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# Renewable Energy: Policy options & integration issues

*Hugh Outhred*
*SP Powergrid, Singapore, 4/12/06*

www.ceem.unsw.edu.au

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## Outline

- Sustainability context
- Renewable energy generation: status & costs
- Renewable energy policy options
- Integration into competitive electricity industries
- Renewable energy case studies - wind & PV
- Key issues with high levels of renewable energy penetration

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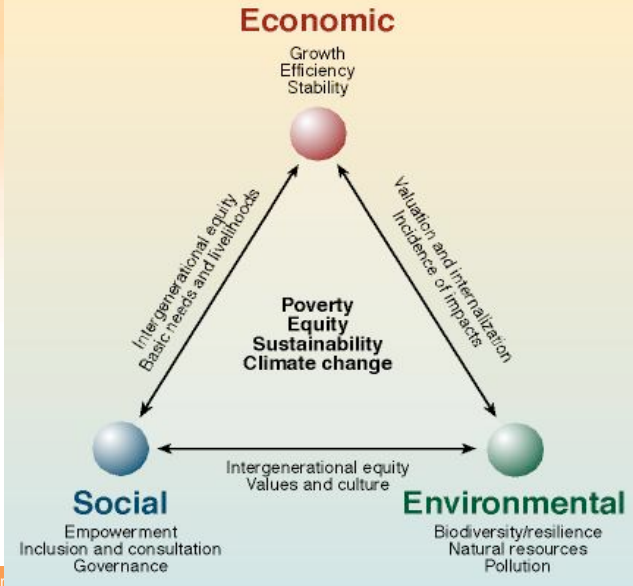
## Sustainability context for the electricity industry
(IPCC COP7)

*Must also achieve resource adequacy:*
*Short & long-term system security (availability & quality of supply)*

## Key elements of sustainable development and interconnections

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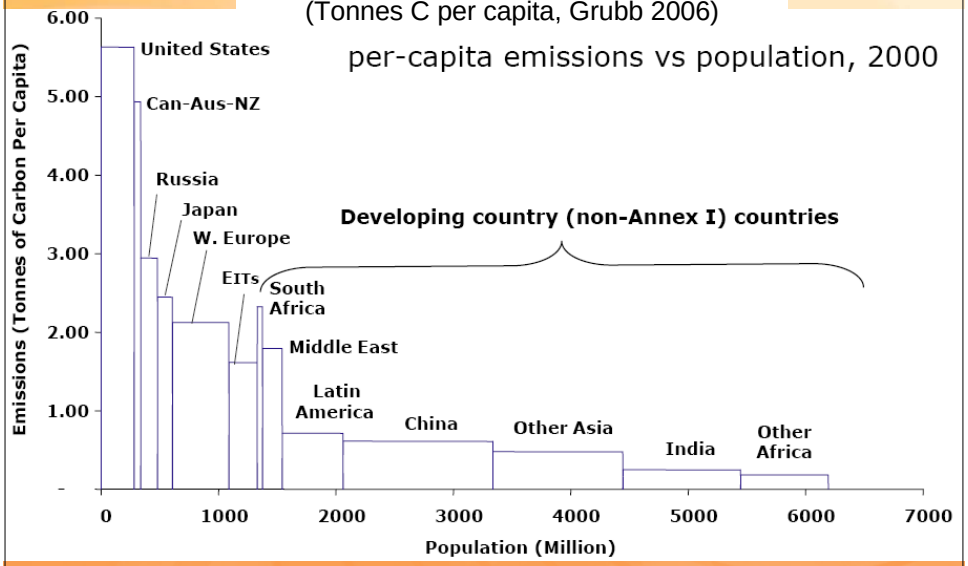
## Climate change emissions
(Tonnes C per capita, Grubb 2006)

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## Renewable energy barriers, challenges & opportunities, IEA, 2006

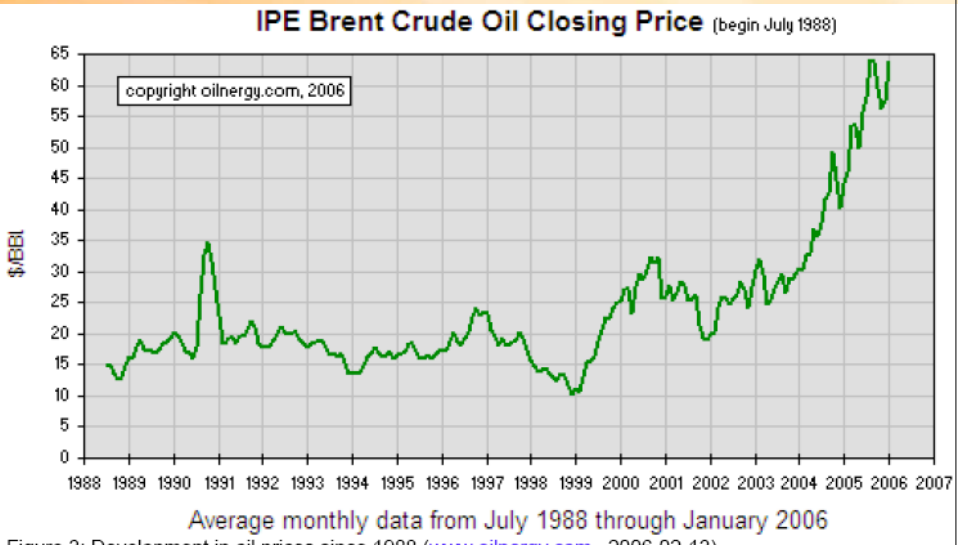


Figure 3: Development in oil prices since 1988 (www.oilnergy.com , 2006-02-13)



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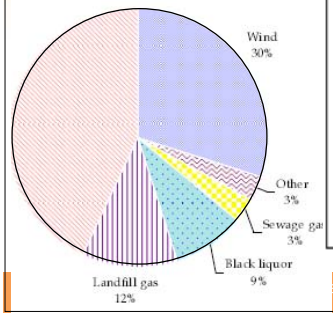
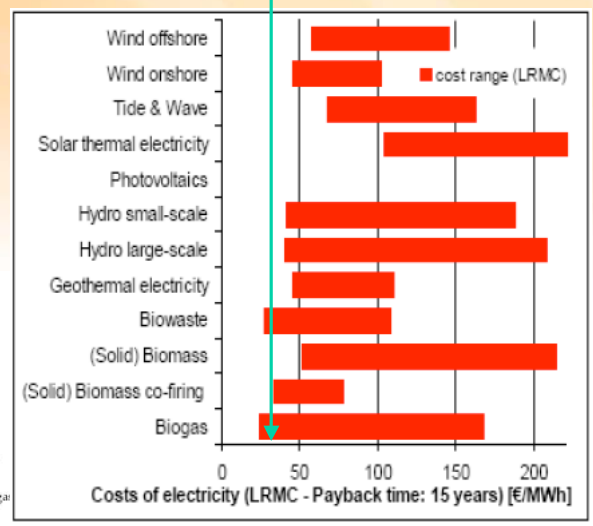
Coal-fired power station approx 35€/MWh

## Renewable energy & coal comparison for Europe (IEA, 2006)

## Aust. non-hydro RE market shares (%)



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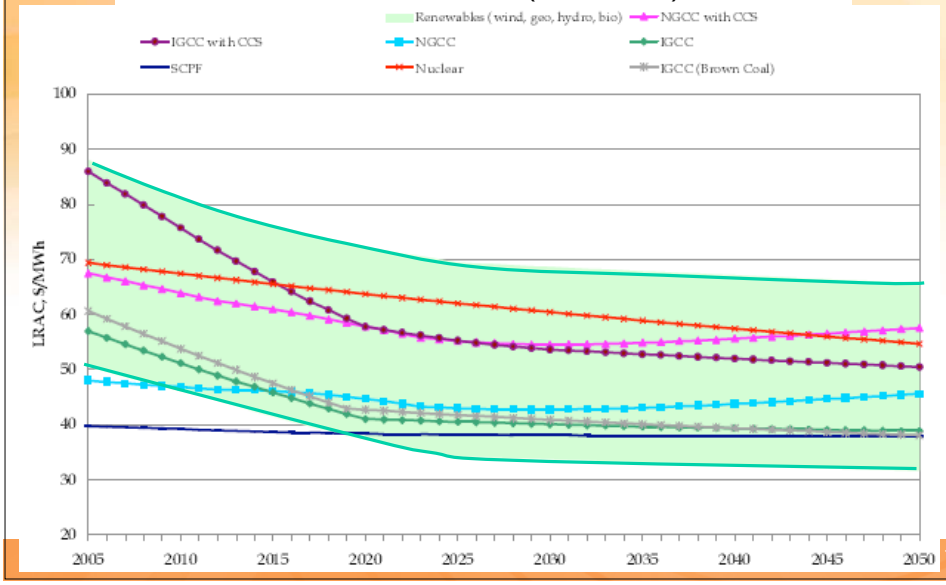
## Low-emission generation cost trends for Australia (MMA, 2006)

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## Status of RE technologies: *hardware perspective* (IEA, 2006)

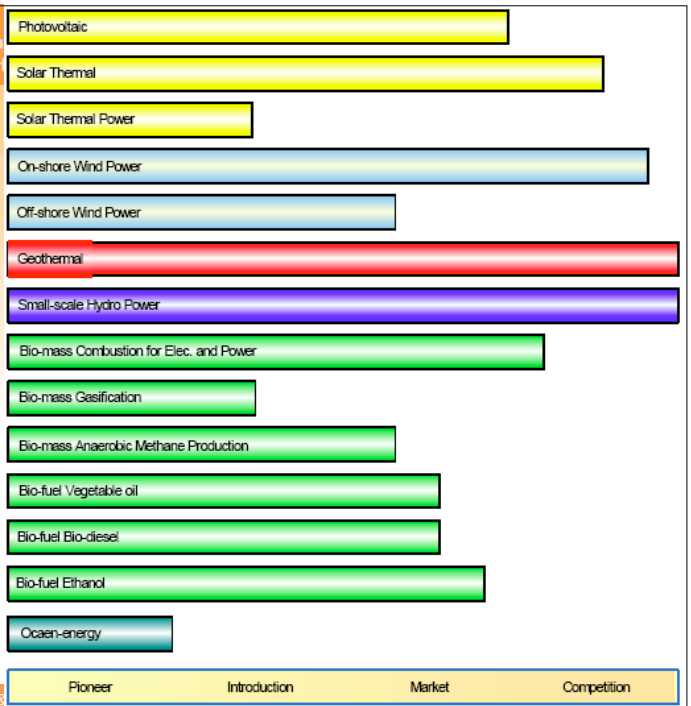


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Figure 4: Development of renewable energy technologies – rough indication! [16]

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The most effective policy options depend on the context (Grubb, 2006)

| | Voluntary, regulatory and systemic instruments | Economic instruments | Innovation instruments |
|---|---|---|---|
| Behaviour |  |  |  |
| Substitution |  |  |  |
| Technical innovation |  |  |  |

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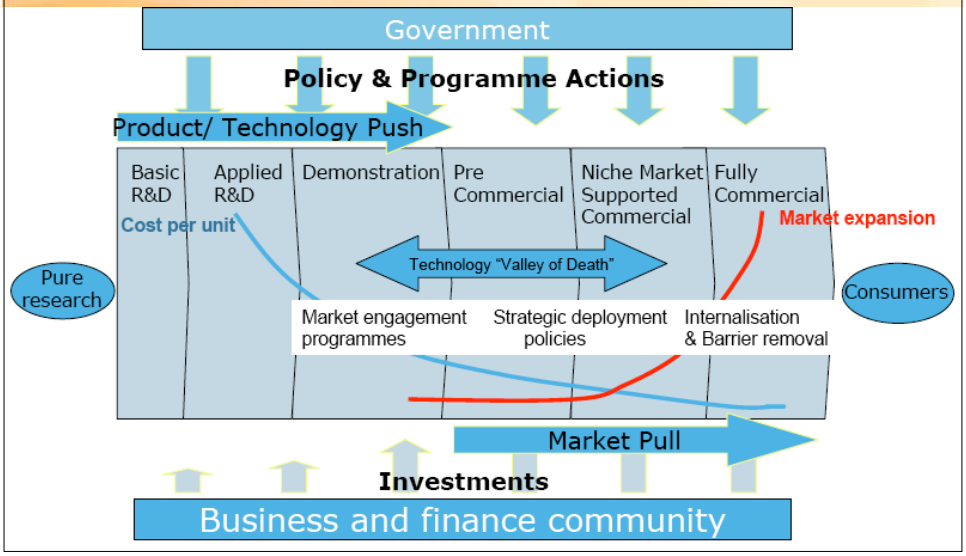
Successful innovation requires both technology push & market pull (Grubb, 2006)



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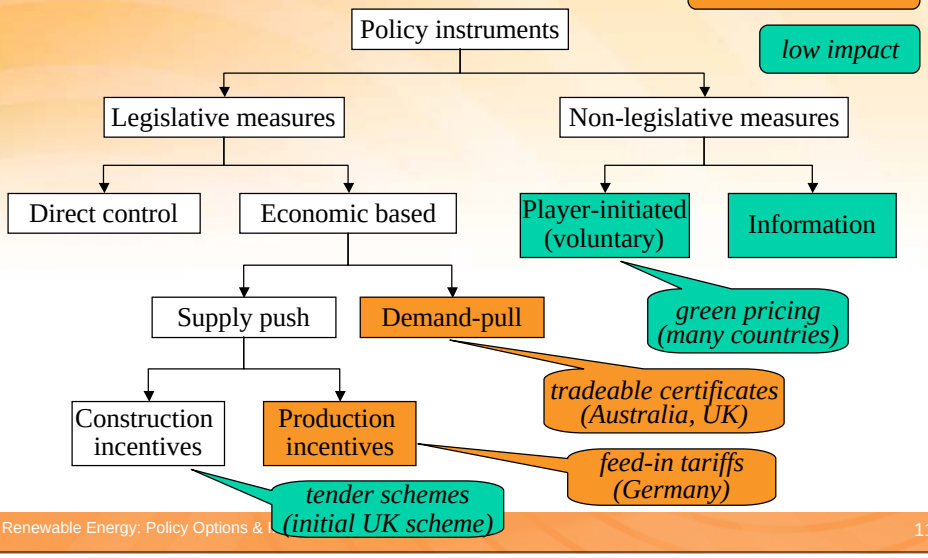
## Renewable energy support policy taxonomy

(Rivier, 2006; Enzesberger et at, 2002)

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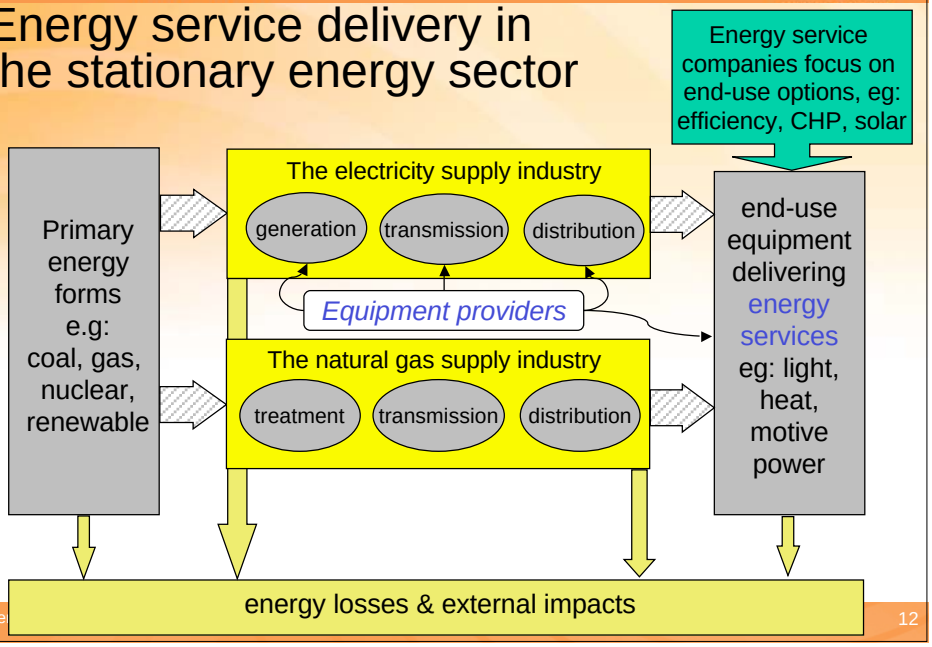
## Energy service delivery in the stationary energy sector

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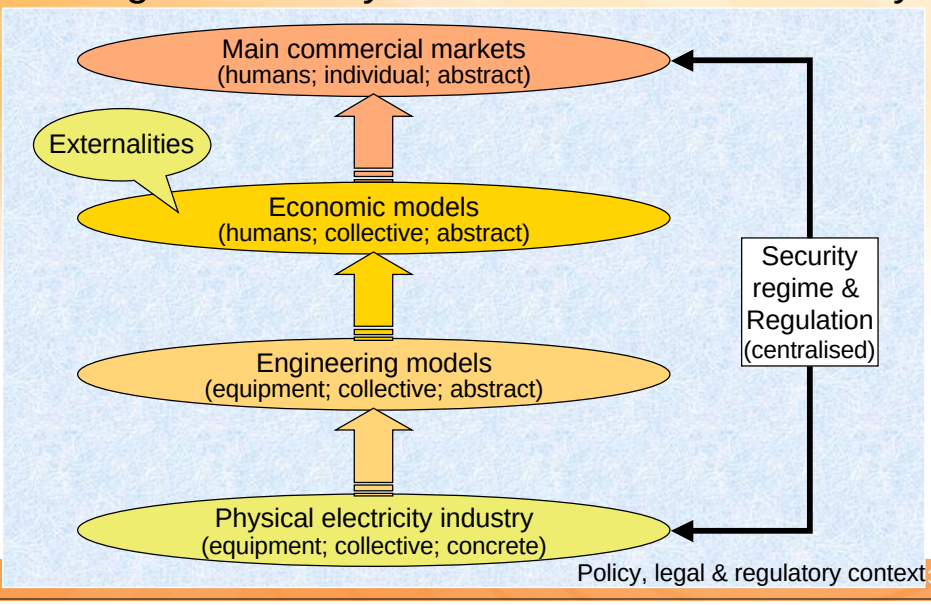
## Trading in electricity:- an abstraction from reality

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## Decision making framework for the electricity industry

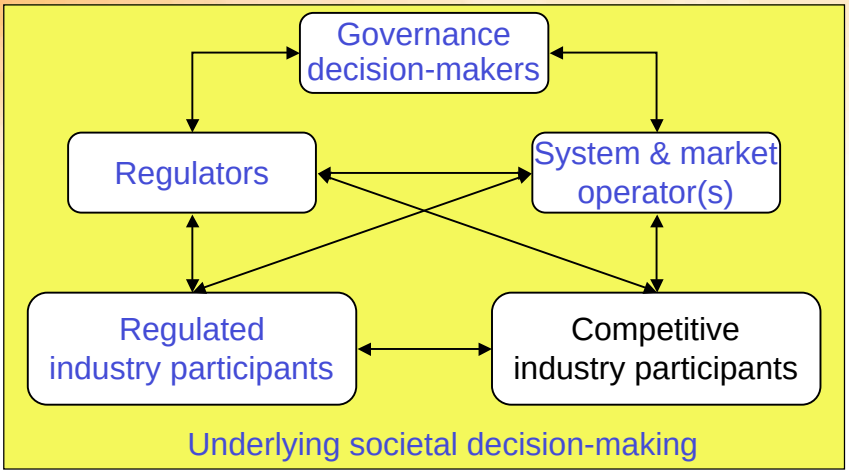


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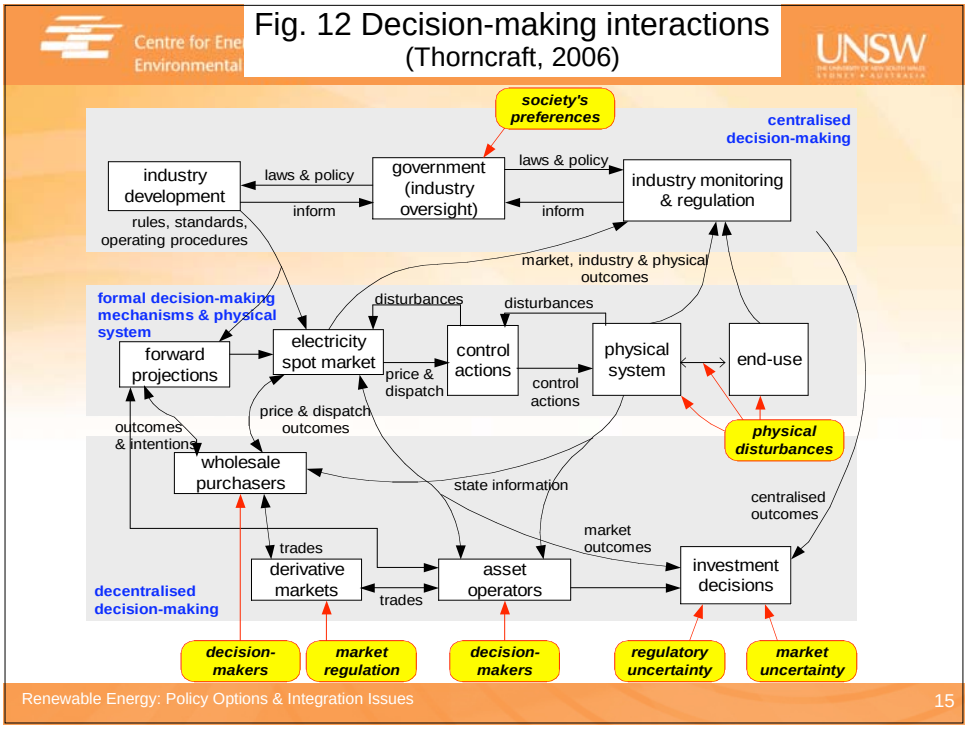
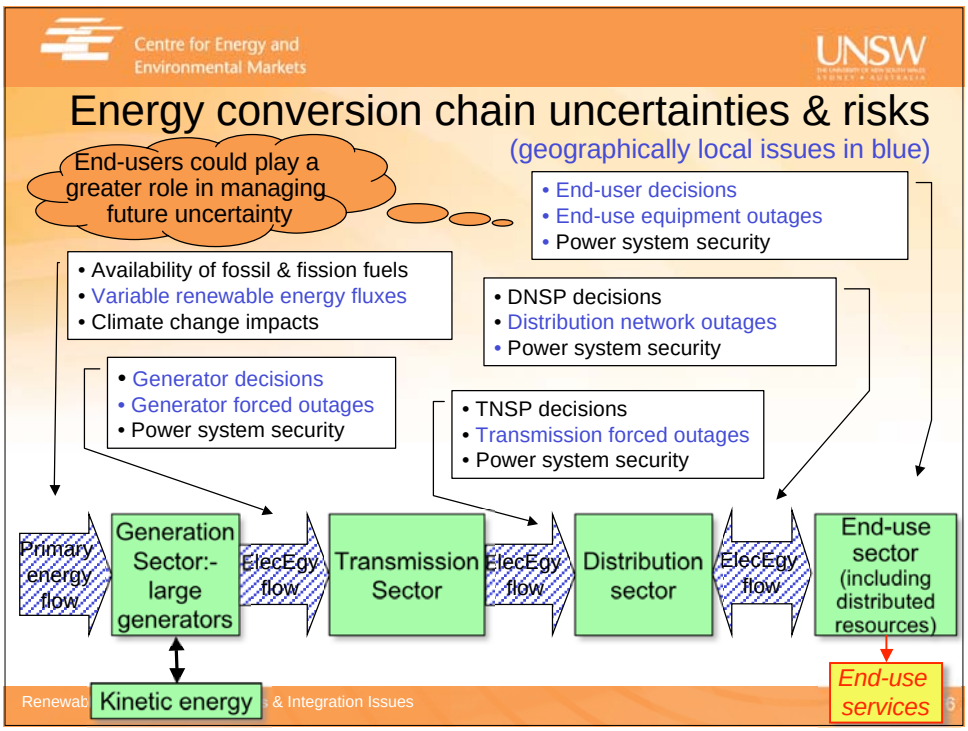
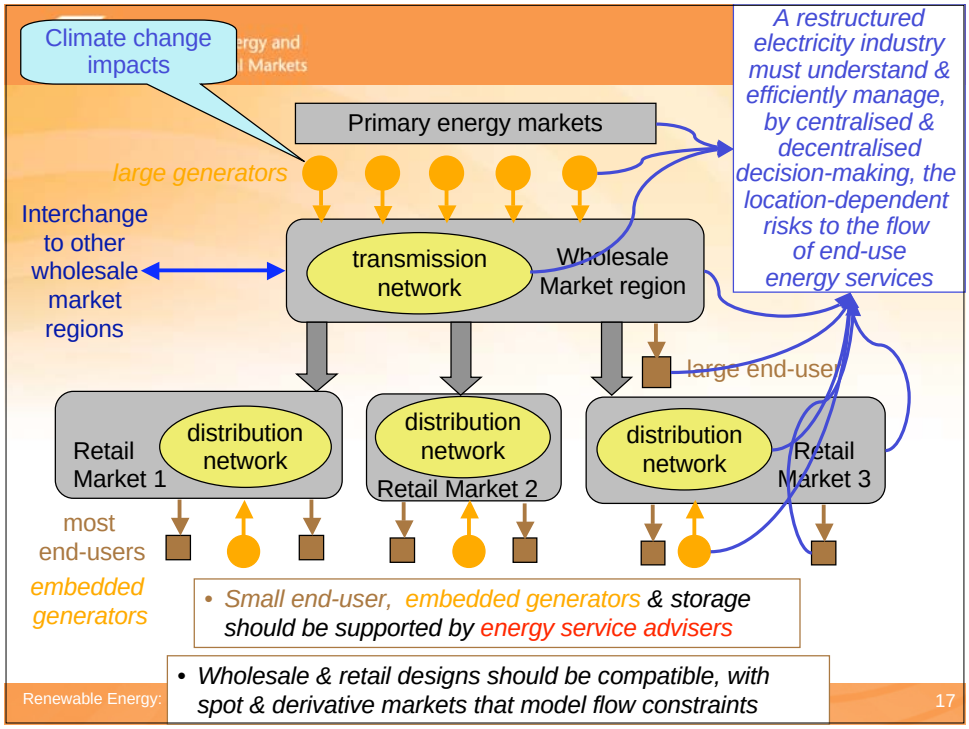
Fig. 12 Decision-making interactions
(Thorncraft, 2006)



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## Contributors to unavailability of electricity supply for small end-users (USA data, AEMC, 2006)

| Contributor | Average unavailability per customer year | |
|---|---|---|
| | (minutes) | (%) |
| Generation/transmission | 0.5 | 0.5 |
| 132 kV | 2.3 | 2.4 |
| 66kV and 33kV | 8.0 | 8.3 |
| 11kV and 6.6kV | 58.8 | 60.7 |
| Low voltage | 11.5 | 11.9 |
| Arranged shutdowns | 15.7 | 16.2 |
| **Total** | **96.8 minutes** | **100.0** |

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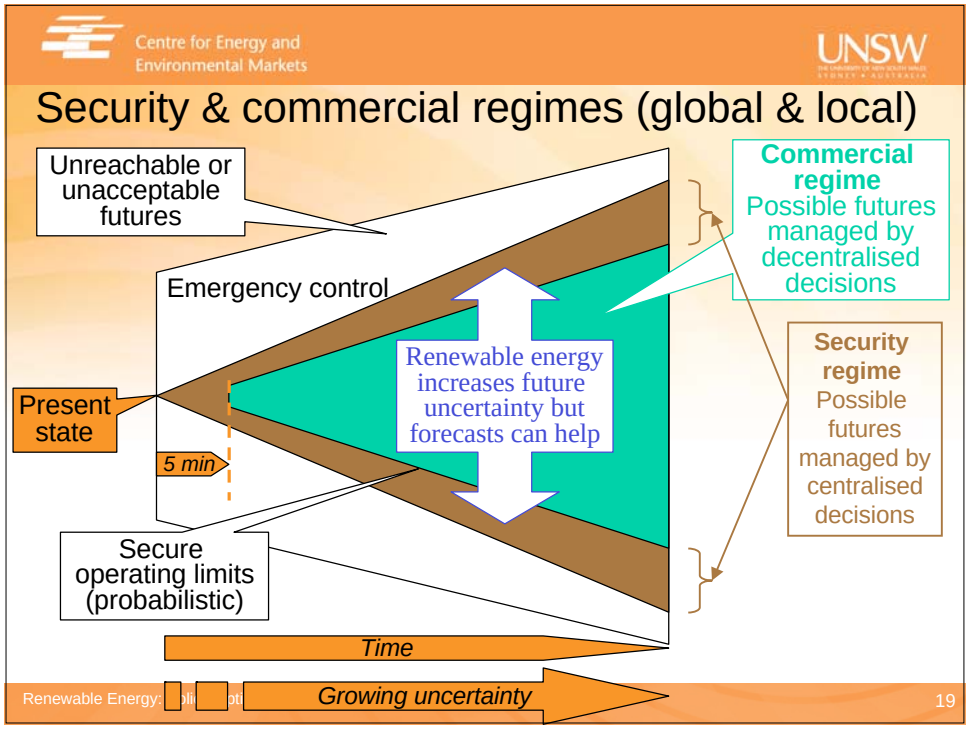
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Security & commercial regimes (global & local)
Unreachable or unacceptable futures
Emergency control
Present state
5 min
Secure operating limits (probabilistic)
Renewable energy increases future uncertainty but forecasts can help
Commercial regime
Possible futures managed by decentralised decisions
Security regime
Possible futures managed by centralised decisions
Time
Growing uncertainty
Renewable Energy:
19

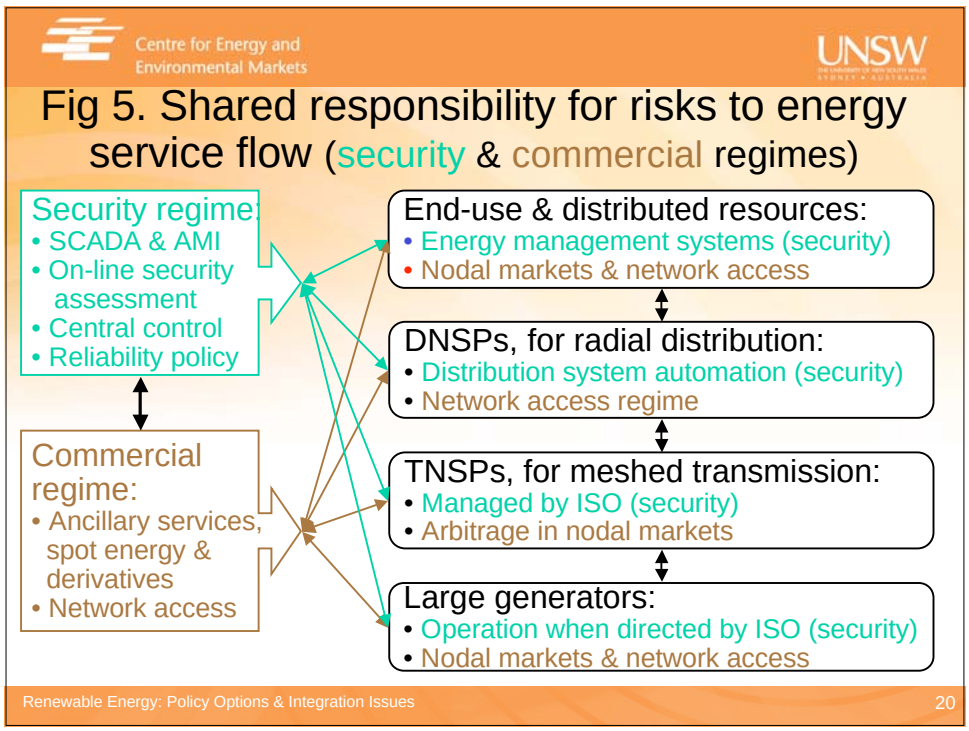
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Fig 5. Shared responsibility for risks to energy service flow (security & commercial regimes)
Security regime:
• SCADA & AMI
• On-line security assessment
• Central control
• Reliability policy
Commercial regime:
• Ancillary services, spot energy & derivatives
• Network access
End-use & distributed resources:
• Energy management systems (security)
• Nodal markets & network access
DNSPs, for radial distribution:
• Distribution system automation (security)
• Network access regime
TNSPs, for meshed transmission:
• Managed by ISO (security)
• Arbitrage in nodal markets
Large generators:
• Operation when directed by ISO (security)
• Nodal markets & network access
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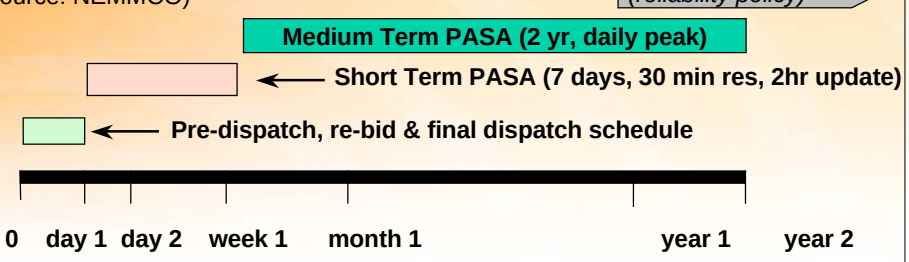
## Dispatch, Pre-dispatch, PASA, SOO & ANTS to manage supply-demand balance

(source: NEMMCO)




- ST & MT Projected Assessment of System Adequacy support reserve assessment & participant operating decisions. ST PASA projects region demand & reserve for 7 days @ 30 min resolution, updated every 2 hours. MT PASA projects daily peak demand & reserve for 2 yrs, updated weekly.
- Statement of Opportunities (SOO) & Annual National Transmission Statement (ANTS) are intended to inform generation, demand & network investment decisions (10 year horizon, issued annually)

Renewable Ener *These procedures all rely heavily on quality of forecasts* 21

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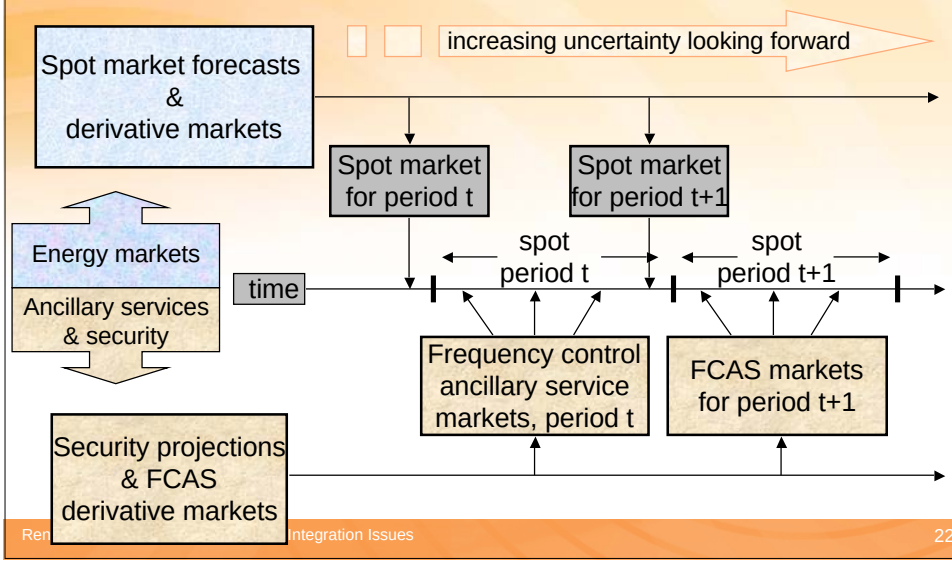
## Managing supply-demand balance in NEM

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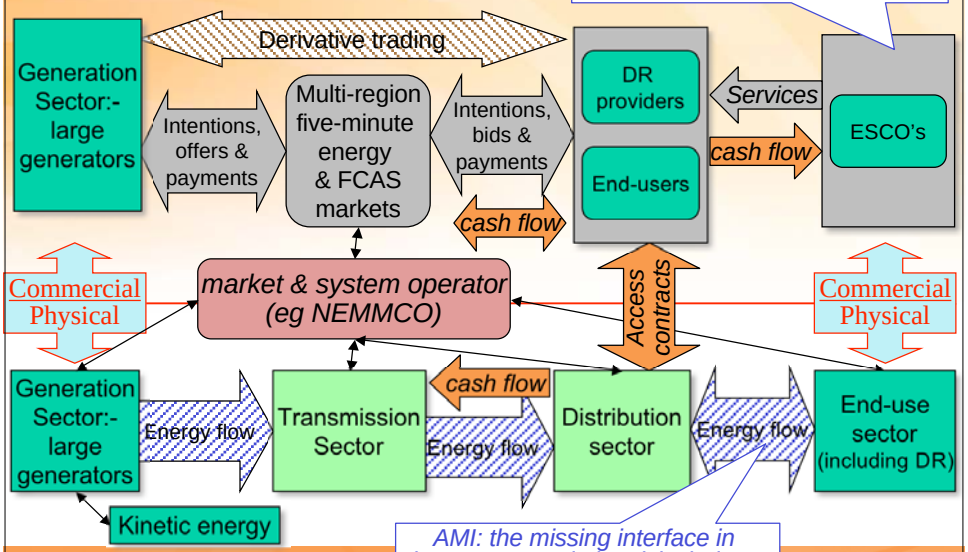
## Enhanced industry structure



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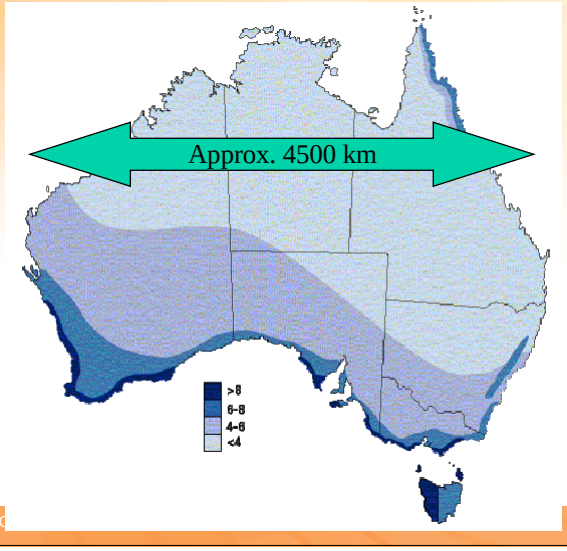
## Australian wind resource

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



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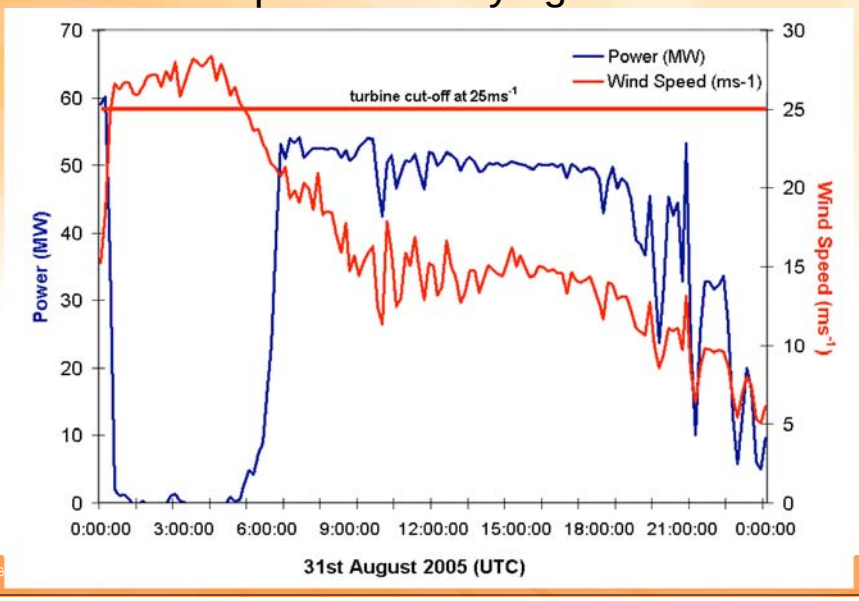
## Wind farm response to varying wind conditions

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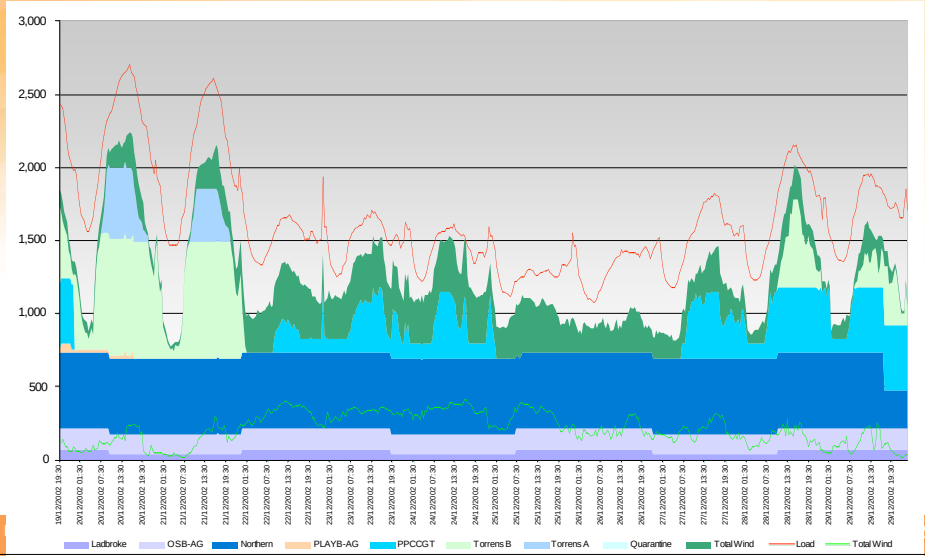
## Simulated dispatch with 500MW wind in SA

(Oakeshott, 2005)




6

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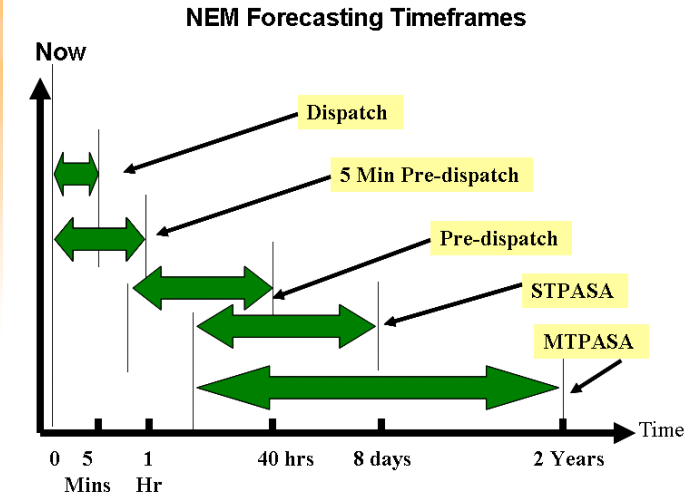
## NEMMCO Forecasting Timeframes




( AWEFS functional requirements, www.nemmco.com.au)



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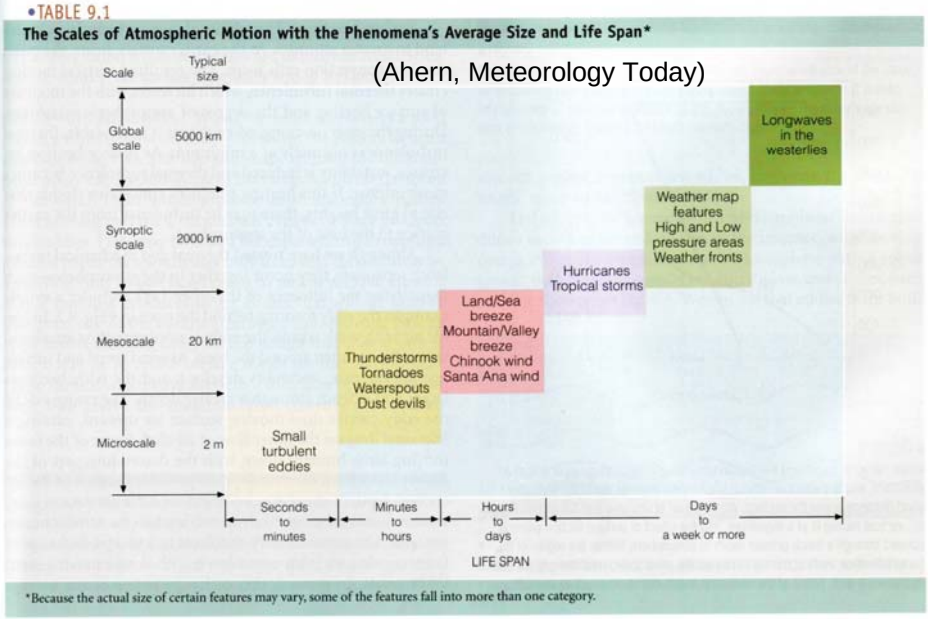


(Ahern, Meteorology Today)

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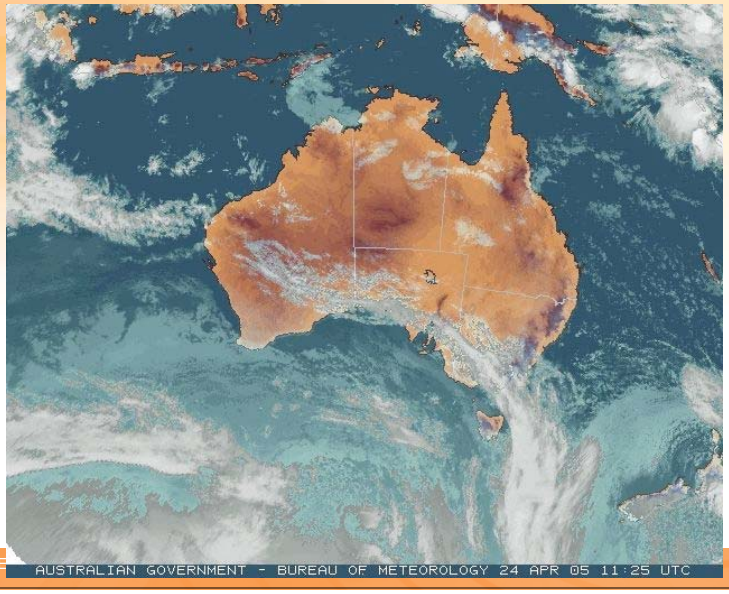
## S1: Infra-red satellite map (BoM Aust,1125 UTC 24/4/05)



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## Low-pressure cell over southern Australia

(BoM, 2006)

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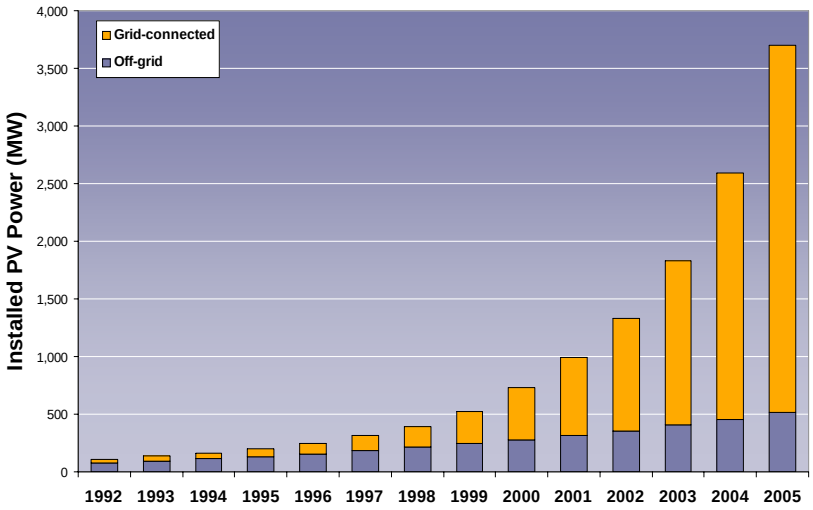
## PV Market in IEA countries,1992-2005 (IEA PVPS, 2006)

**Figure 1 Cumulative installed grid-connected and off-grid PV power in the reporting countries – Years 1992-2005**

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## Australian PV Concentrator Technology

- Each dish has 112 curved mirrors which focus sunlight onto a central receiver, 500x concentration, 25kW
- Dishes are cooled & independently track the sun
- Suited to end of grid applications & CHP
- Installed in 6 diesel grids
- Another 30 dishes (750kW) for 3 NT Power and Water Authority diesel grids
- 150MW now funded for rural Victoria

Solar Systems Pty Ltd: *220 kW PV Concentrator power plant at the Pitjantjara lands*

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## Aust. Govt. Solar Cities program

- $75M over 5 years from 2006 to demonstrate high penetration uptake of solar technologies, energy efficiency, smart metering
- Aimed at improving the market for distributed generation and demand side energy solutions
- Tenders called 2005 – must include matching funds, PV, efficiency, monitoring, advanced tariffs, marketing and financing strategies
- Eleven consortia short-listed from 23 applications
- Funds so far awarded to Adelaide & Townsville



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

Photo: BP Solar

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## Newington Solar Village

- 780 houses with 1kW PV; 199 houses with 0.5kW PV.
- Passive solar design, energy efficient appliances
  - Loads av 16 kWh/day cf 7.5 design
  - Load profile 'peakier' than for normal houses
- 30 houses monitored July 04-June 05
  - Ave daily PV output per house 3.2 kWh (~20% of load)
  - 2 systems faulty, when removed, 3.4 kWh/house ave, about 10% lower than expected (although 2005 may not be a typical year)
  - Average peak output for 30 houses, 13 kW



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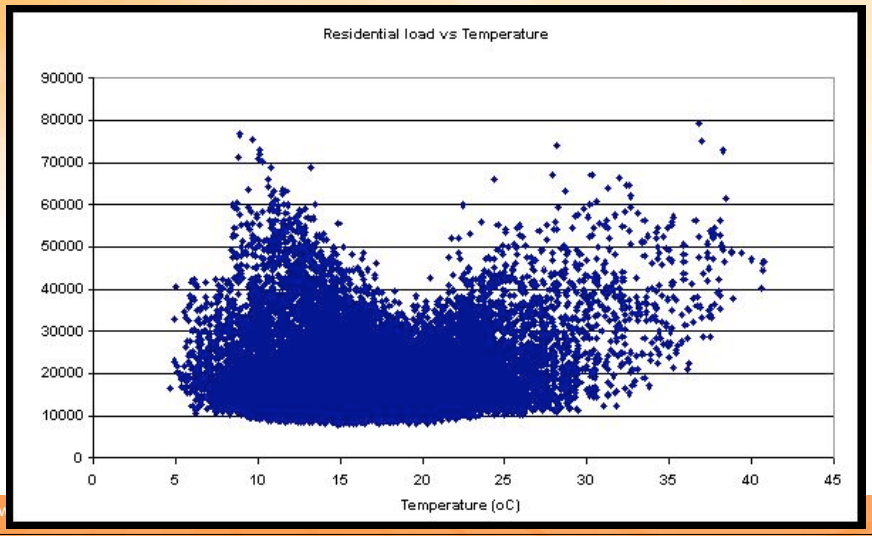
## Relationship between electricity use and temperature, Newington



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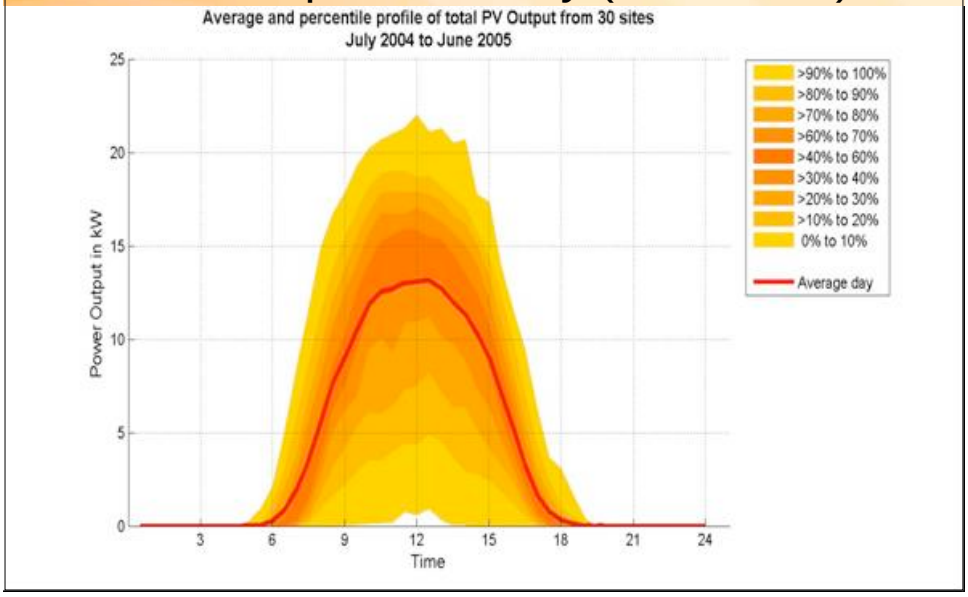
## PV output variability (30 houses)

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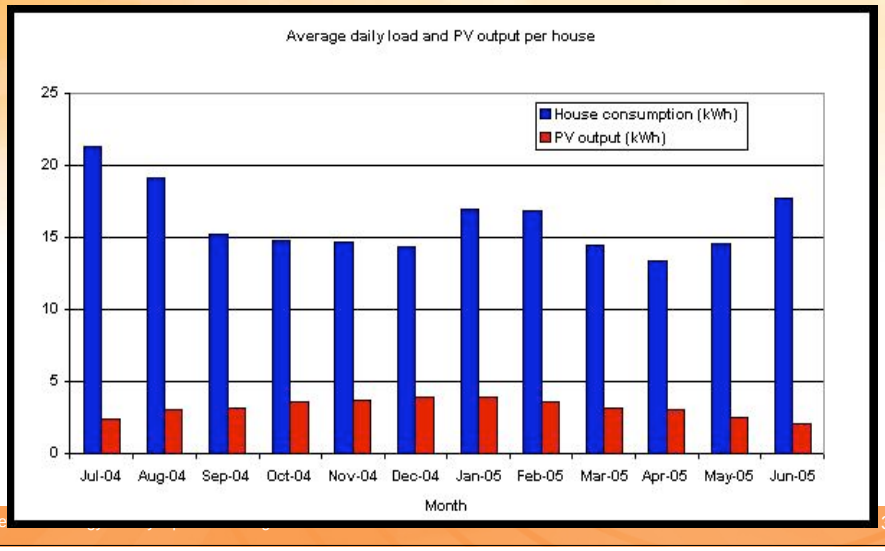
## Household Load and PV Output

average over 30 houses



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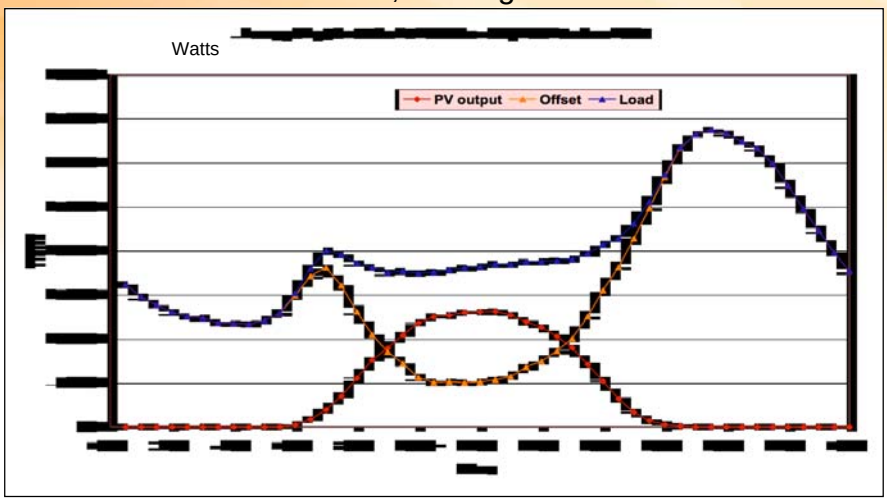
## Annual Average Daily PV Output, Household Load and Offset, Newington

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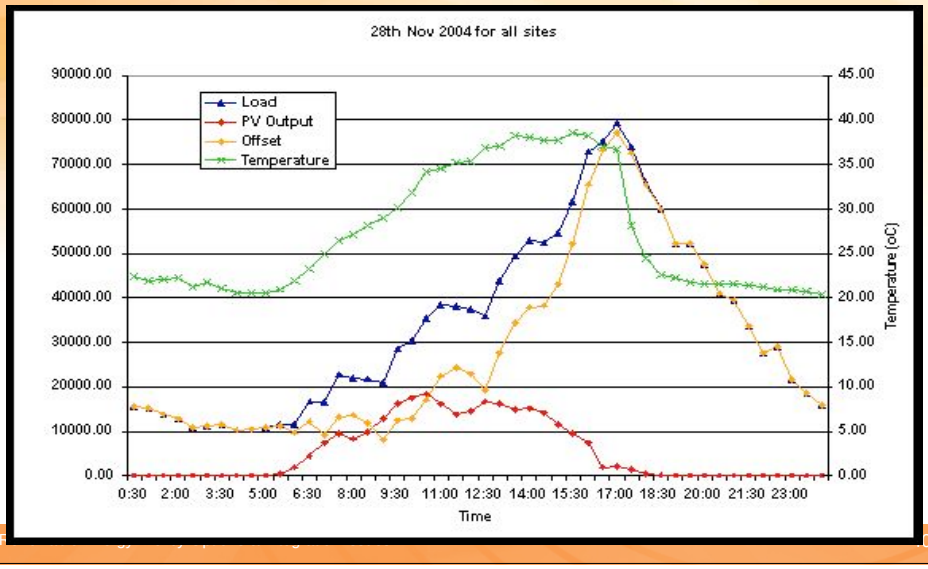
## PV Output, Household Load and Temperature - Peak Summer Day, Newington



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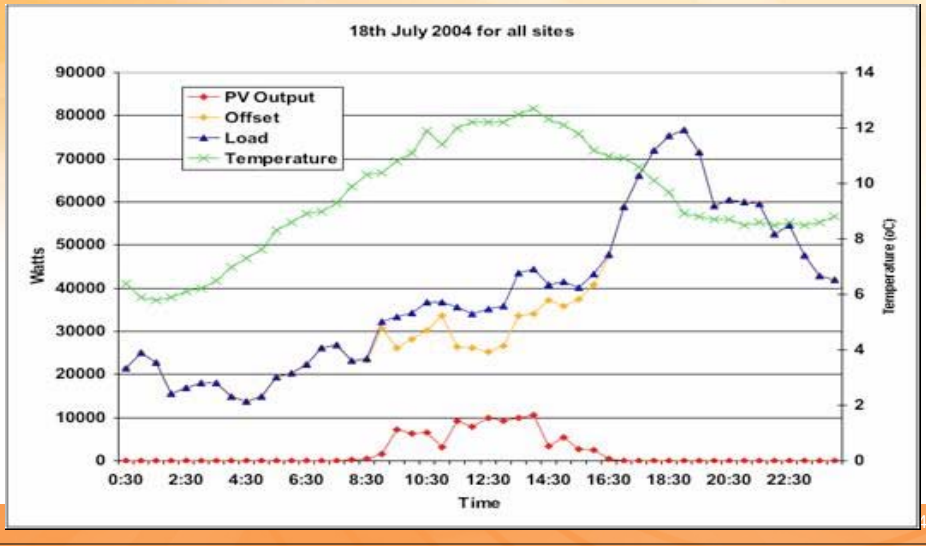
## PV Output, Household Load and Temperature - Peak Winter Day, Newington

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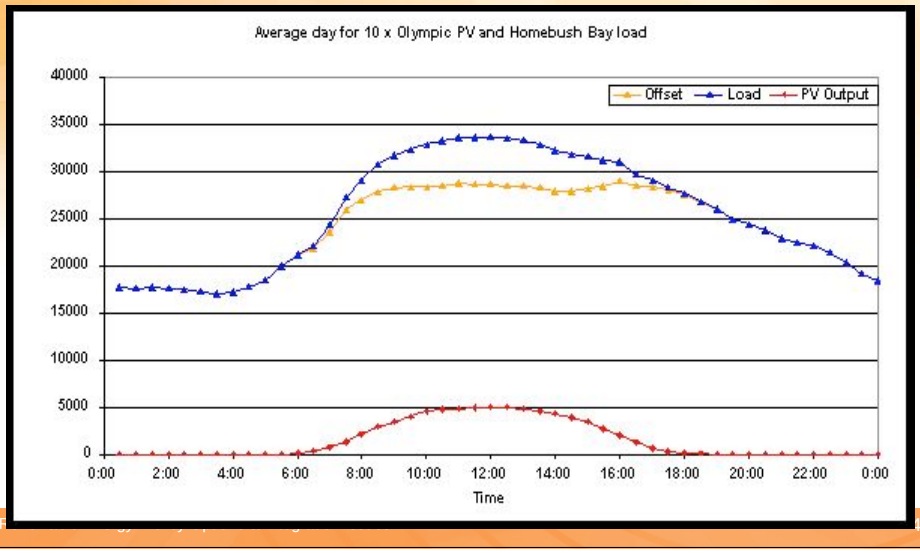
## Annual Average PV Output (X10) and Homebush Bay Substation Load



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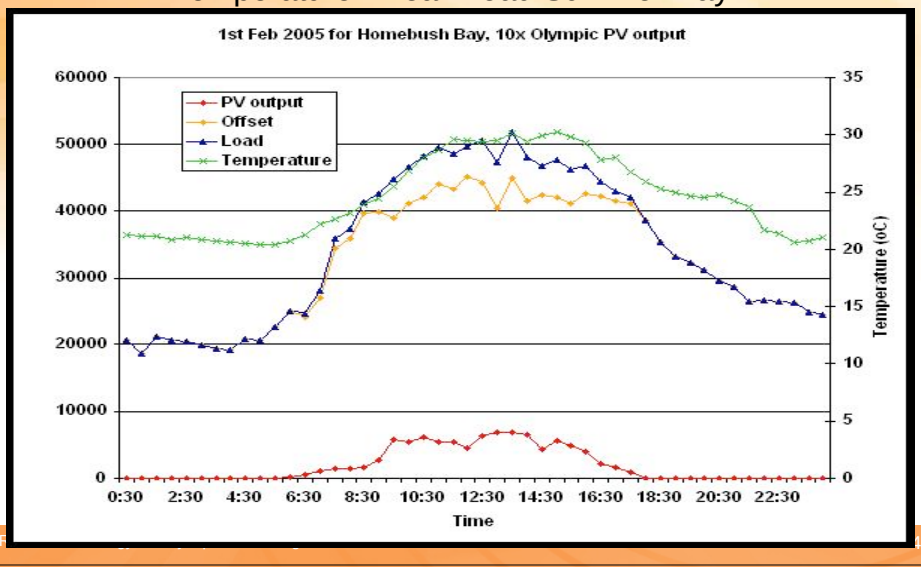
## PV Output, Homebush Bay Substation Load and Temperature - Peak Load Summer Day



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## Key technical issues for high-penetration renewable energy

- Design & demonstration of distributed resource systems (generation, storage, end-use response)
- Advanced metering, communication & control for distributed resources
- Improved power electronic devices
- Compact, high-capacity & cost-effective reversible energy storage
- Mathematic modelling & forecasting for renewable energy generation & distributed resources

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## Key regulatory & policy issues for high-penetration renewable energy

- Institutional issues:
  - Robust security regime with security-constrained dispatch
  - Efficient commercial regime (operation & investment)
  - Effective regulatory framework (network services)
  - Compatible arrangements for gas industry
- Policy issues:
  - Appropriate innovation in renewable energy technologies
  - Correct location & timing for investment in renewables
  - Forecasting for security & commercial regimes
  - Active end-user participation (value, timing, efficiency)
  - Skill development in all relevant areas



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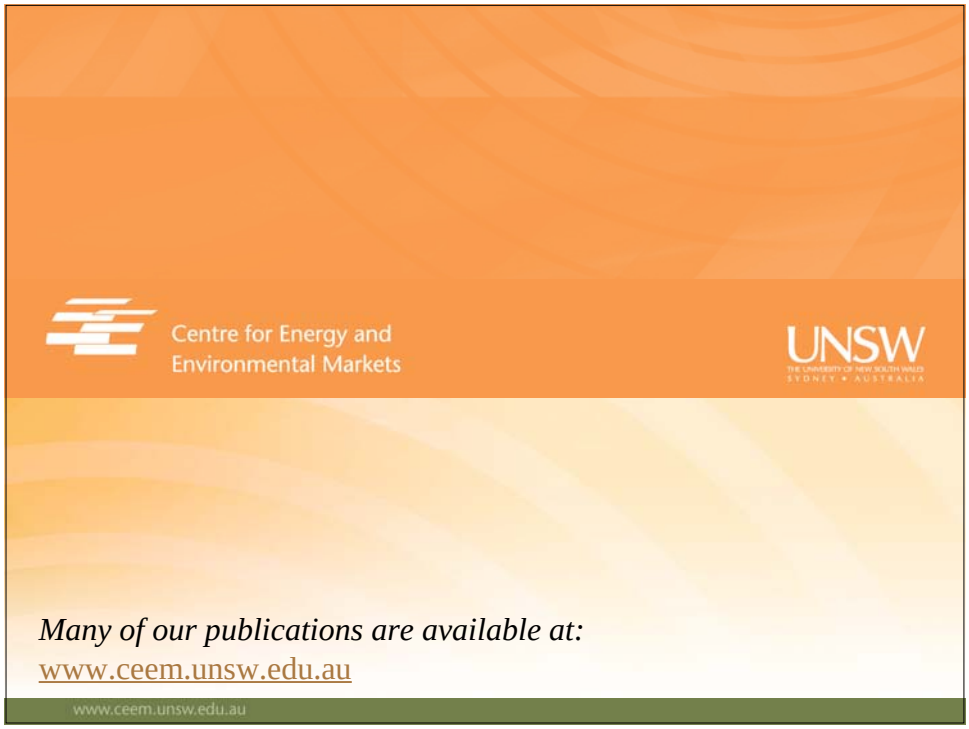
## Key commercial issues for high RE

- Advanced auction-style electricity markets:
  - Spot & derivative energy; ancillary services
    - Within continually updated security constraints
    - With active end-users supported by ESCOs
    - With attention to equity issues
- Efficient network access regimes:
  - Availability & quality; active end-user participation
- Renewable energy forecasting tools for:
  - Renewable energy generators
  - Other generators and end-users
  - System operators & policy-makers
- Efficient financial mechanisms to counter un-costed fossil fuel externalities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