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## Prospects for wind energy in Australia

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*ANZSES NSW Branch, Sydney, 24/7/08*

[www.ceem.unsw.edu.au](http://www.ceem.unsw.edu.au)



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## Outline

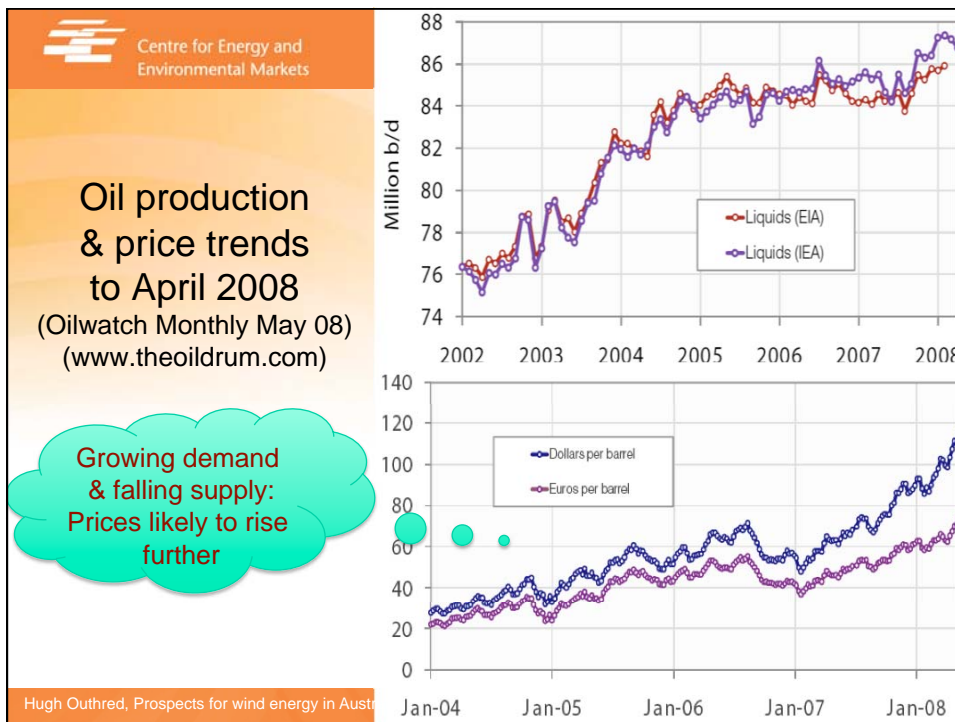
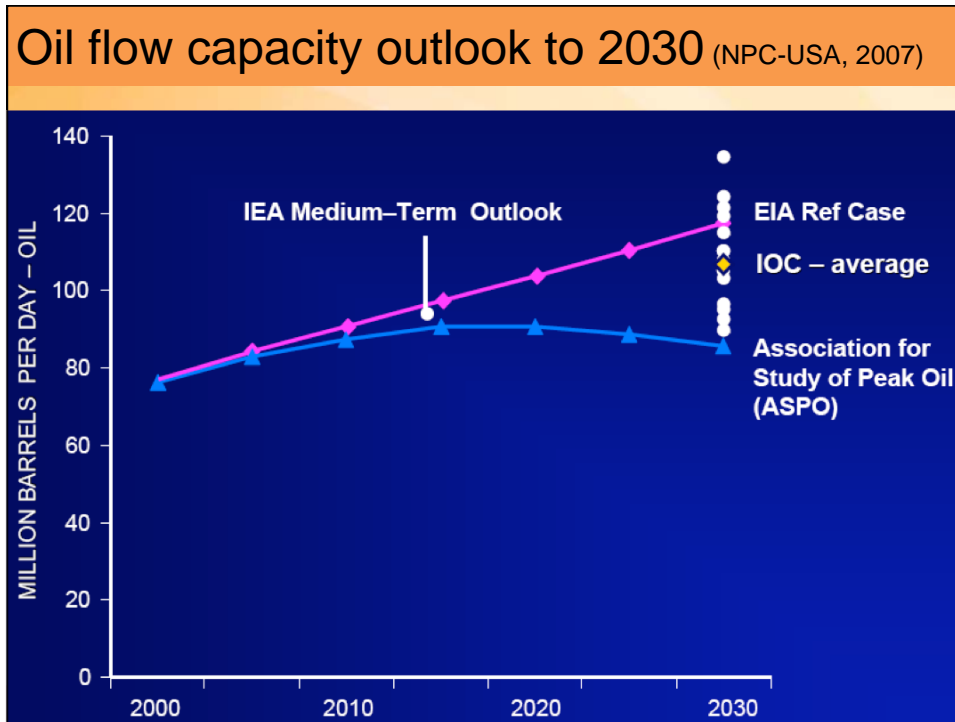
- Global energy-related crises:
  - Energy security, fossil fuel prices, climate change
- Implications for the stationary energy sector
- Wind energy resource & technology issues
- Issues in integrating large amounts of wind energy into the Australian electricity industry
- Conclusions

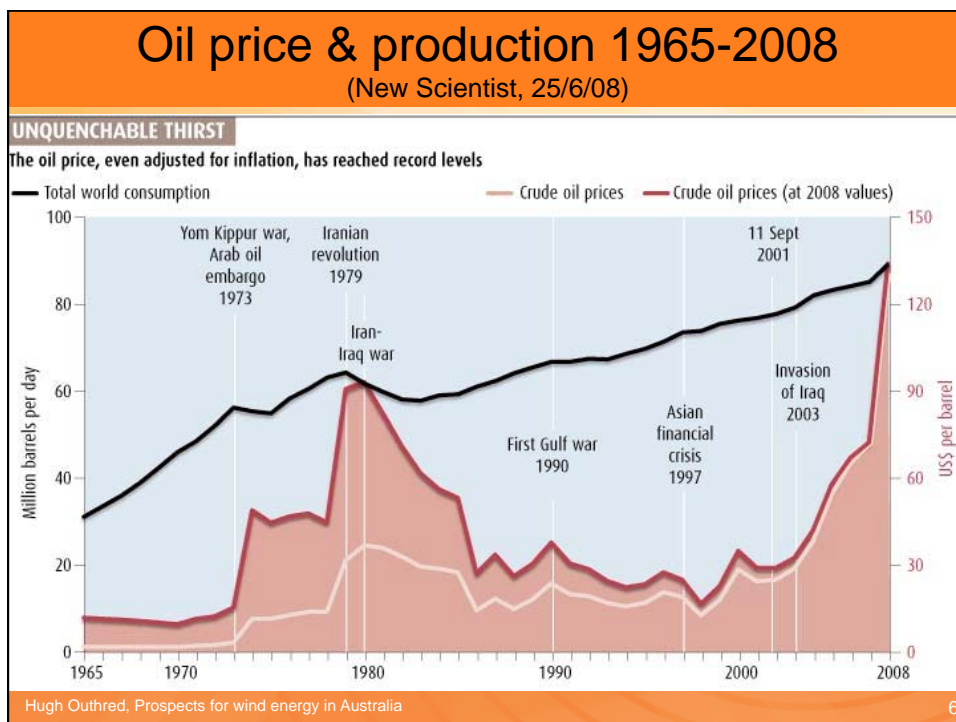
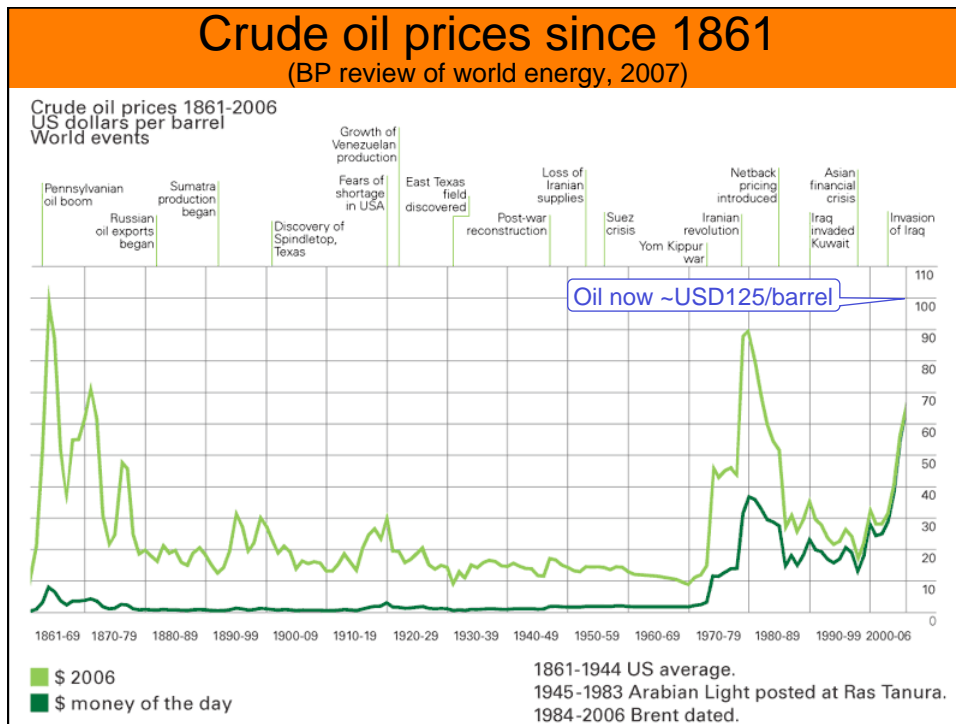
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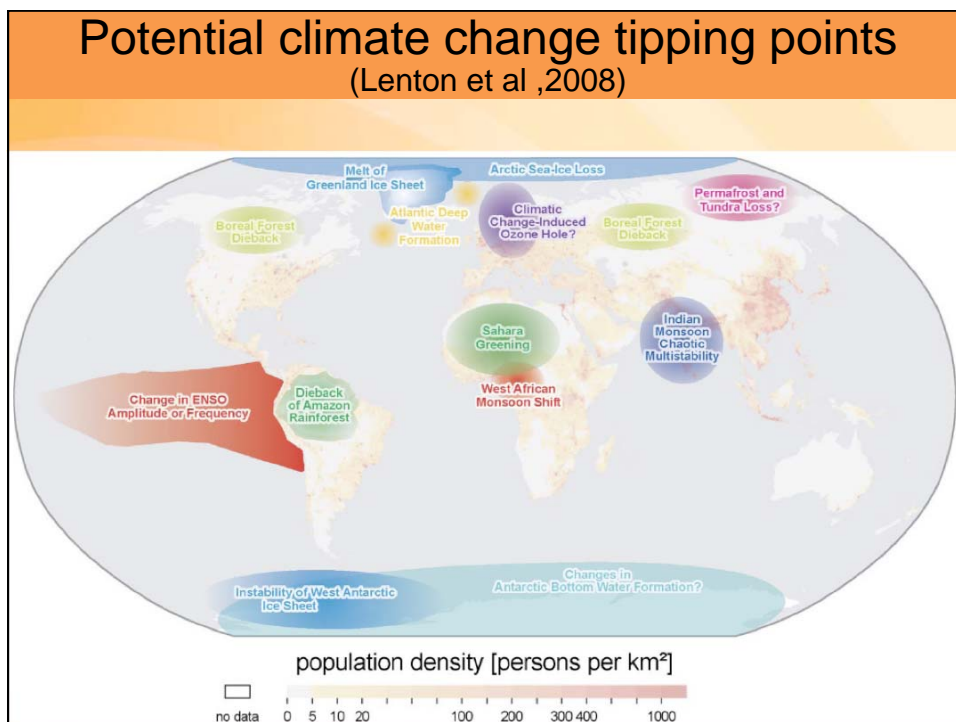
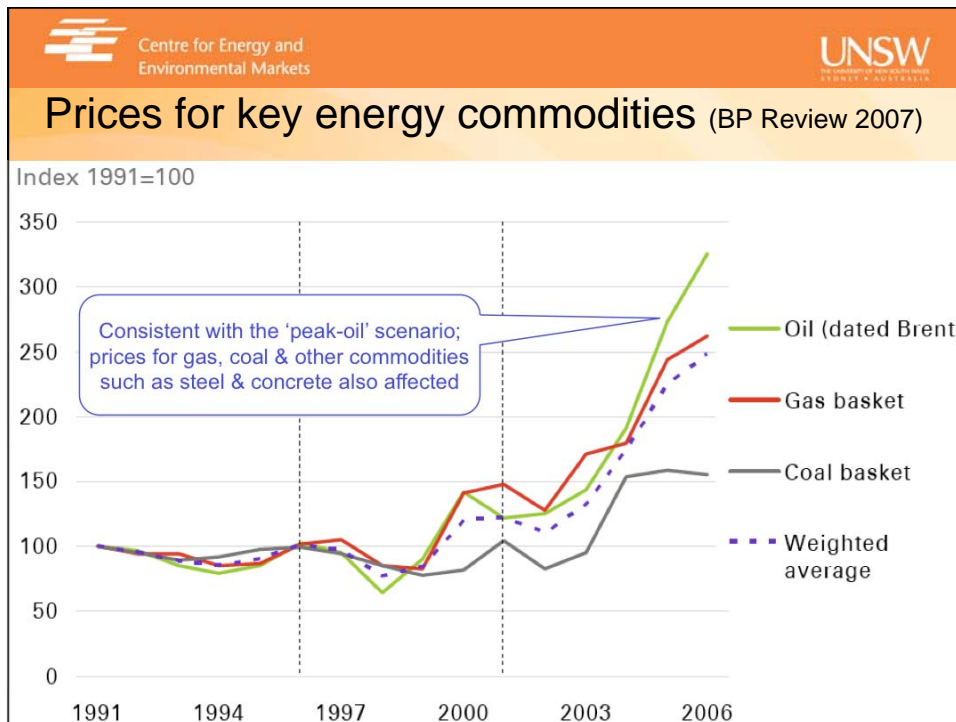
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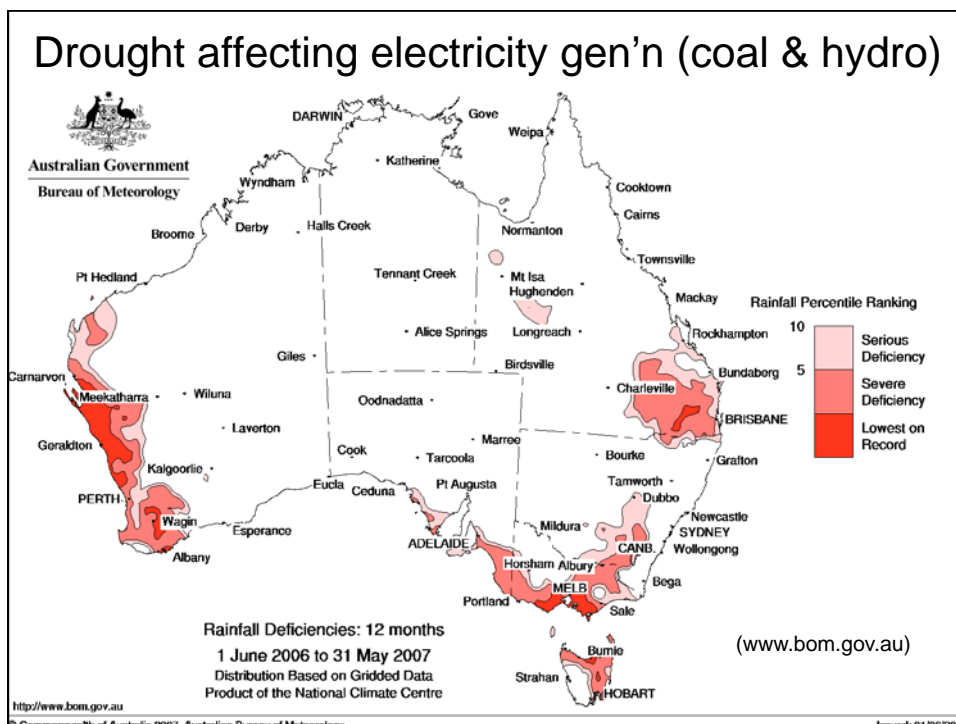
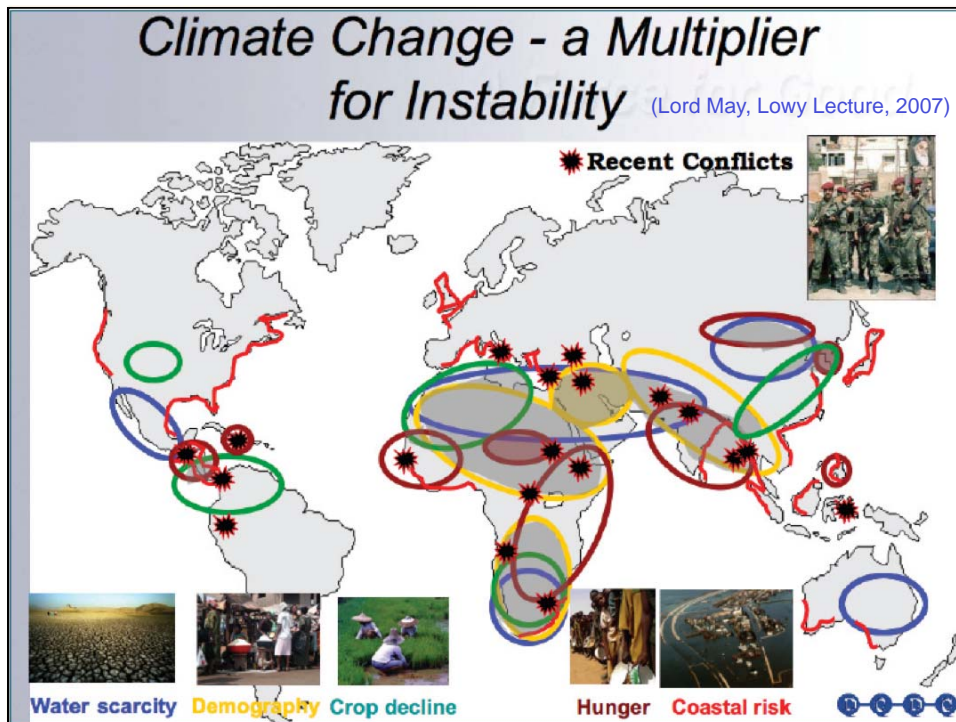


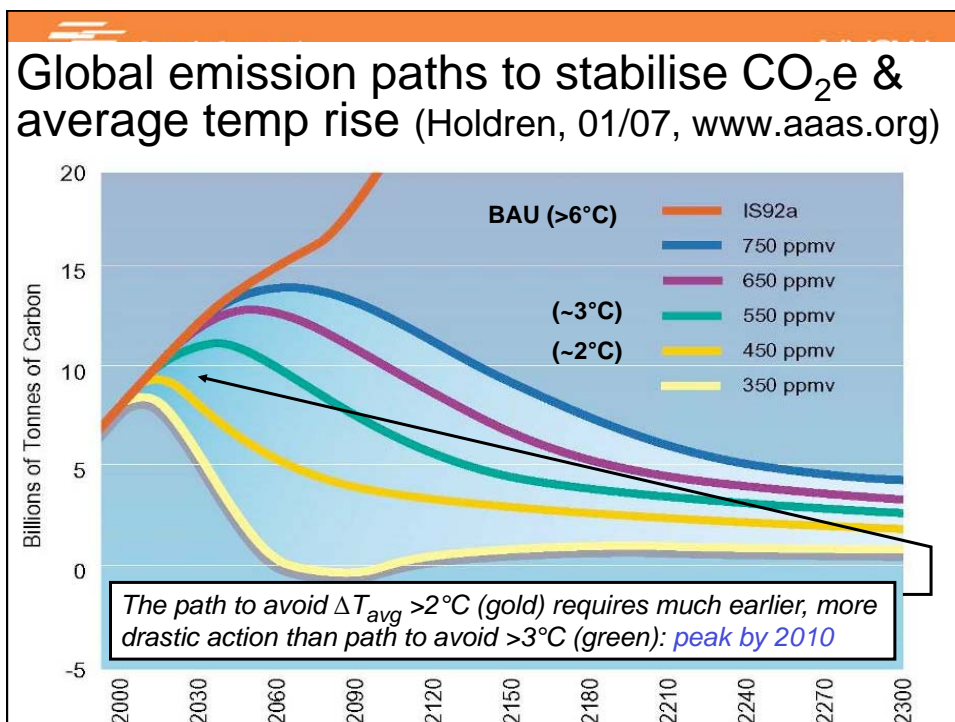
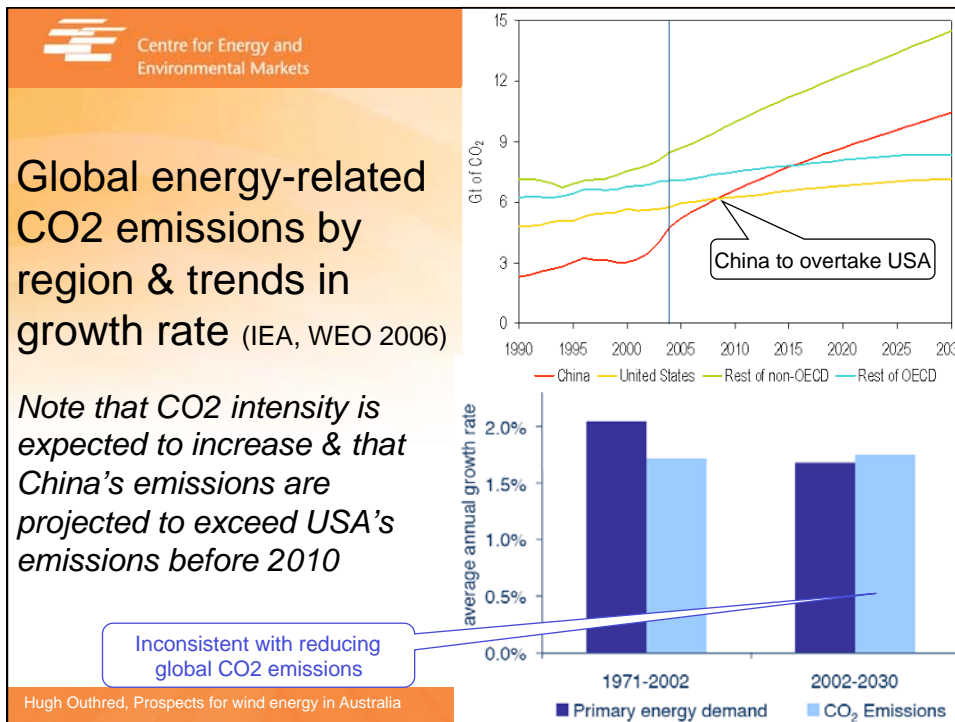
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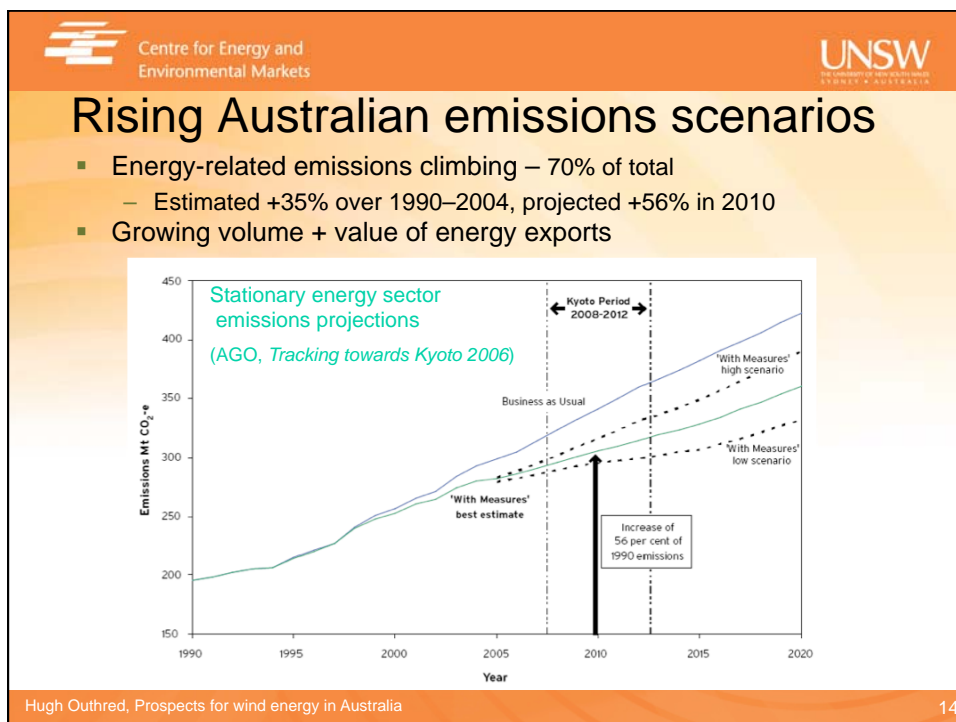
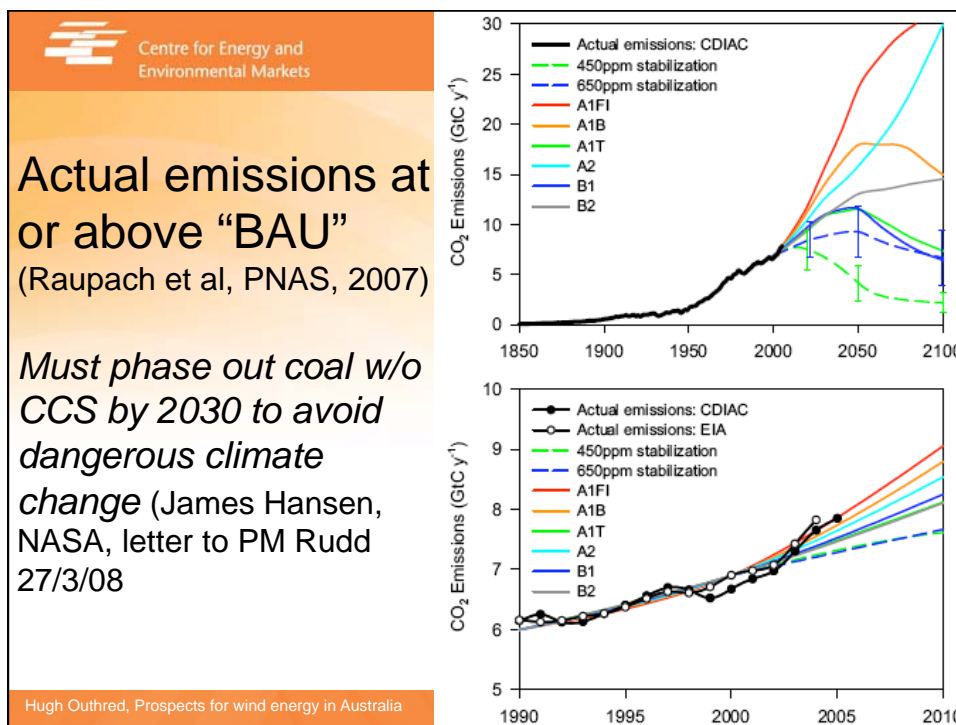


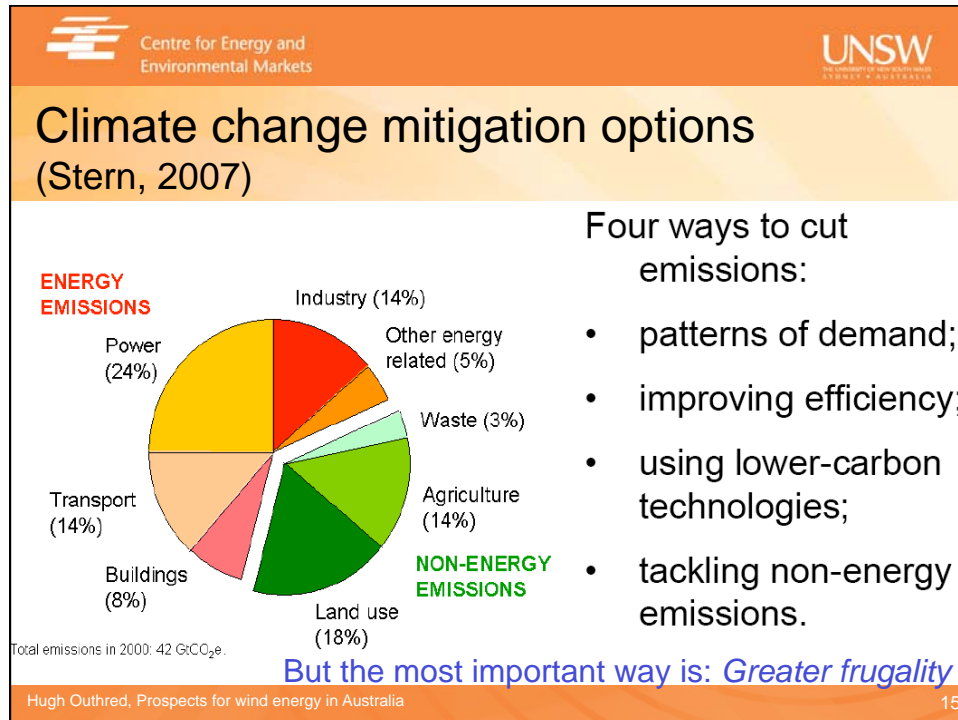




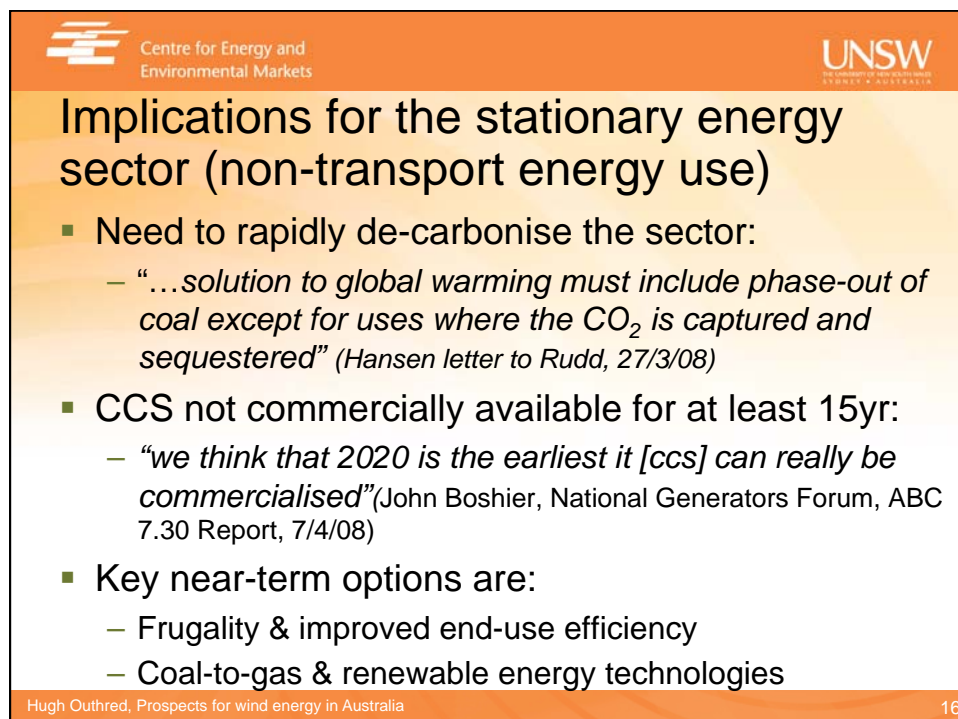








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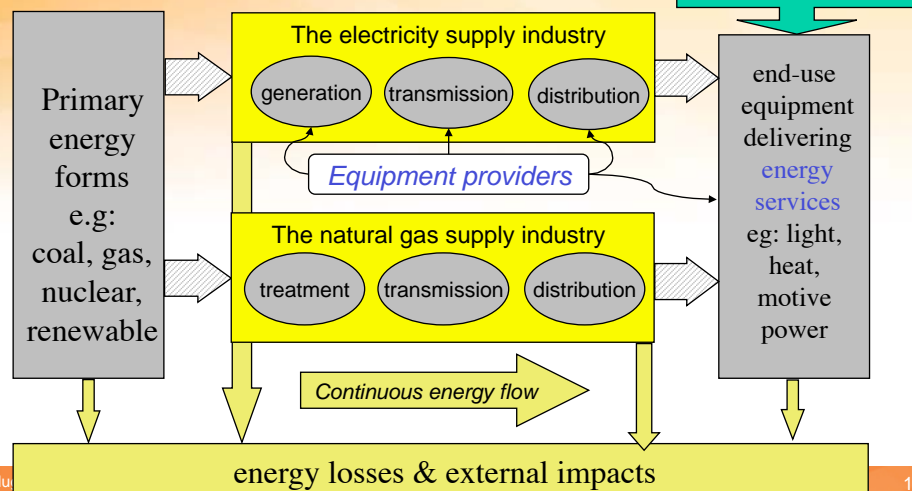


## Summary of the presentation so far...

- Human species faces energy-related challenges:
  - Fossil fuel flow physical constraints:
    - “Peak-oil” now & in future “peak-gas”, “peak-coal”, “peak-uranium”
  - Energy security concerns:
    - Unequal distribution of energy resources among nation states
  - Growing risk of dangerous climate change:
    - Excessive release by human activity of CO<sub>2</sub> & other climate change gases
- These challenges are primarily matters of equity:
  - Intra-generational: rich versus poor
  - Inter-generational: old versus young & future generations
  - *Our best hope is frugality but we prefer to party*



## Energy service delivery in the stationary energy sector (a complex technological system)





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## 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.

### What is technology?

([www.iiasa.ac.at](http://www.iiasa.ac.at))

**Technology = Hardware + Software + "Orgware"**

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

**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 >>**

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## Issues for enhancing EI sustainability

- Energy flow constraints, energy security & rapid climate change present massive challenges
- Response tasks must largely be delegated to industry participants (companies & communities):
  - Through “socially-organised decision-making”
- Policies must:
  - Develop capabilities in companies & communities
  - Reward socially-beneficial technological innovation
  - Correctly assign incentives & penalties to induce decisions that are in the long-term public interest

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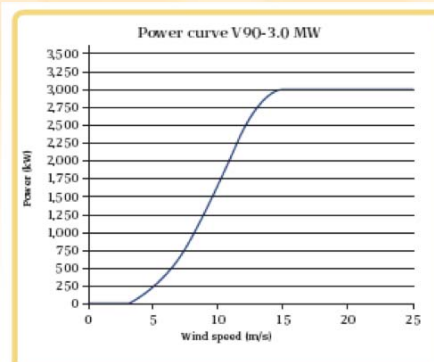
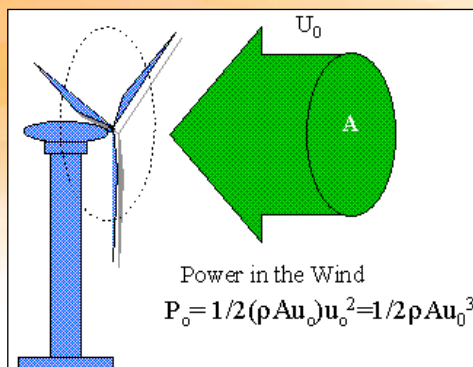


## Socially-organised decision-making

- Most human decision-making occurs within a social (group) context supported by public policy:
  - “Effective policies are those that support socially valued outcomes not only by harnessing selfish motives but also by evoking, cultivating and empowering public spirited motives” (Gintis, Bowles & Fehr (eds), *Moral Sentiments and Material Interests*, MIT press, 2007)
- Electricity industry: *a complex technological system*:
  - Policies should address hardware, software & orgware
  - Enhanced end-user engagement will be essential



## Wind power density & wind turbine conversion curve



- Doubling wind speed increases wind power density 8 times
- A wind turbine is designed with a varying conversion efficiency of up to ~50% between 5 and 10 m/s



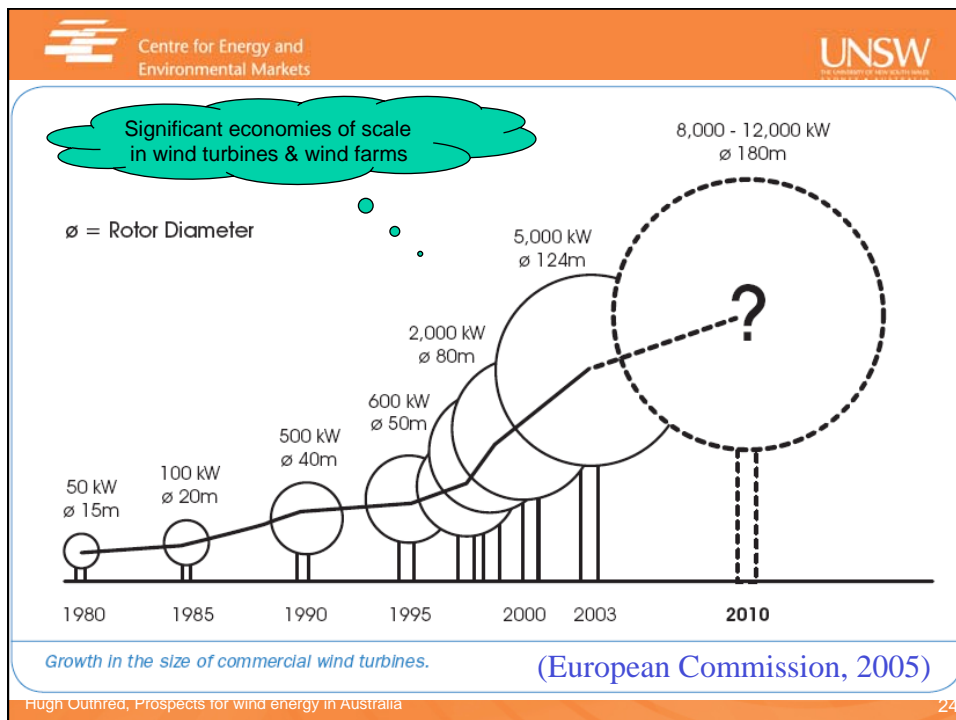


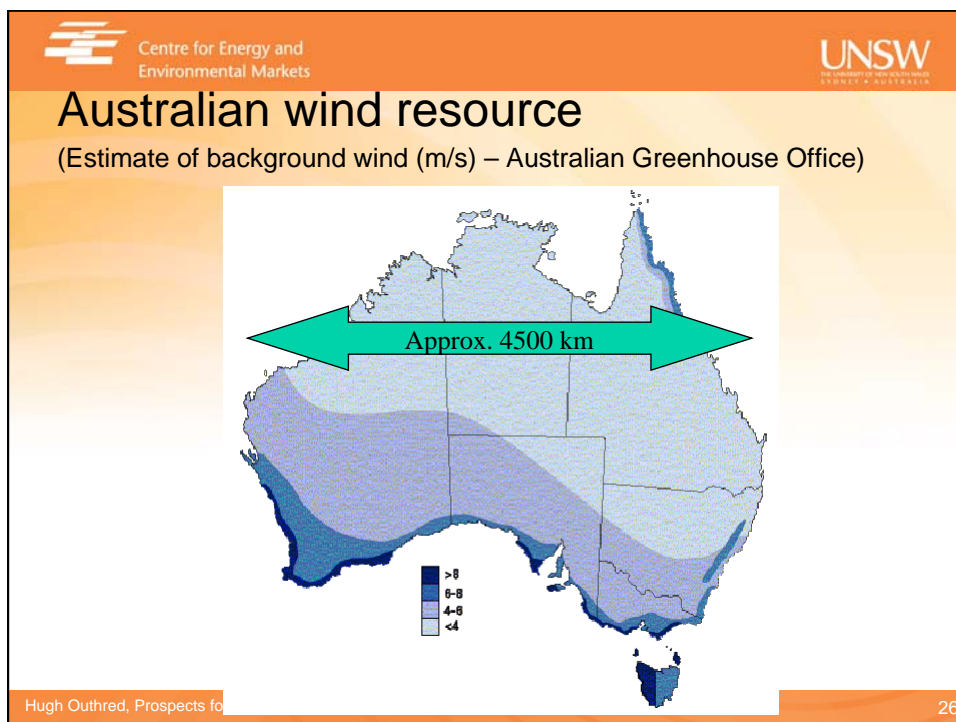
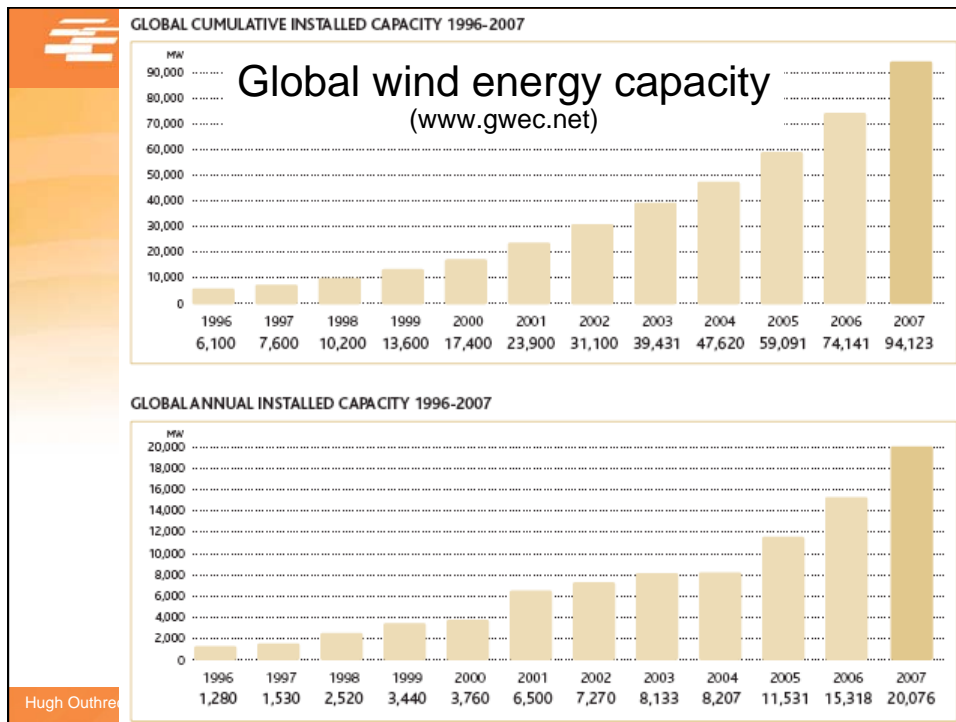
## A modern 3MW wind turbine (www.vestas.com)

### Technical specifications

|                                     |                           |                          |                   |
|-------------------------------------|---------------------------|--------------------------|-------------------|
| 1 Oil cooler                        | 4 Service crane           | 11 Mechanical disc brake | 18 Pitch cylinder |
| 2 Water cooler for generator        | 5 OptiSpeed generator     | 12 Machine foundation    | 19 Hub controller |
| 3 High voltage transformer          | 6 Composite disc coupling | 13 Blade bearing         |                   |
| 7 Ultrasonic wind sensors           | 8 Yaw gears               | 14 Blade hub             |                   |
| 9 VMP Top controller with converter | 9 Gearbox                 | 15 Blade                 |                   |

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## Some Wind Farms in Australia




Mt Millar, Tarong Energy




Wattle Point, Dave Clark



Blayney, Eraring Energy



Woolnorth, Hydro Tas



Albany, Verve Energy

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**Rottnest Island, WA:**  
600kW



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

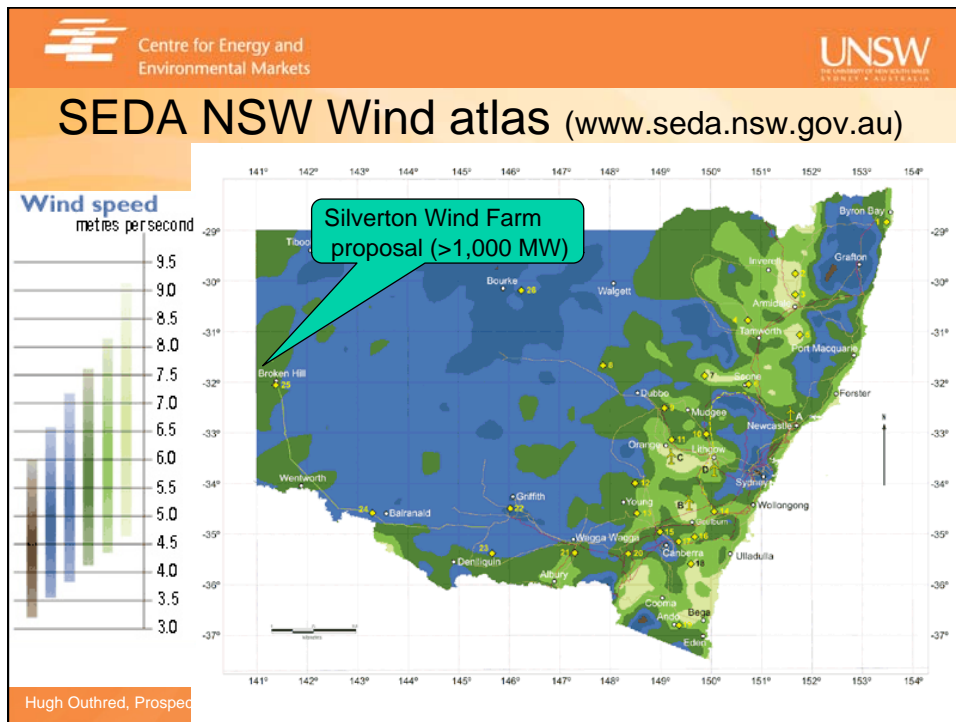


**Albany, WA:** 22MW,  
12x1.8MW



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





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**Blayney, NSW, 10MW, 15x660kW:**

- Good ridge location
- Little interference with farming activity

**Hampton, NSW, 2x660kW:**

- Good ridge location but turbulence fairly high
- Easy connect to 11kV feeders
- Too small to capture economies of scale

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## Australian wind farm size compared to base-load coal generator size in the NEM

### Largest Wind Farm Built In Australi

| Year   | Size (MW) |
|--------|-----------|
| 1998   | 0         |
| 1999   | 0         |
| 2000   | 10        |
| 2001   | 20        |
| 2002   | 30        |
| 2003   | 50        |
| 2004   | 80        |
| 2005   | 100       |
| 2006   | 80        |
| 2007*  | 200       |
| 2008** | 340       |

### Generator Sizes

Largest generators in the NEM

\* Under construction \*\* Planning Approved

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## Wind farms marginal at \$70/MWH (PWC, 2002)

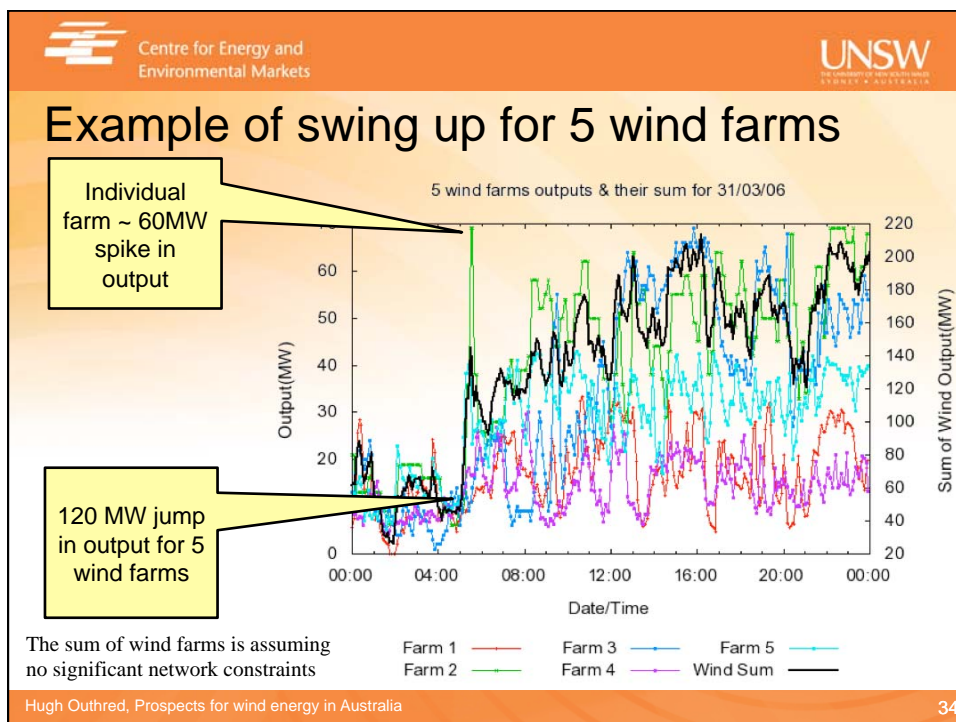
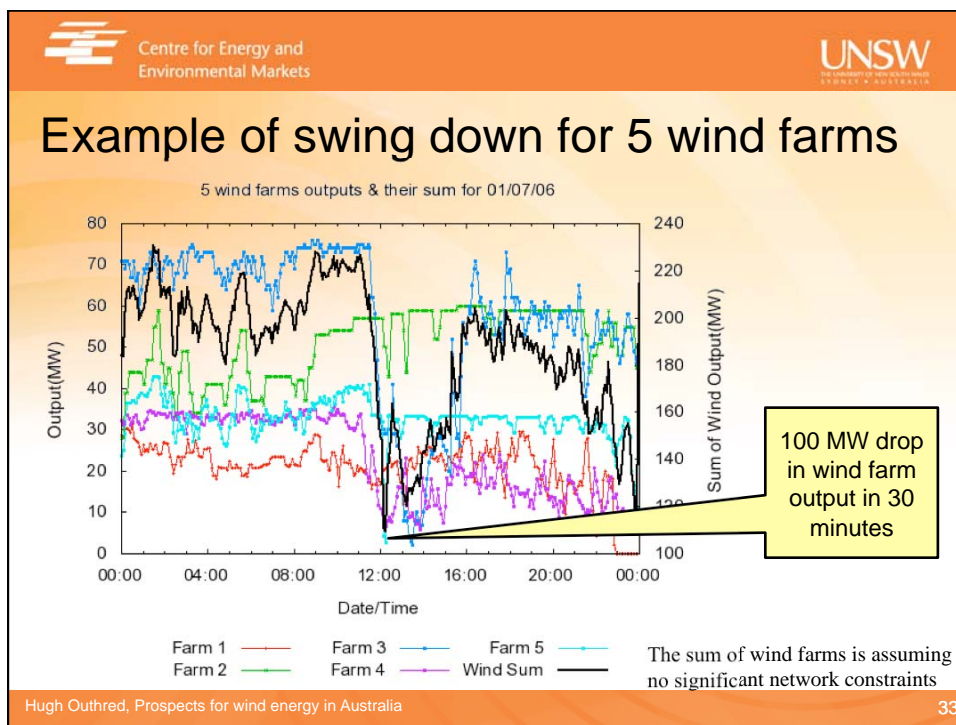
### Impact of Wind Speed and PPA Prices on IRR

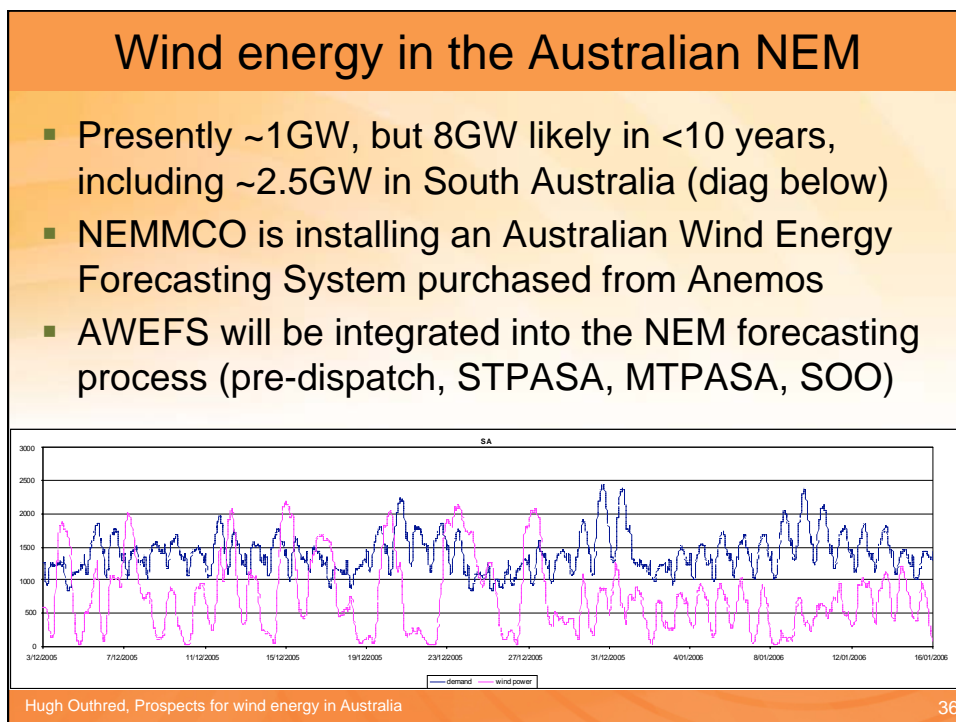
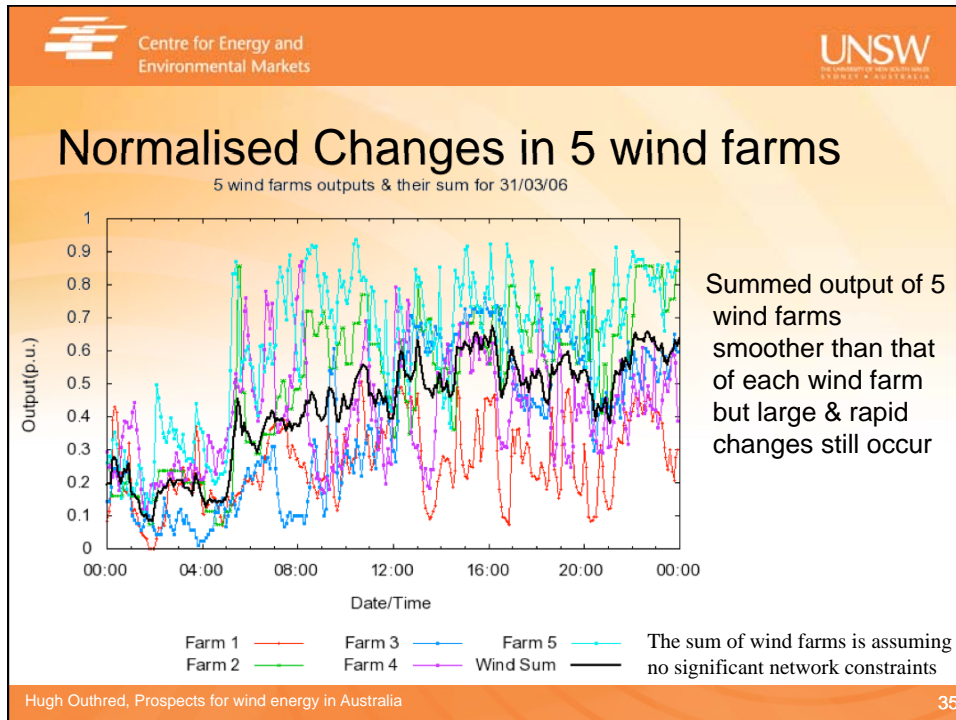
| Wind Speed (m/s) @ 30 m | IRR (Post Tax & Funding) - \$70.00 | IRR (Post Tax & Funding) - \$75.00 | IRR (Post Tax & Funding) - \$80.00 |
|-------------------------|------------------------------------|------------------------------------|------------------------------------|
| 6                       | 2.0%                               | 3.0%                               | 4.0%                               |
| 6.5                     | 4.0%                               | 5.0%                               | 6.0%                               |
| 7                       | 6.0%                               | 7.0%                               | 8.0%                               |
| 7.5                     | 8.0%                               | 9.0%                               | 10.0%                              |
| 8                       | 10.0%                              | 11.0%                              | 12.0%                              |
| 8.5                     | 12.0%                              | 13.0%                              | 14.0%                              |
| 9                       | 14.0%                              | 15.0%                              | 16.0%                              |

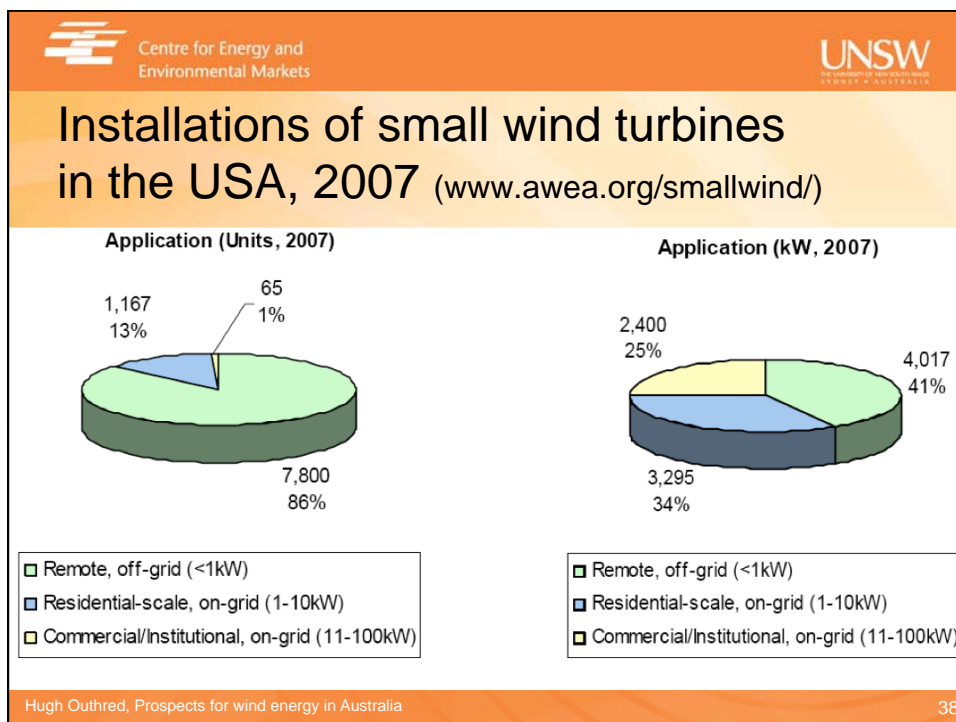
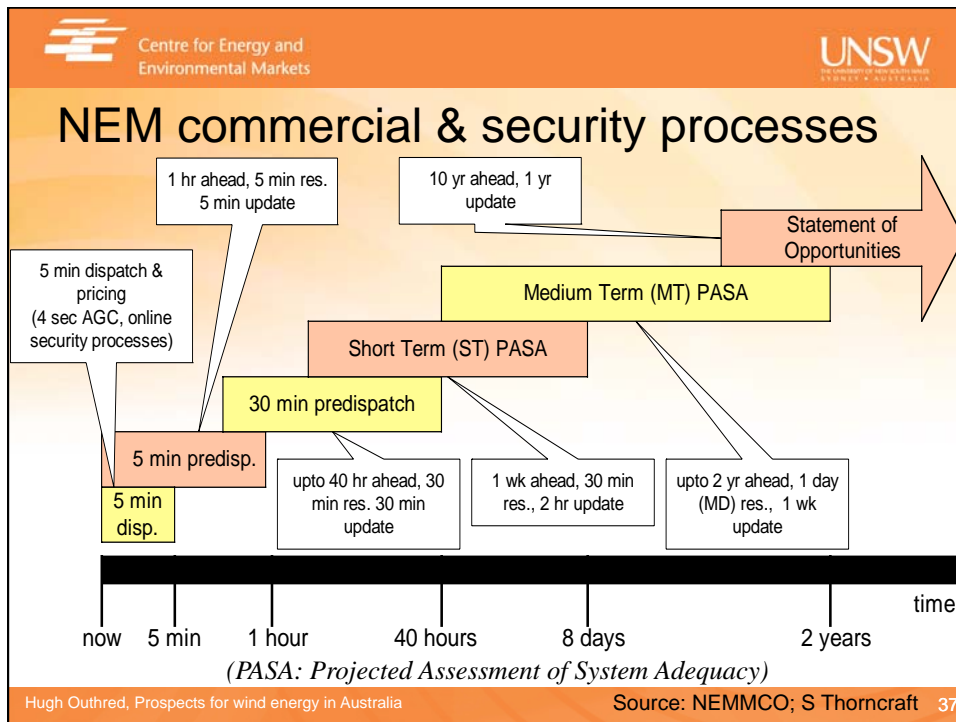
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## Small wind turbines



- Defined by AWEA as <math><100\text{kW}</math>
- Market growing more slowly than for large turbines:
  - More expensive (\$/W); turbines less reliable; less suited to grid connection; lower & more turbulent winds; concerns about noise, accidents & visual impacts
- Internet resources for small wind turbines:
  - [www.awea.org/smallwind/](http://www.awea.org/smallwind/); [www.nrel.org/wind/](http://www.nrel.org/wind/)
  - [www.bergey.com/School/Primer.html](http://www.bergey.com/School/Primer.html)

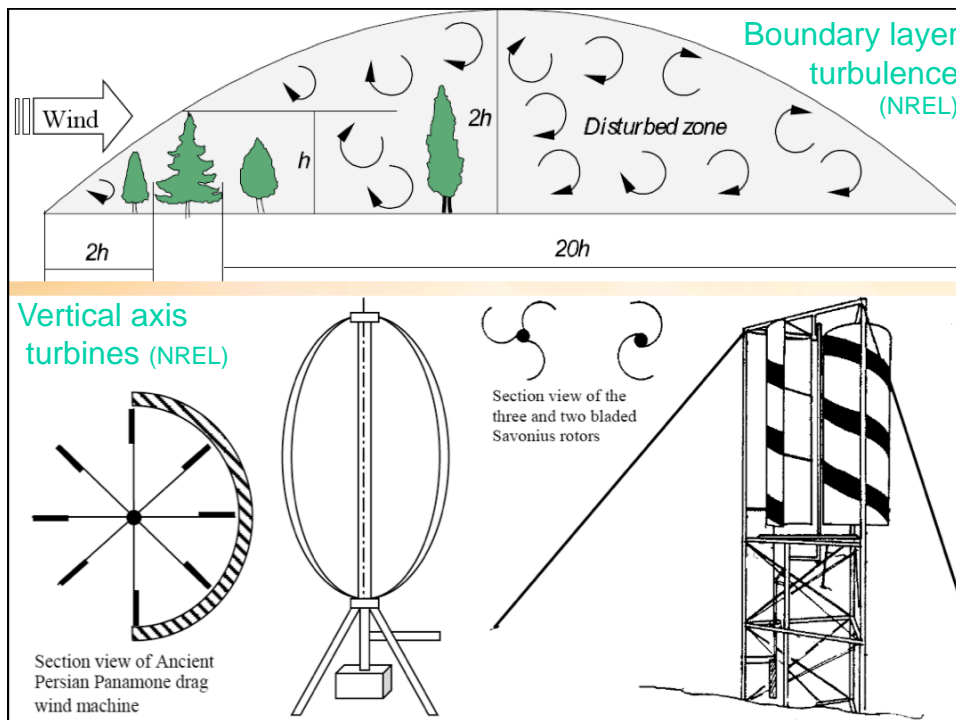
## Small wind turbine examples (www.nrel.gov)





## Residential wind turbine invention, Graeme Attey, Perth

(<http://www.youtube.com/watch?v=WZ5kX5Yw4eY>)  
(<http://www.abc.net.au/news/stories/2007/06/27/1963676.htm?section=business>)





## Conclusions

- Sustainability challenges are of global-scale:
  - Fossil fuel availability & pricing
  - Climate change
  - *Also food, water and other resources*
- Electricity industries must contribute to solutions:
  - Efficient & frugal end-use
  - Low-carbon, locally available primary energy resources
- Wind energy has an important role to play:
  - Active community participation to align projects with community attitudes & expectations
  - Enhanced forecasting & power system security regime



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