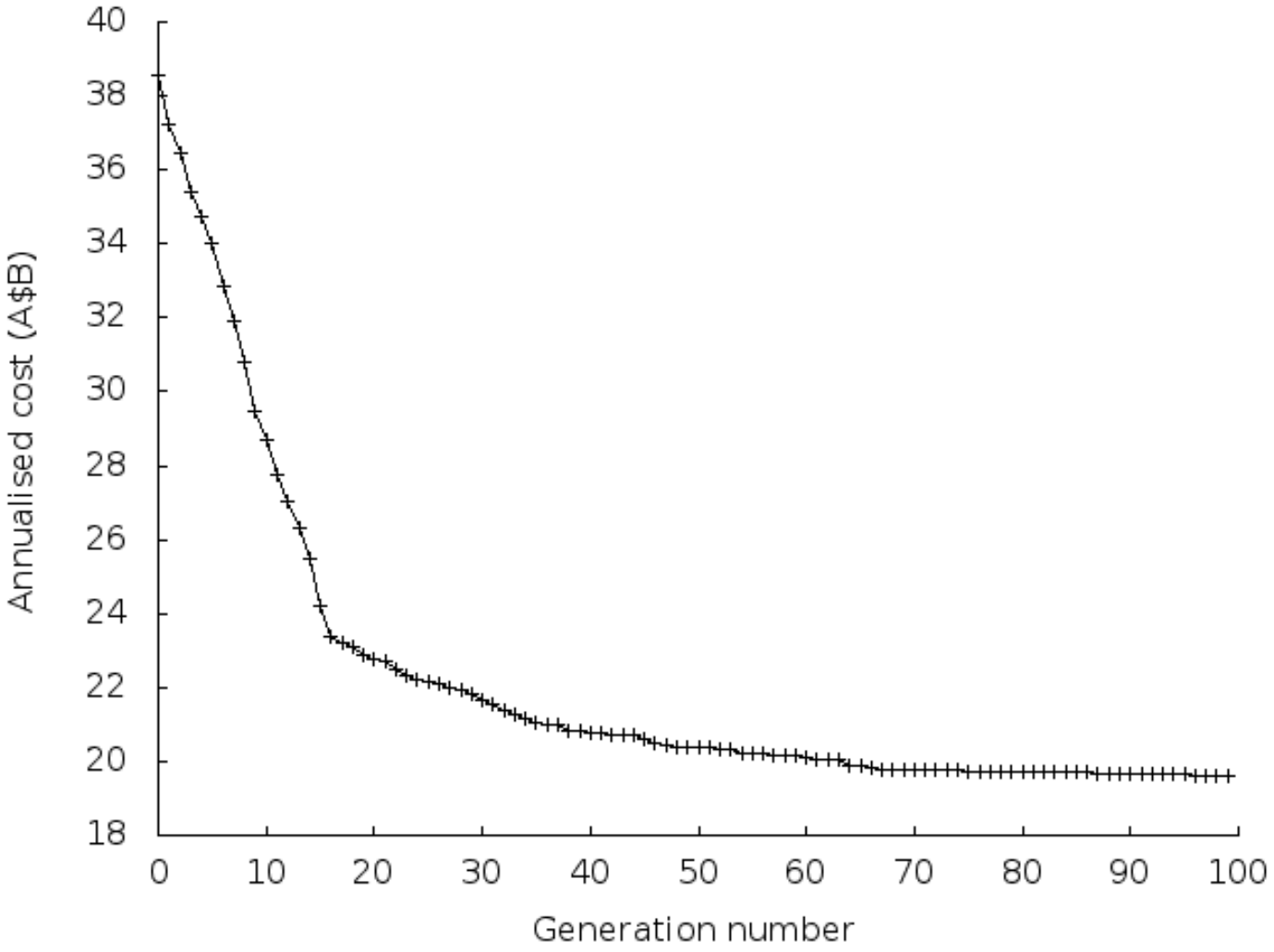
Marchwood 842 MW 2-on-1 CCGT (Hampshire, UK)

Traditional view of least cost mix



System-wide load duration curve for NEM in 2010

GA search for least cost mix



Baseline parameter values

Coal price	$1.86	per GJ
Gas price	$11	per GJ
Carbon price	$56	per t CO2
CO2 storage cost	$27	per t CO2
Emissions rate of coal plant	0.8	t/MWh
Emissions rate of OCGT plant	0.7	t/mWh
Emissions rate of CCGT plant	0.4	t/MWh
CCS post-combustion capture rate	85	%
Discount rate	5	%
Black coal PCC CCS plant capital cost	$4,453	2030 (low)
CCGT plant capital cost	$1,015	2030 (low)
CCGT with PCC CCS plant capital cost	$2,095	2030 (low)

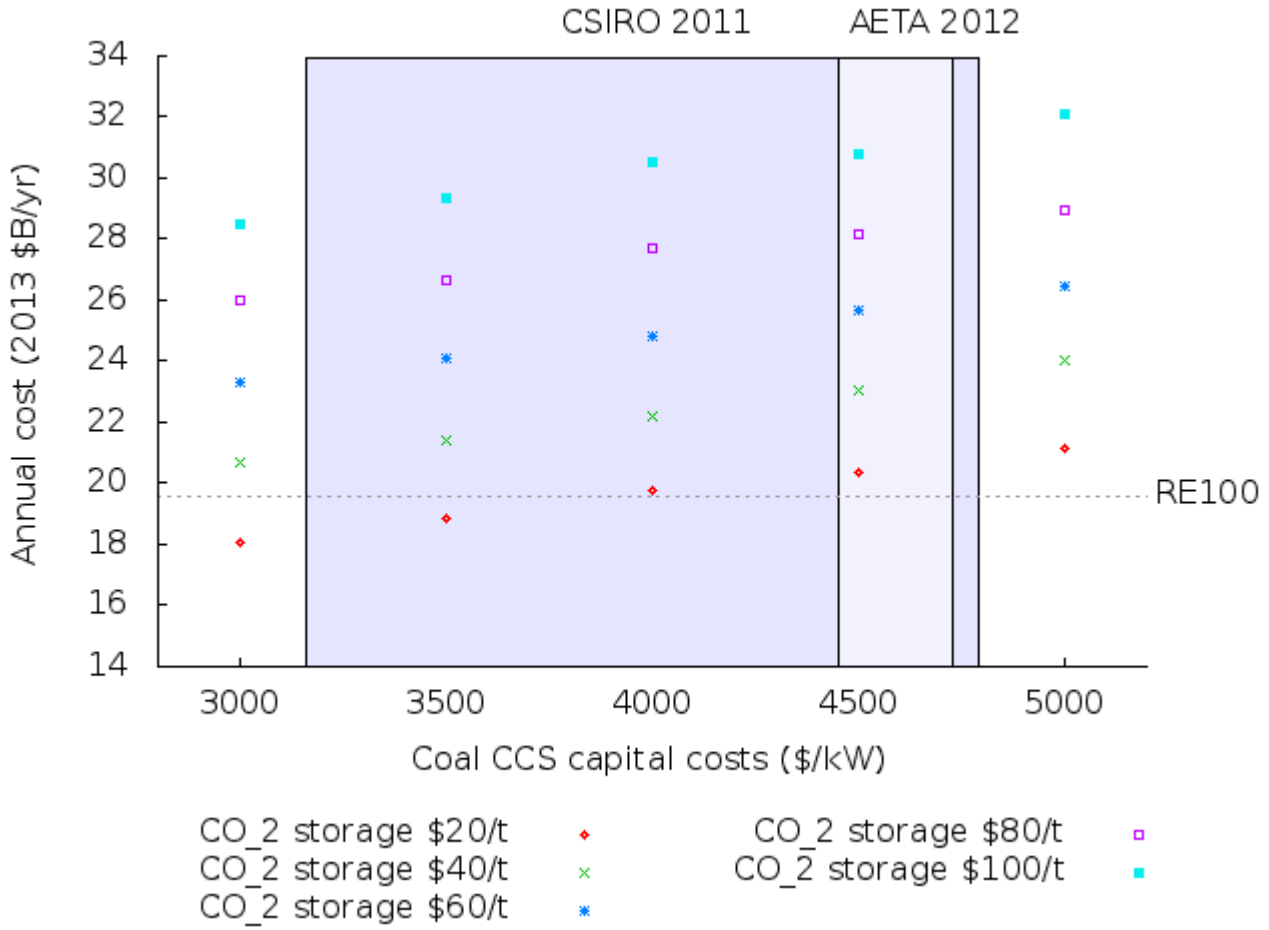
CO2 transportation and storage

Source: Allinson et al

CO2 transport and storage costs

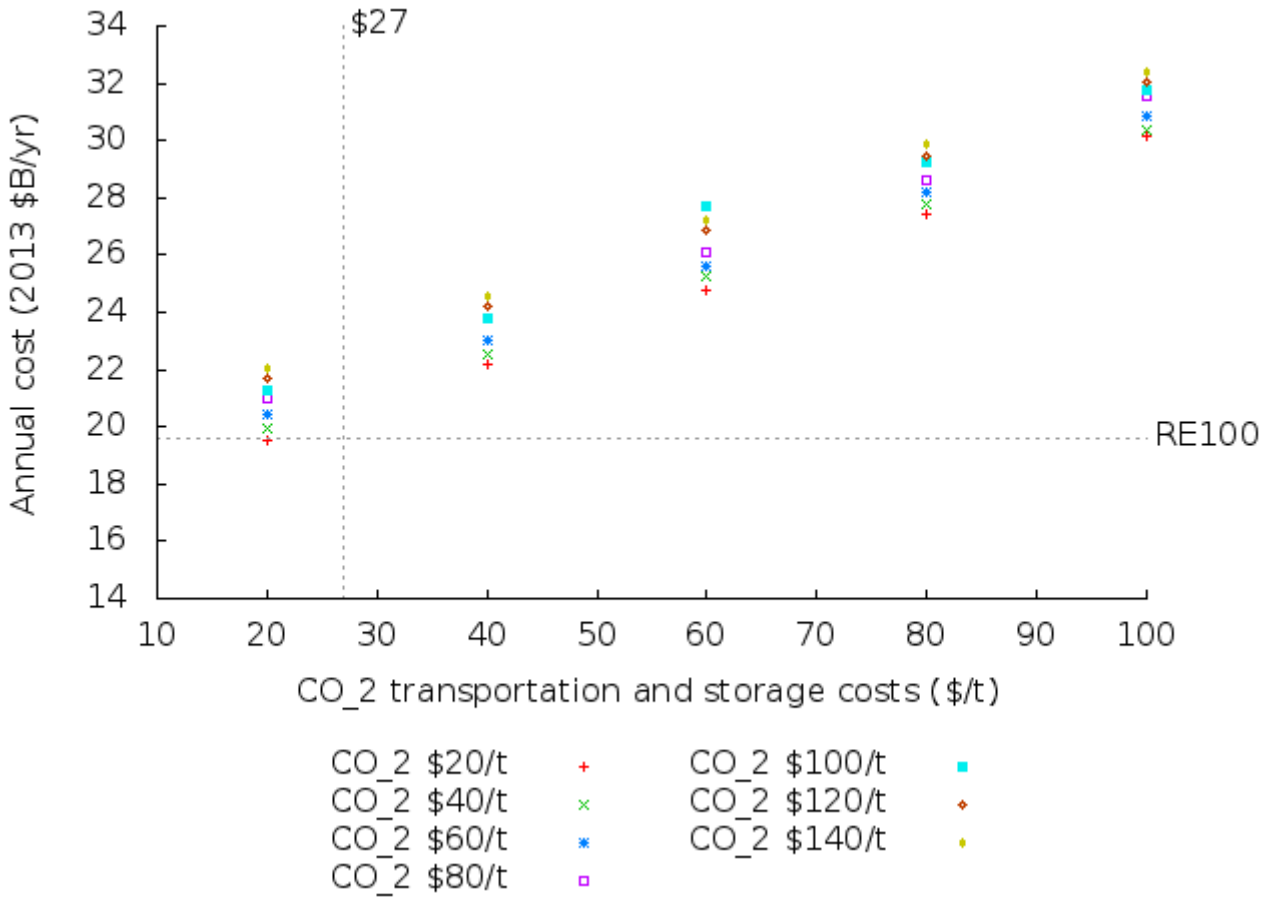
Region	2013 $ per tonne (5% disc. rate)
North Queensland	28
South Queensland	15
New South Wales	48
Victoria	17
NEM-wide average	27

Results



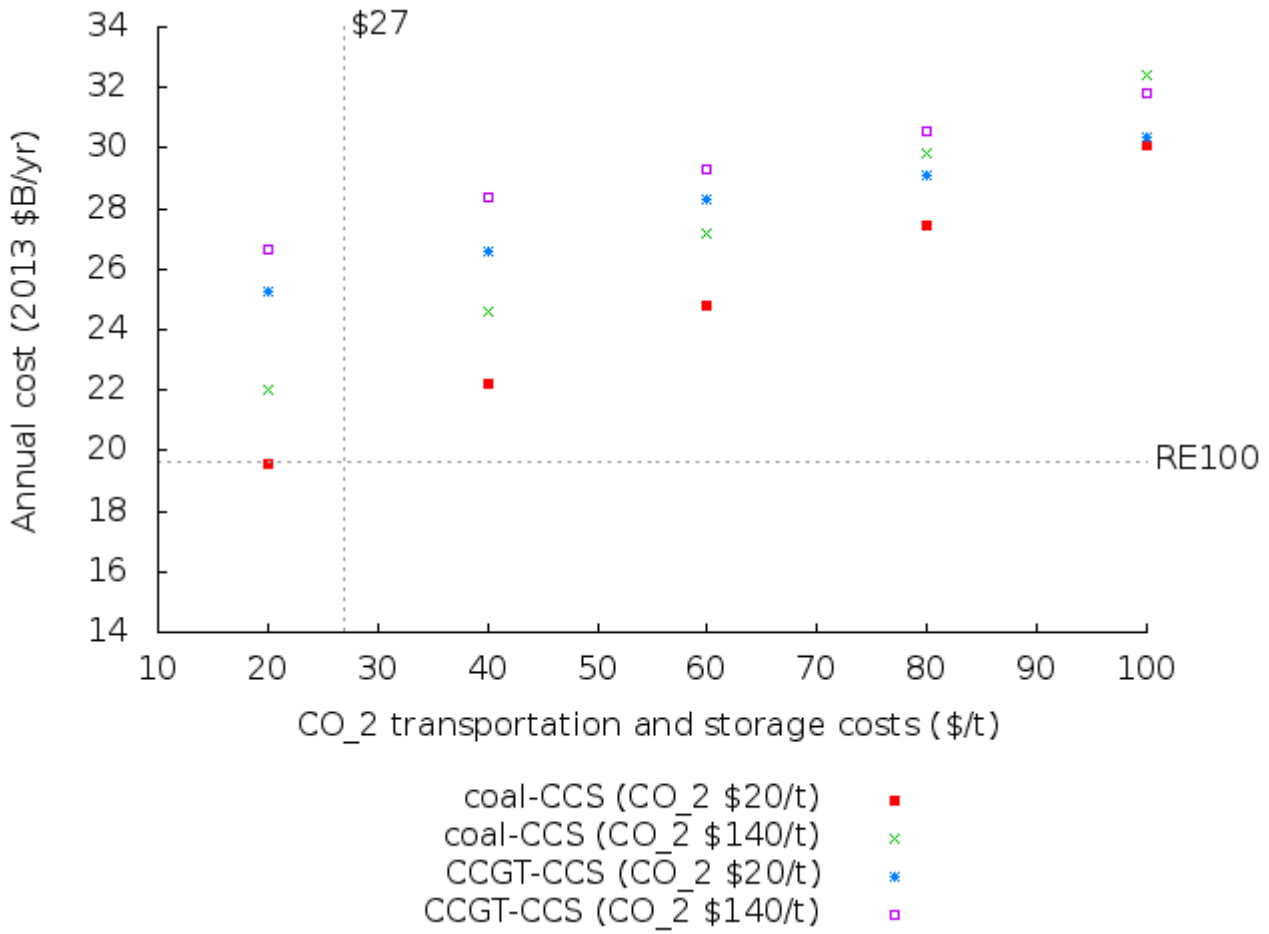
Sensitivity to coal CCS capital costs and CO2 storage costs

Results



Coal CCS scenario with varied carbon price and CO2 storage costs

Results



Sensitivity to CO2 storage costs and carbon price ($20, $140)

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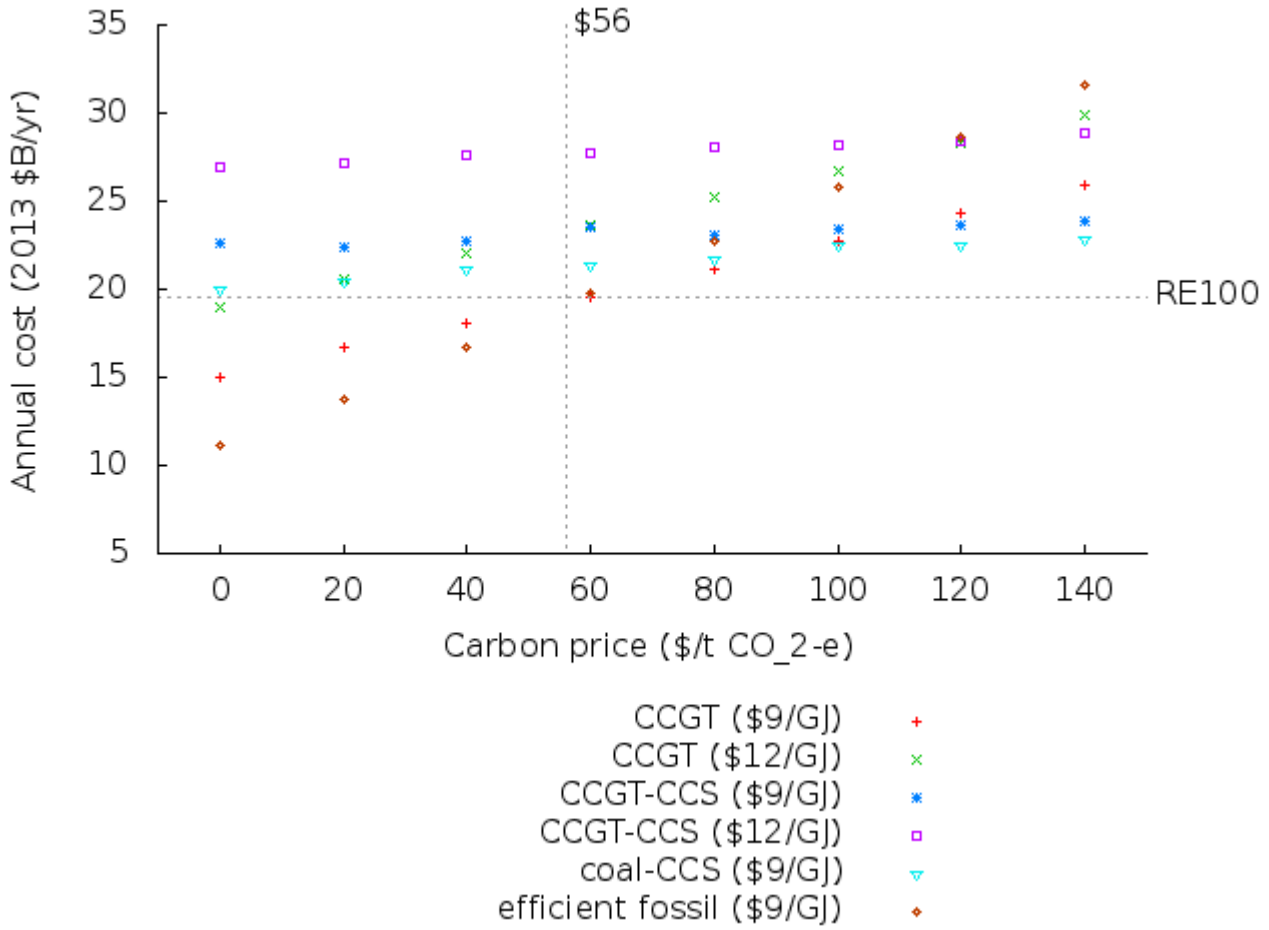
Results



Sensitivity to carbon price (and gas price)

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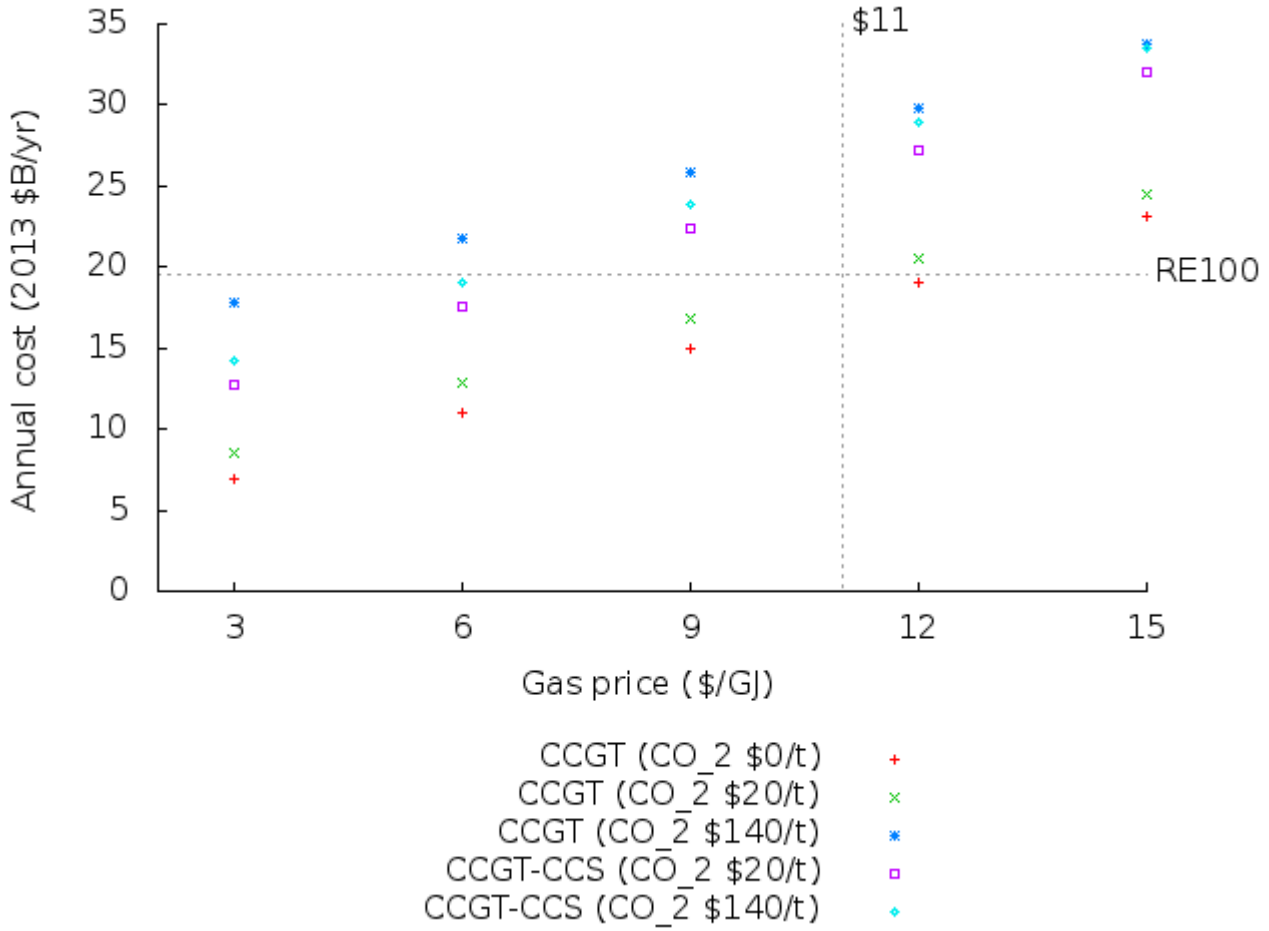
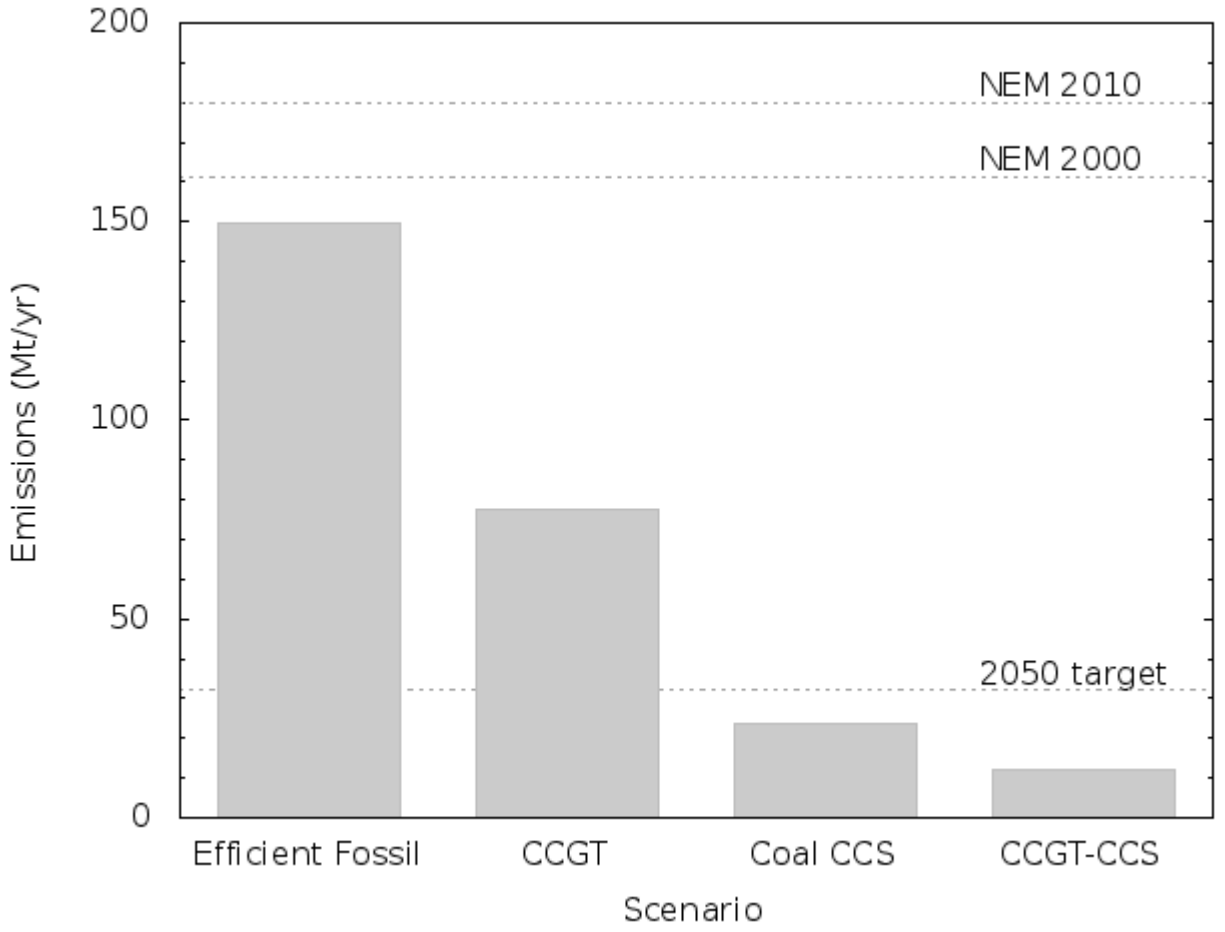
Results



Sensitivity to gas price (and carbon price)

Results: Emissions by scenario



Conclusions

- Cost of CCS unlikely to be robustly lower than 100% RE
- Without CCS, deep cuts are possible with commercially available technology
- Only RE100 achieves near-zero emissions
- CCGT scenario still produces 77 Mt/y CO2
- Lots of uncertainty, but policies to promote high penetrations of renewables appear to represent lower risk