Centre for Energy and Environmental Markets

UNSW
THE UNIVERSITY OF NEW SOUTH WALES
SYDNEY • AUSTRALIA

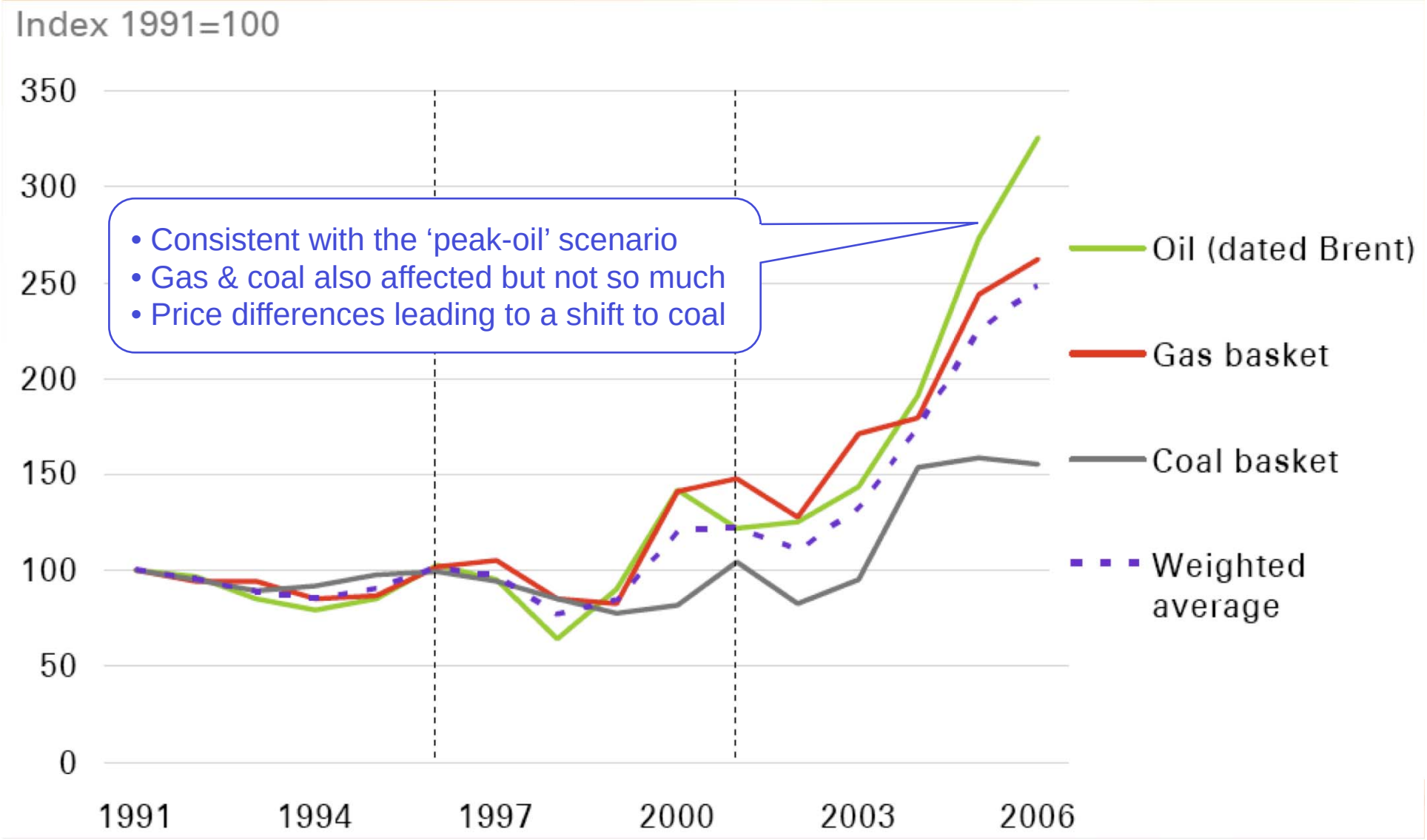


What is the outlook for low emission technologies in the Australian National Electricity Market?

Hugh Outhred, email: h.outhred@unsw.edu.au

Carbon Trading, Clean Energy & the Cost of Inaction 26/6/08

Prices for key energy commodities (BP Review 2007)



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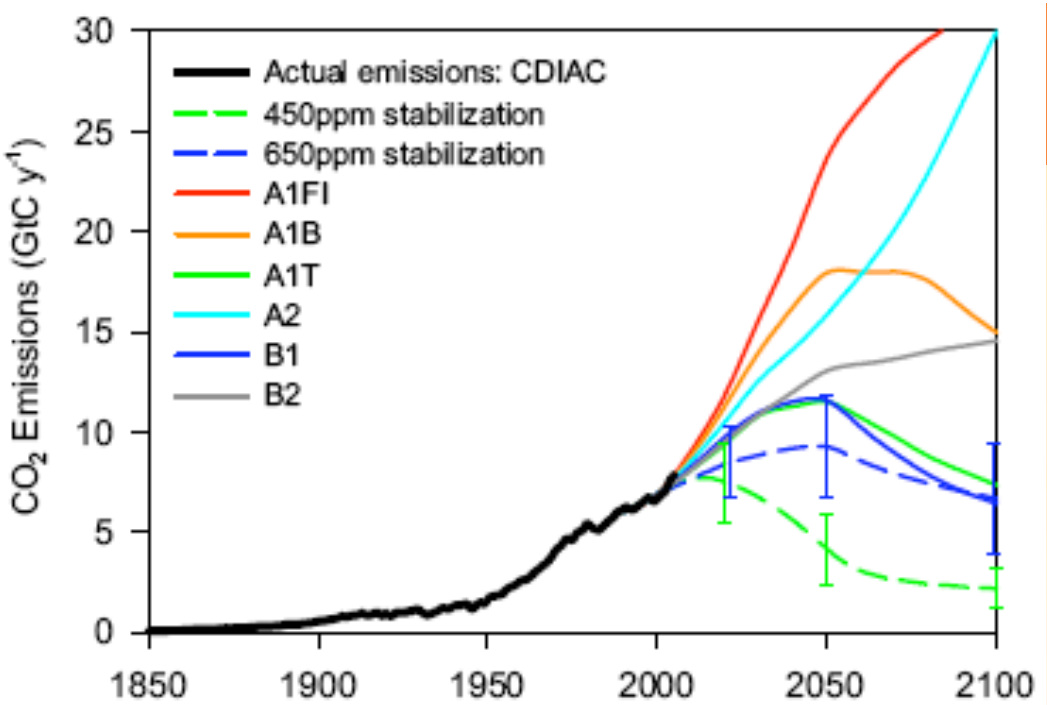
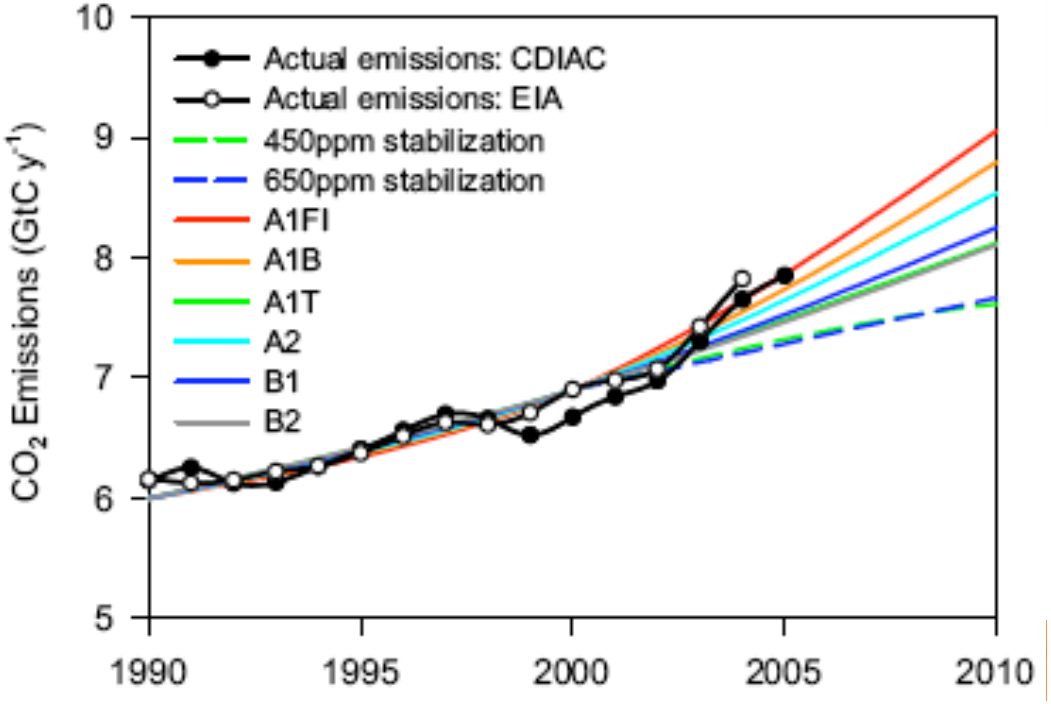
Actual emissions at or above "BAU"

(Raupach et al, PNAS, April 2007)





Issues for enhancing EI sustainability

- Energy security & rapid climate change are challenging problems
- Response tasks must largely be delegated to industry participants (companies & individuals)
- Policies must correctly assign incentives & penalties to deliver a rapid, coherent response:
  - Through “socially-organised decision-making”
  - Emphasizing frugality, enhanced end-use efficiency & low emission generation technologies
- Must overcome fierce vested-interest opposition

ABARE, Energy in Australia, 2008

30 Projected Australian electricity generation by fuel a

	2009-10 PJ	2014-15 PJ	2019-20 PJ	2024-25 PJ	2029-30 PJ
Thermal					
Black coal	528	565	603	671	740
Lignite	208	224	247	260	260
Oil	20	22	23	24	25
Gas	171	234	279	311	355
Total thermal	927	1 045	1 152	1 266	1 380
Renewables					
Hydro	63	65	68	71	73
Wind	15	16	16	17	19
Biomass	8	9	15	15	15
Biogas	6	7	7	7	8
Total renewables b	92	97	106	110	115

a Projections include only the impacts of policy measures in operation during 2007. b Does not include solar, wave and geothermal. *Source*: ABARE, *Australian Energy: National and State Projections to 2029-30*.

What is technology?
(www.iiasa.ac.at)

Software & orgware are critical issues in complex technological systems such as an electricity industry

The Art of Knowing and Doing

The study of **technology** concerns *what* things are made and *how* things are made. Technology, from the Greek *science of* (practical) *arts,* has both a *material* and an *immaterial* aspect.

Technology = Hardware + Software + "Orgware"



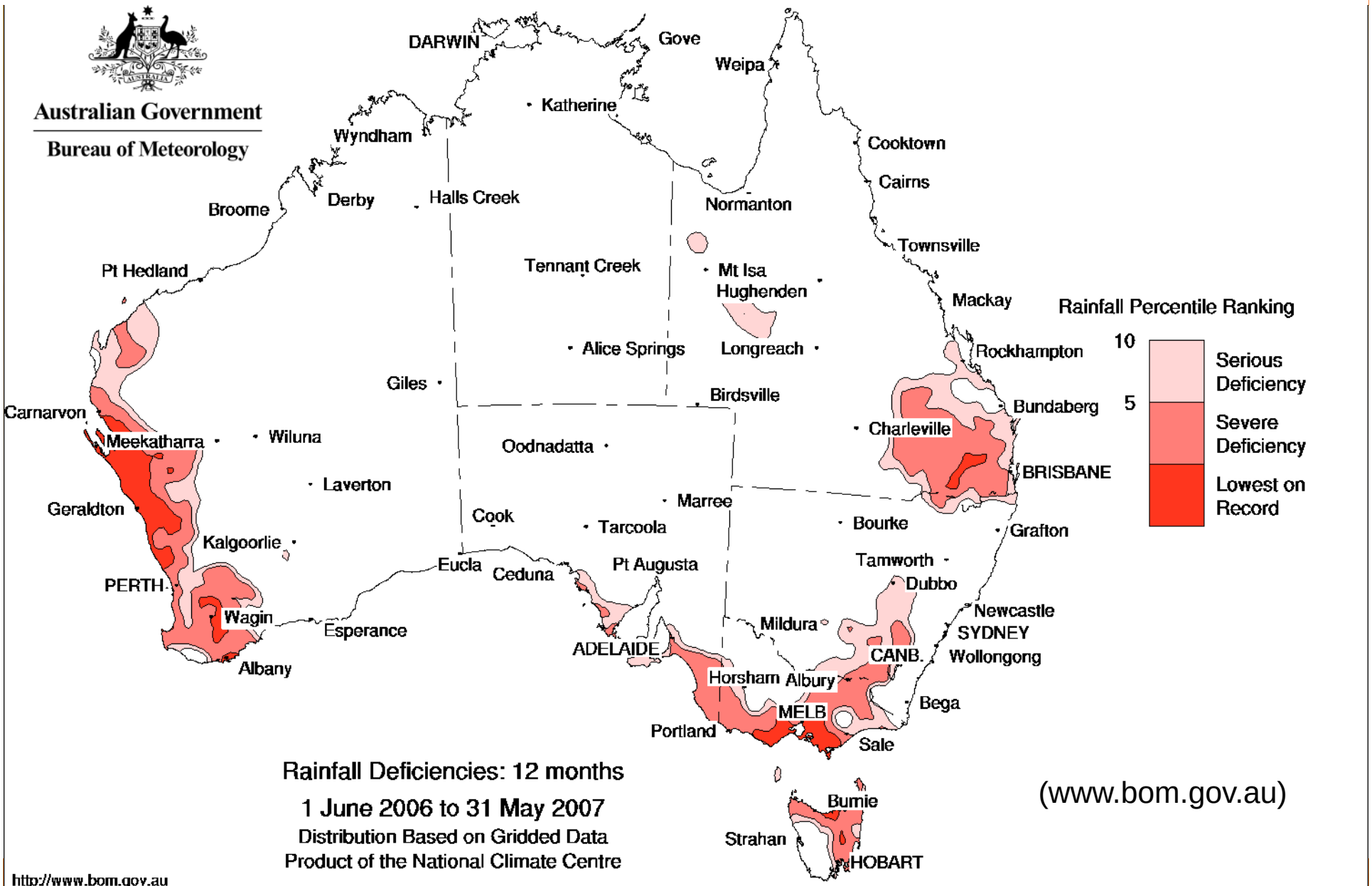

Hardware:	Manufactured objects (artifacts)
Software:	Knowledge required to design, manufacture, and use technology hardware
"Orgware":	Institutional settings and rules for the generation of technological knowledge and for the use of technologies

Technology's most important characteristic: ***Continuous change >>***

Characteristics of renewable energy

- Energy fluxes with limited storage:
  - Solar, wind, hydro, biomass, geothermal, ocean
- Characteristics of renewable energy forms:
  - Geographical distribution is a function resource type
  - Energy fluxes may be time-varying & uncertain
- Characteristics of renewable energy technologies:
  - Electricity generation, direct end-use or fuels
  - May have economies of scale

Drought & electricity gen'n (coal & hydro)



Flat annual CFD prices for NSW (NGF, 2007)

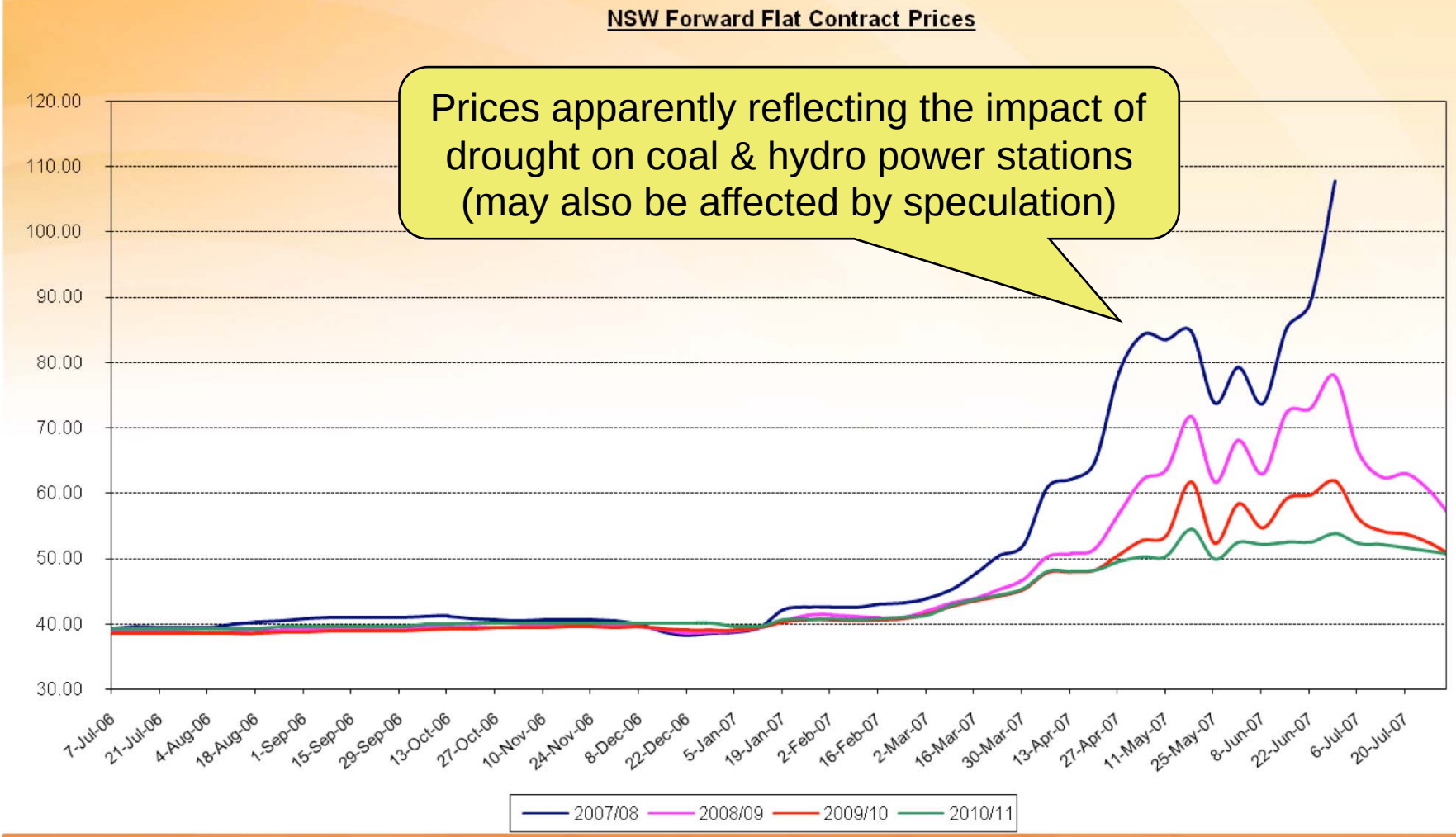
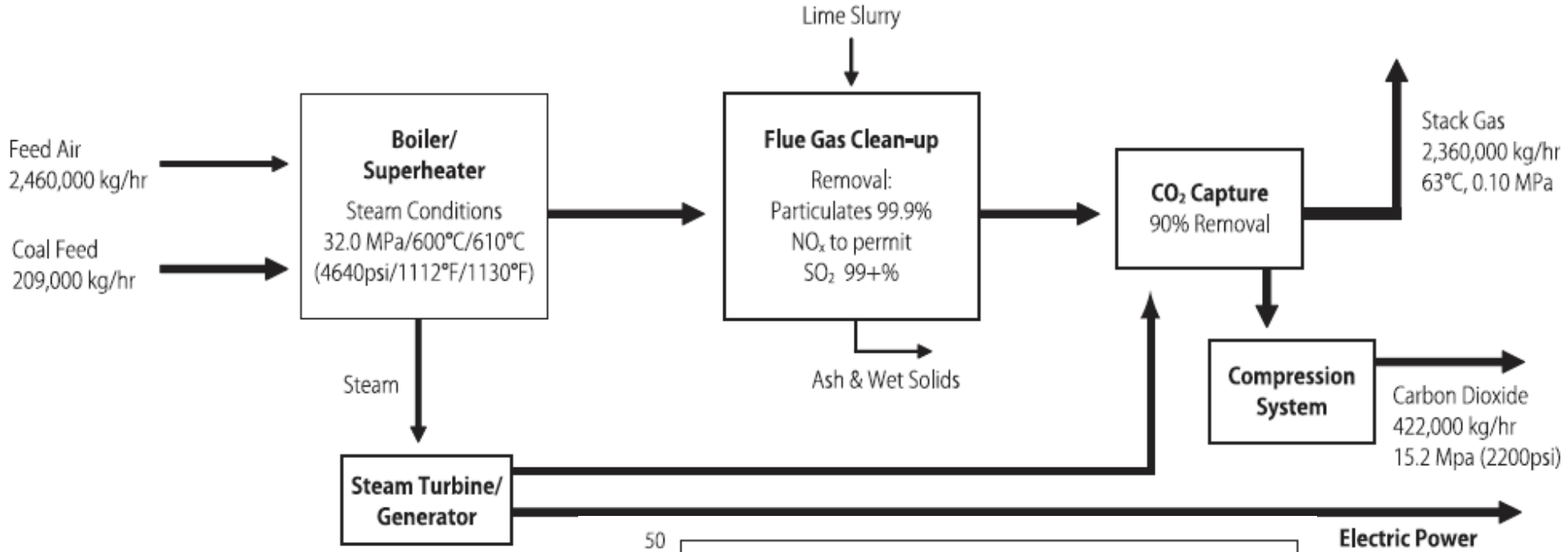
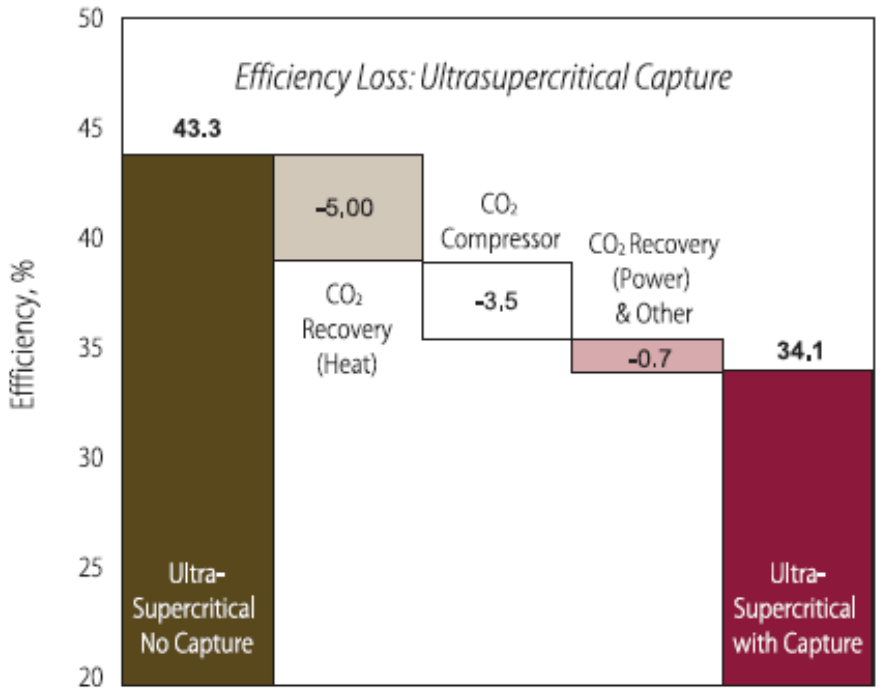


Figure 3.6 Ultra-Supercritical 500 MW_e Pulverized Coal Unit with CO_2 Capture

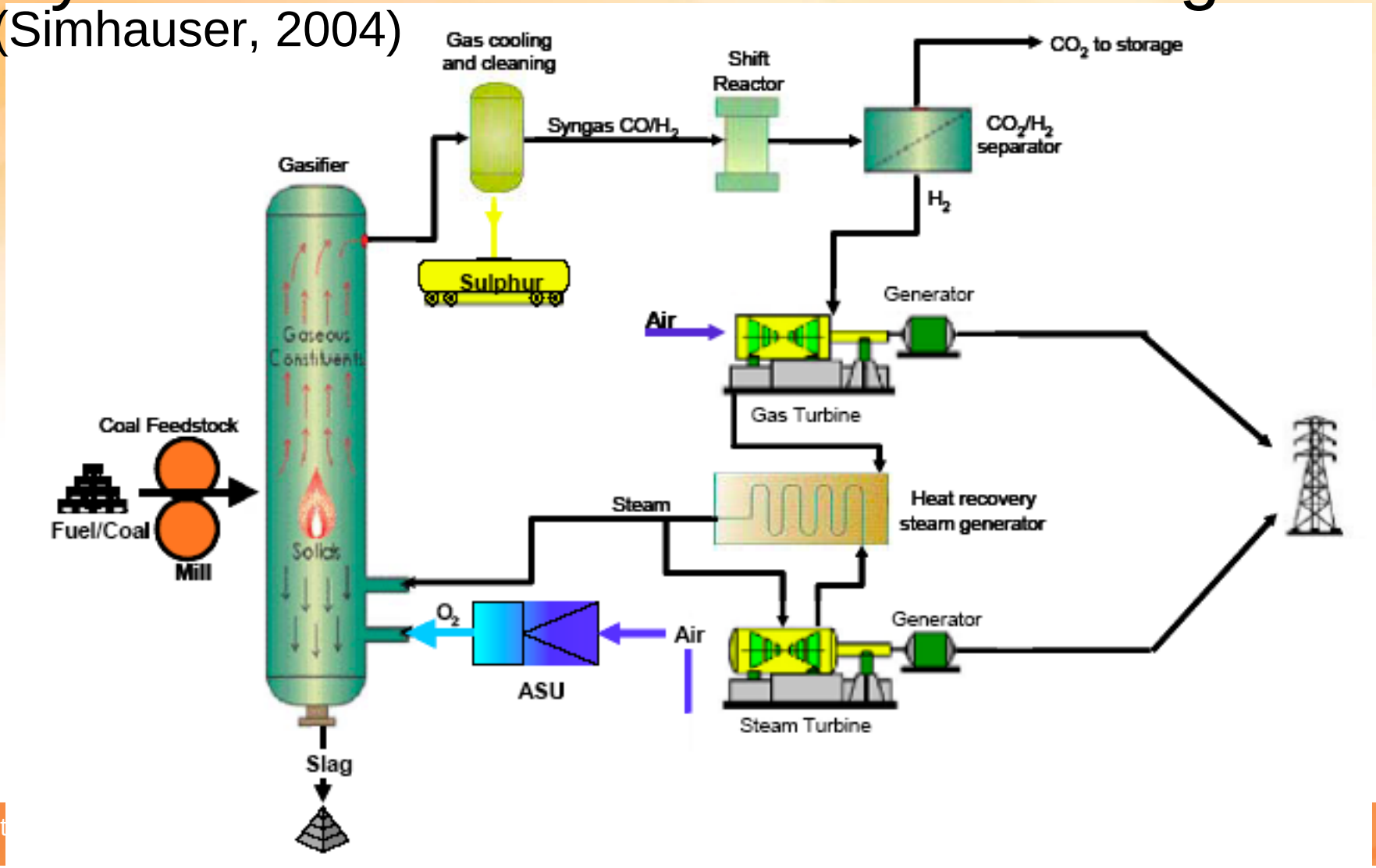


(Carbon capture: *The Future of Coal*, MIT, 2007)

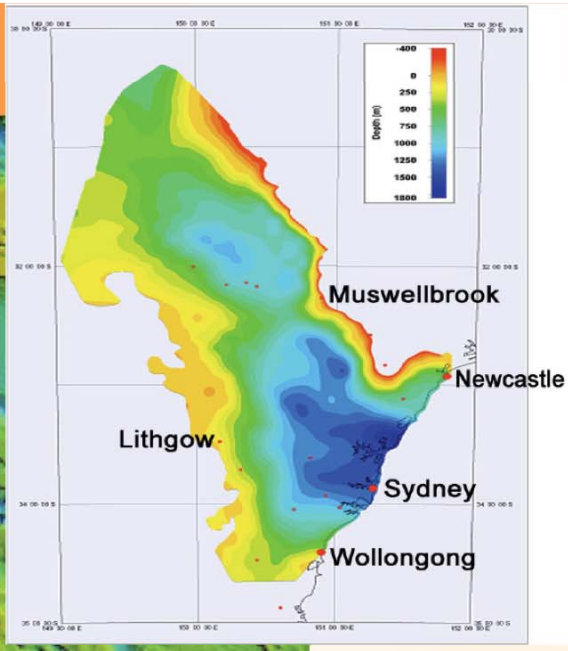


Integrated coal gasification & combined cycle with carbon collection & storage

(Simhauser, 2004)



CO2 sequestration options in Aust.



depth > 2,000m

Darling Basin

Sydney Basin

(Owen Inquiry Report, App. 3, 2007)

Key findings of IPCC CCS report

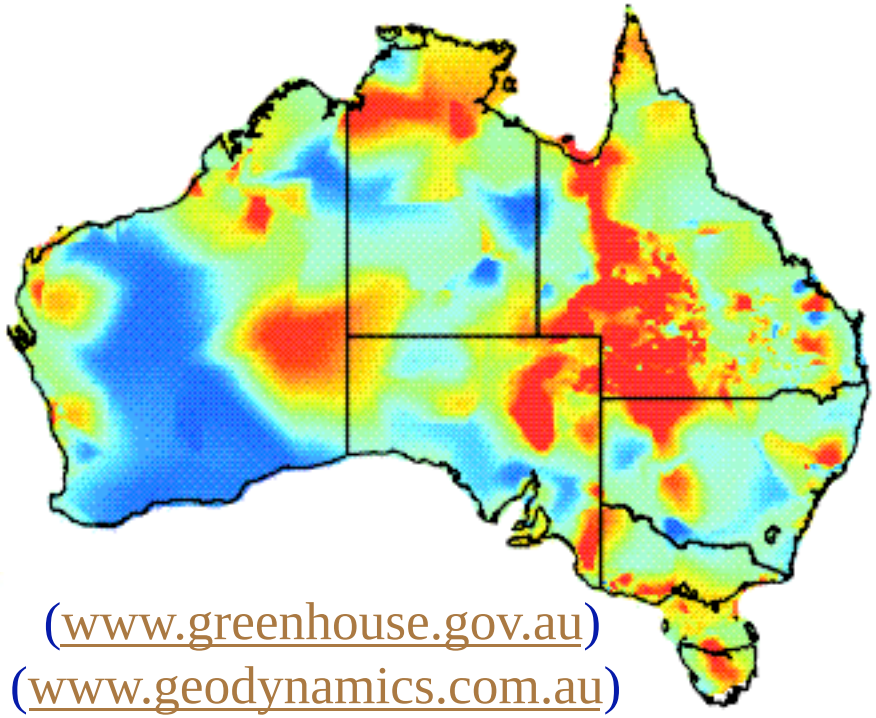
(www.ipcc.ch, 2005)

- A portfolio of mitigation measures will be needed (CCS alone not sufficient)
- Large-scale CCS power plant don't yet exist
- By 2050, 20-40% of fossil fuel CO_2 technically suitable for CCS at cost of 13 to 67 A$/MWh
- Deployment needs CO_2 price of 25-30 US$/MWh
- CCS might contribute 15-44% of cumulative mitigation effort to 2100, may be limited beyond that (identified storage sites would then be full)

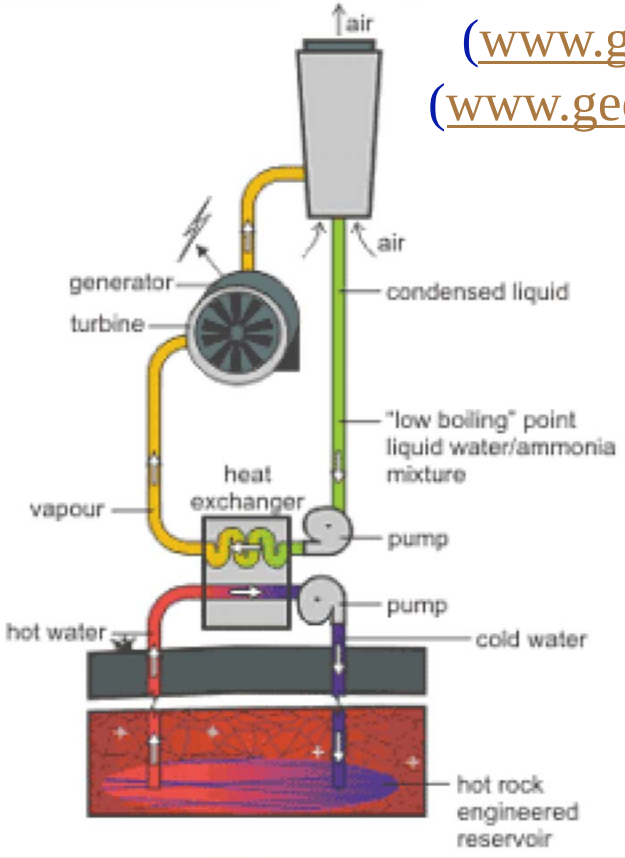
Geothermal energy - radioactive rock

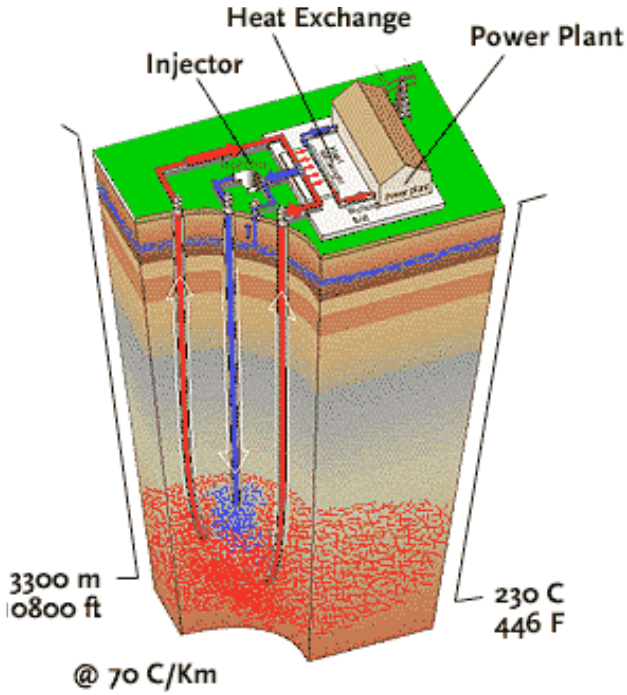
Australia has plentiful radioactive rock at ~3,000m covered by insulating layers:- *safe nuclear energy*

eg: Geodynamics trial at Cooper Basin, SA

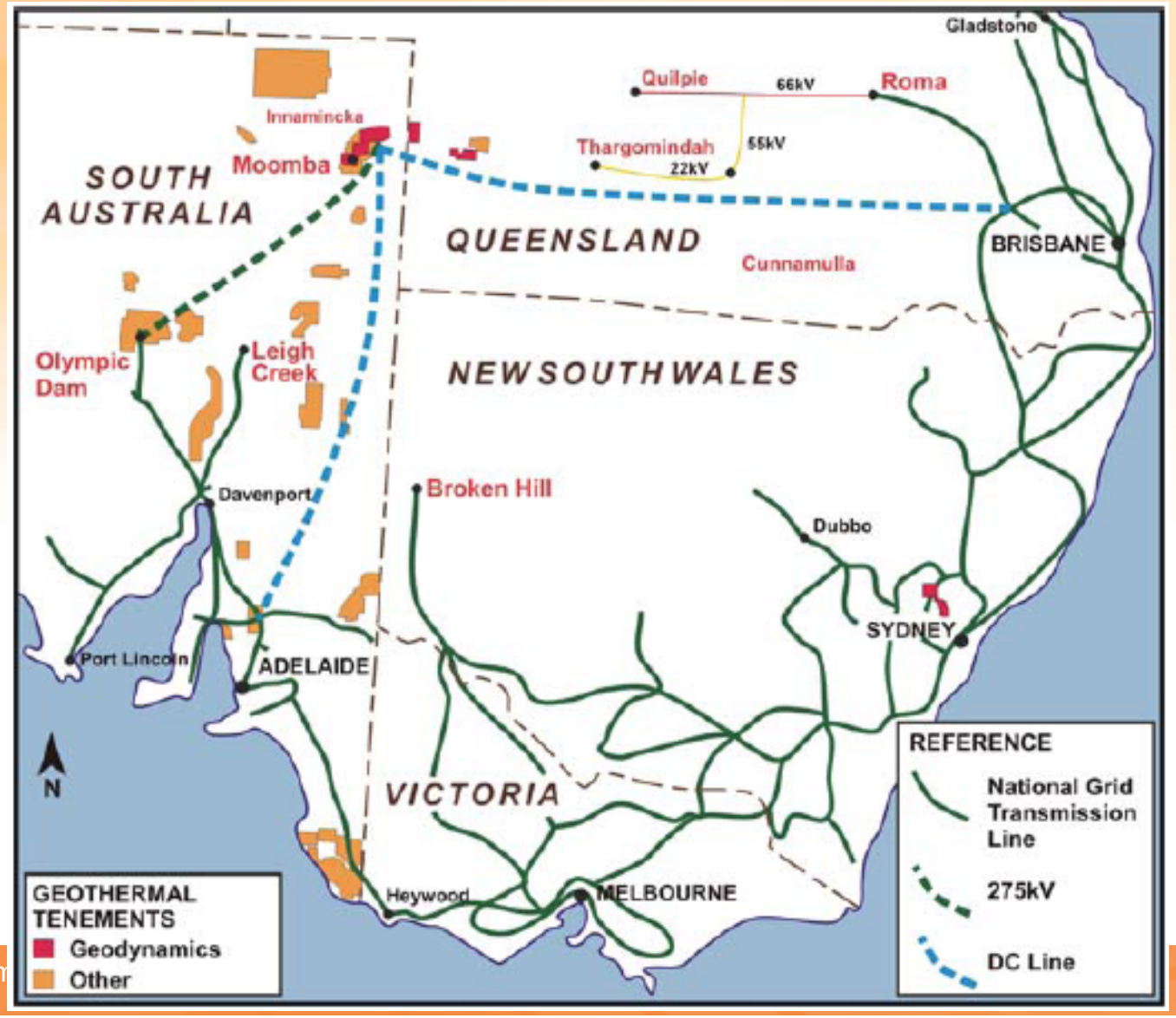


(www.greenhouse.gov.au)
(www.geodynamics.com.au)



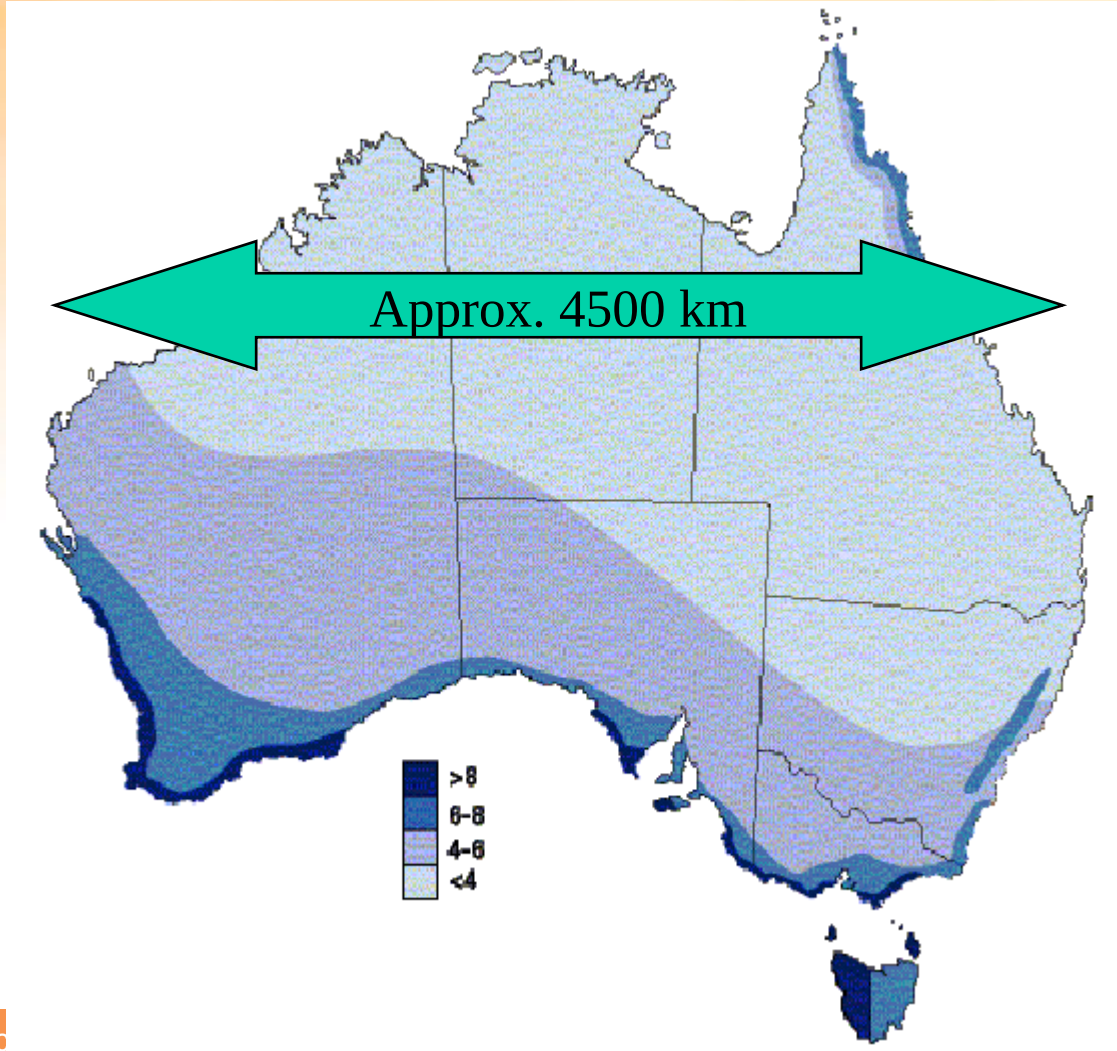


Geothermal energy - grid connection
(Geodynamics, 2006)



Australian wind resource

(Estimate of background wind (m/s) – Australian Greenhouse Office)



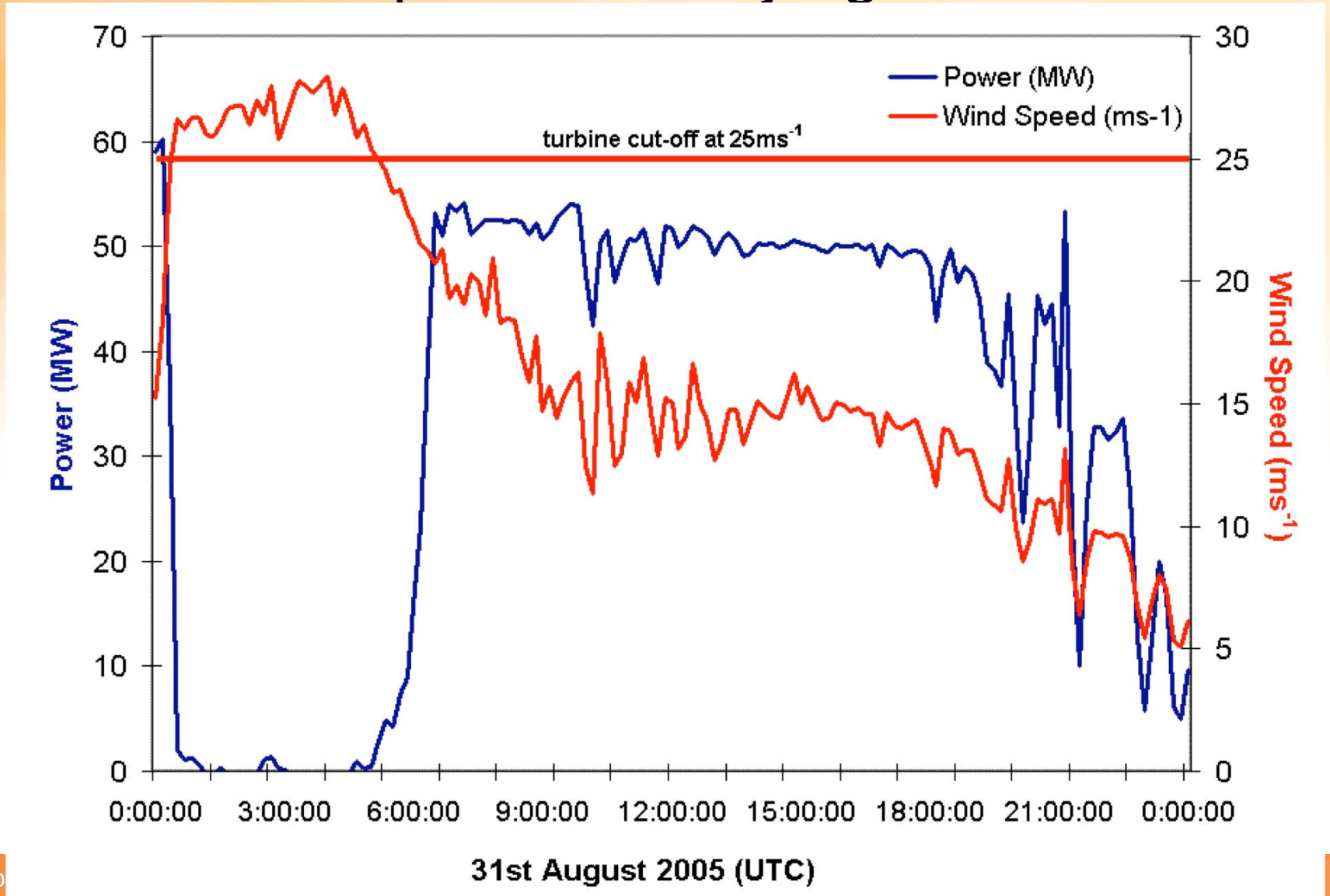
Rottnest Island, WA:
600kW

Emu Downs, Geraldton, WA:
80 MW, 48x1.65MW

Albany,WA: 22MW,
12x1.8MW

Alinta, Geraldton, WA:
90 MW, 55x1.65MW

Wind farm response to varying wind conditions



IDV65059

WIND CHANGE FORECAST CHART

ISSUED: 2100 on Thursday 22 April 2004

BUREAU OF METEOROLOGY - VICTORIAN REGIONAL OFFICE
P.O. Box 1636M Melbourne Vic 3001 http://www.bom.gov.au Severe Weather Ph: (03) 9669 4923

COMMENTS:

Northerly wind 15 to 30 km/hr ahead of front. West to southwesterly wind 15 to 25 km/hr west of front initially but wind gradually tending southwesterly and increasing 25 to 35 km/hr.

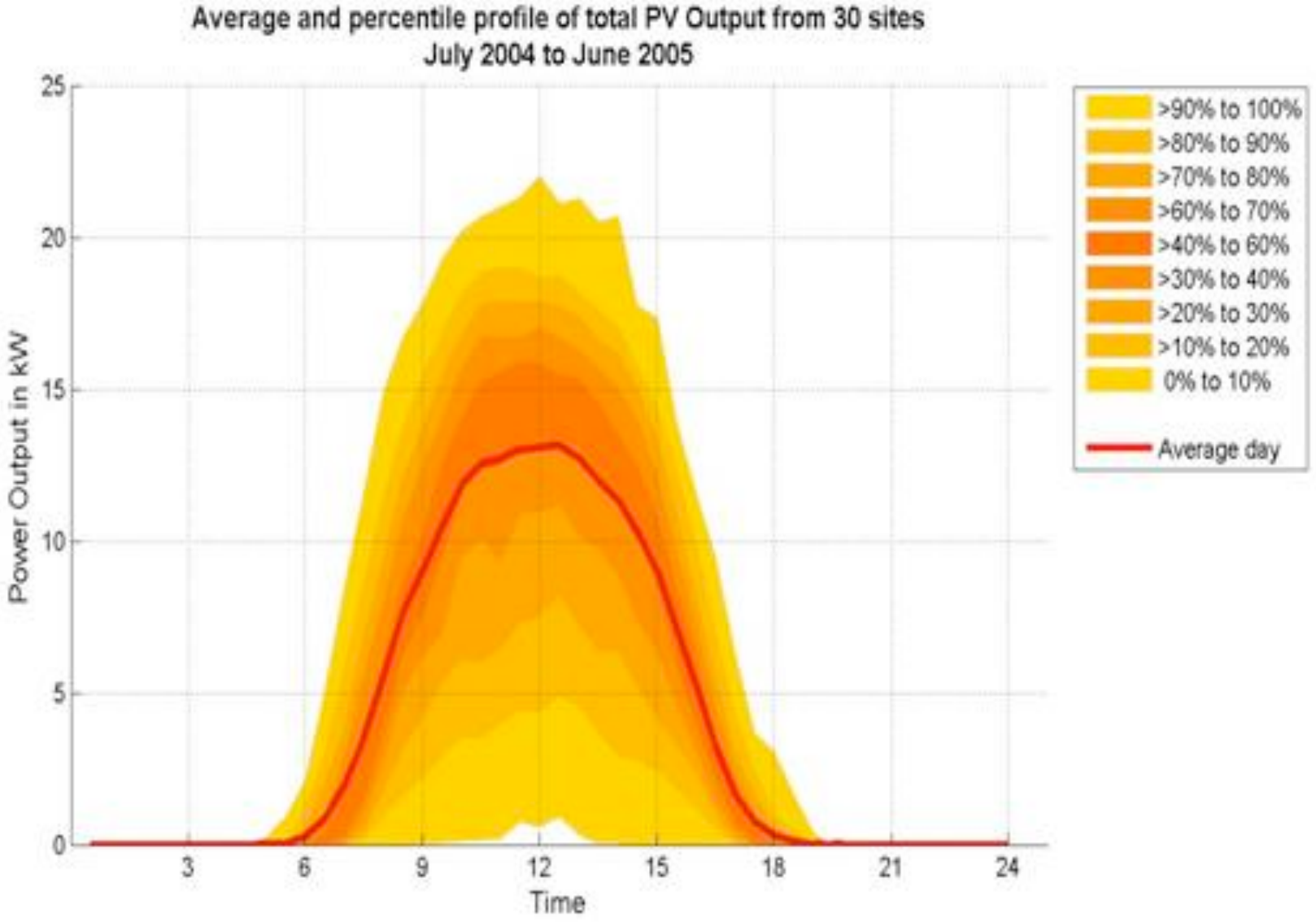
This approach may be valuable for predicting the timing of large changes in summated wind farm output

** Note: Timing of wind changes cannot be forecast with precision and positions are best estimates. **

PV Case Study for NSW Dept of Planning: Newington Solar Village (PV+SWH)

Photo: BP Solar

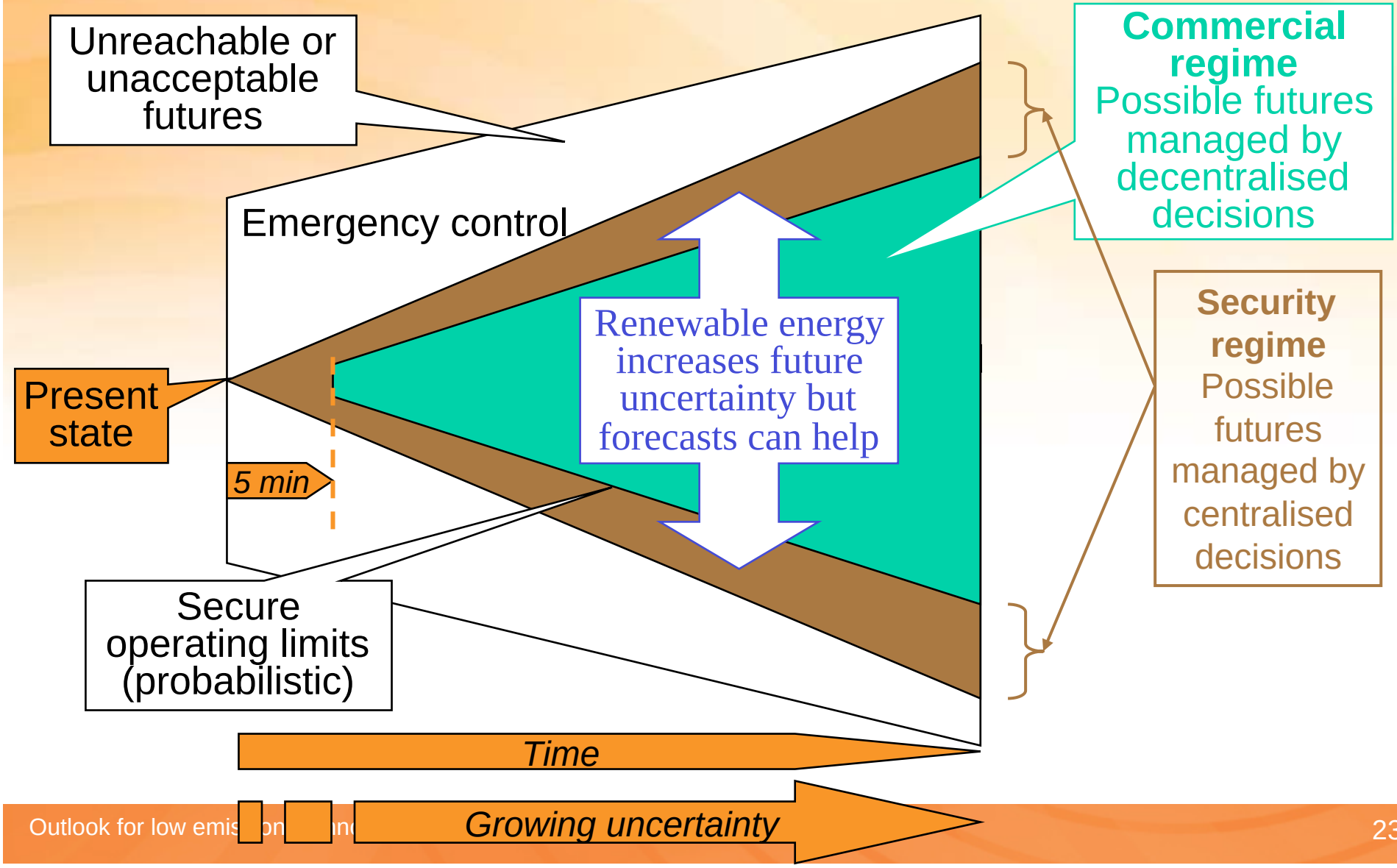
PV output variability (30 houses)



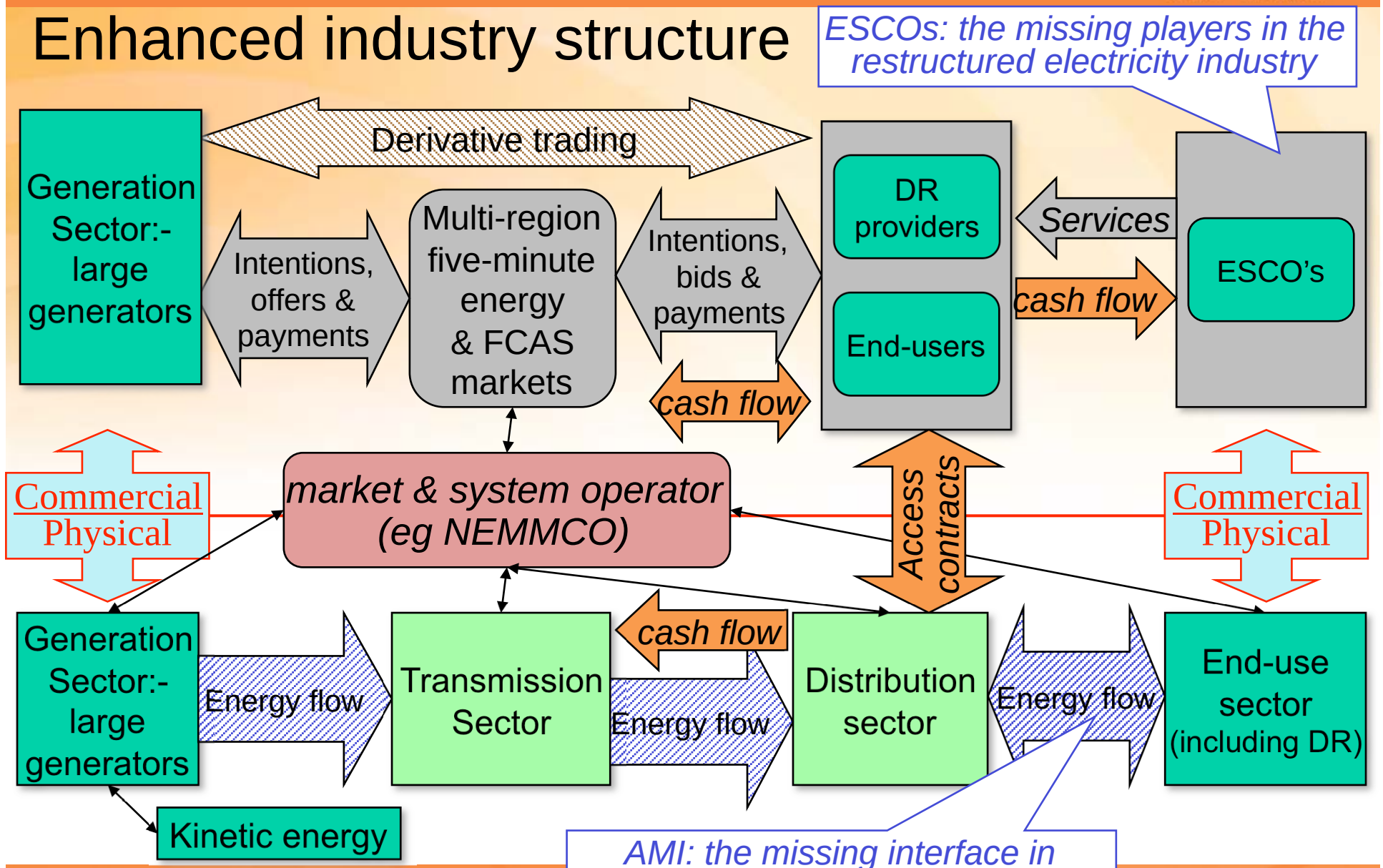
Decision-making framework for a restructured electricity industry (EI)

Governance regime	▪ Formal institutions, legislation & policies ▪ *Informal social context including politics*
Security regime	▪ Responsible for core integrity on local or industry-wide basis, with power to override
Technical regime	▪ Engineering design to allow industry components to function as single, industry-wide machine when connected together
Commercial regime	▪ Decentralised decision-making according to commercial criteria within a market context ▪ Includes formally designed markets ▪ *Needs adequate competitive pressures*

Security & commercial regimes (global & local)



Enhanced industry structure



Key electricity industry issues for high-penetration renewable energy #1

- Structural issues:
  - Robust security regime with security-constrained dispatch
  - Efficient commercial regime (operation & investment)
  - Effective regulation of network services
  - Compatible arrangements for gas industry
- Development issues:
  - Innovation in renewable energy technologies
  - Forecasting for security & commercial regimes
  - Active end-user participation (value, timing, efficiency)
  - Education & training in all relevant areas

Key electricity industry issues for high-penetration renewable energy #2

- Auction-style, security-constrained markets:
  - For spot energy, ancillary services & derivatives
  - Active end-users supported by ESCOs & equity policies
- Efficient network service regime:
  - Augmentation; availability & quality; distributed resources
- Renewable energy forecasting tools for:
  - Security, commercial & governance regimes
- Internalisation of un-costed fossil fuel externalities:
  - Carbon taxes
  - Development & deployment of low emission technologies

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