Centre for Energy and Environmental Markets

UNSW

The Energy Debate: Climate change and energy options for Australia

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The potential for sustainable energy futures

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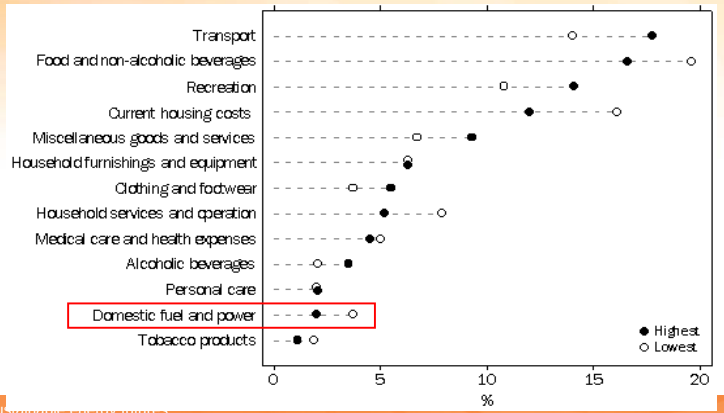
Outline

- Defining a sustainable energy future
  - Energy for societal welfare and progress
  - Energy security
  - Environmental impacts
- Some guidance for exploring the future
  - Scientific laws and constraints take precedence
  - What exists is possible
  - What doesn't yet exist may be possible… or may not, and it will take time to establish its feasibility while existence, alone, is not sufficient to ensure success
- Tools for exploring possible sustainable energy futures
  - Technology assessment
  - The challenges of forecasting
- The policy challenge

Energy for societal welfare of the 'energy' poor…

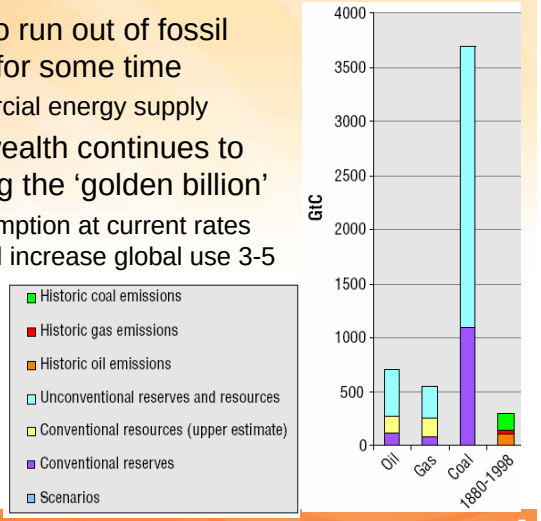
… different challenge from that of energy 'rich'

Australian domestic expenditure on different services
(ABS, 2001)



Energy security concerns grow for oil and gas

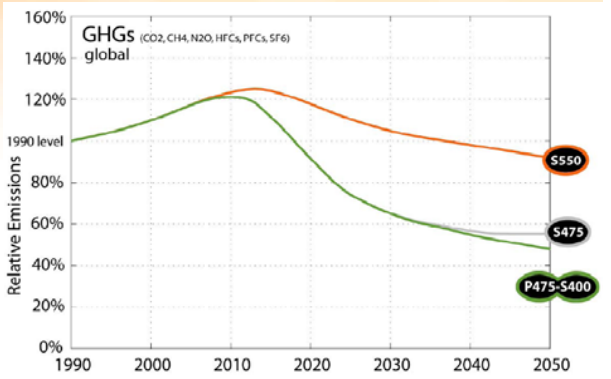
- …but we are unlikely to run out of fossil fuels in global context for some time
  - approx. 80% of commercial energy supply
- at least while energy wealth continues to be concentrated among the 'golden billion'
  - universal energy consumption at current rates of the energy rich would increase global use 3-5 times
- and Australia is an "energy superpower"



To avoid dangerous warming

(Meinshausen, Avoiding Dangerous Climate Change, 2005)

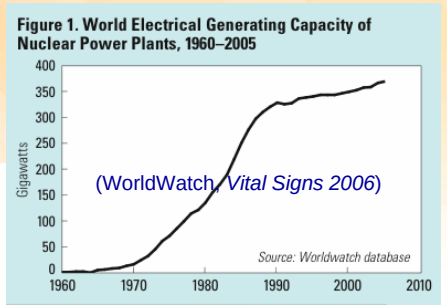
- A reasonable chance of keeping warming less than 2 deg.C may require stabilisation at 400-475ppm
- … requiring major global reductions by 2050
- while any delays in taking action greatly increase necessary rate of reduction
  - 20 year delay means 3-7 x faster fall required



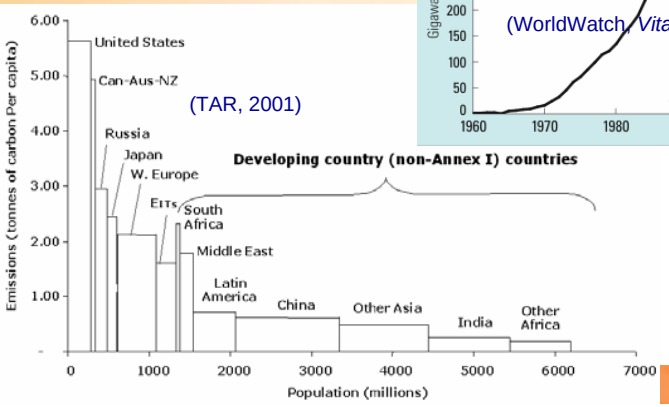
Guidance for assessing future - fundamentals

- Fundamental scientific laws
  - eg. energy conservation and entropy
- and potential constraints
  - eg. renewable energy fluxes, ultimately recoverable fossil fuel resources
- and the underlying science of natural systems
  - eg. our climate system response to additional radiative forcing from increased atmospheric levels of particular greenhouse gases
- are outside our control, and set constraints within which our decision making will have to take place

What exists is possible… at least in a context



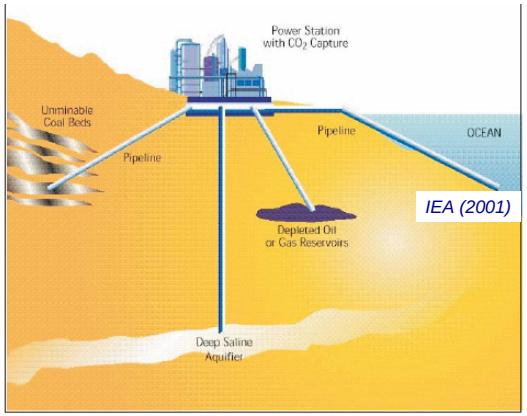
(WorldWatch, *Vital Signs 2006*)



(TAR, 2001)

What doesn't yet exist may be possible.. or not..

- Carbon Capture and storage from power stations has not yet been demonstrated in integrated, large scale manner
  - Proving effective storage of injected CO2 may take decades.



IEA (2001)

… and technology innovation involves uncertainties and hence risks – *societal choice is final test*

Technology
'hardware' + 'software' + 'orgware'

Technological innovation

Invention
↓
Commercial-isation
↓
Diffusion/ adoption

Typical technological change

(IIASA)

Tools for exploring future: technology assessment

eg. A range of power generation options of varied status and promise for reducing greenhouse emissions

- Current coal-fired base-load and gas-fired peak-load
- Improved end-use energy efficiency
  - Wide range of end-use technologies + hence opportunities
- Lower emission and distributed fossil fuel technologies
  - eg. CCGT, CHP
- Range of renewable technologies
- Nuclear power
- Emerging lower emission fossil fuel techs through Carbon Capture and Storage (CCS)
- Other emerging technologies - eg. fuel cells

A risk-based technology assessment framework

- *Technical status*
  - unproven => mature, emerging => widespread
- *Delivered energy services and benefits*
  - **GHG emission reductions**, flexibility, integration
- *Present costs* where known + possible future costs
  - Often wide disagreement on costs of established technologies, let alone emerging technologies
- *Potential scale of deployment*
  - possible physical, technical + cost constraints
- *Potential speed of deployment*
  - time and effort required to achieve scale
- *Other possible societal outcomes*
  - eg. other environmental impacts, energy security

Why risk-based?

- Experts tend to optimism bias
  - "… due to the experts' involvement and their underestimation of realisation and diffusion problems" (Tichy, 2004)
- Conventional decision making models under uncertainty
  - inevitably yield inaccurate estimates of expected benefits of any given option
  - such estimates generally over-optimistic and less well understood the problem, greater the errors.

  => can bias decision making towards poorly understood options

=> need to apply precautionary principle to technology assessment with focus on downside risks (Quiggin, 2004)

Federal Government technology assessment

- Not clear criteria or process…. appears to have now changed?

Table 2: Technology assessments

Market leader	Fast follower	Reserve
Play a leading role in international R&D efforts.	Strongly position Australia to follow international developments quickly.	Position Australia to monitor international developments and follow as needed.
Energy supply technologies		
Advanced brown coal	Advanced black coal	Hydrogen
Geosequestration	Natural gas	Tidal
Hot dry rocks	Wind	Large-scale hydro
Photovoltaics	Biomass	Nuclear
Remote area power systems	Wave	
Coal mining and extraction		
Energy demand technologies		
Solid Oxide Fuel Cells	Intelligent transport systems	Other fuel cells
	Energy efficiency	
	Advanced conventional vehicles	
	Hybrid electric vehicles	

Tools for exploring future - forecasting

- "Prediction is difficult, especially about the future"

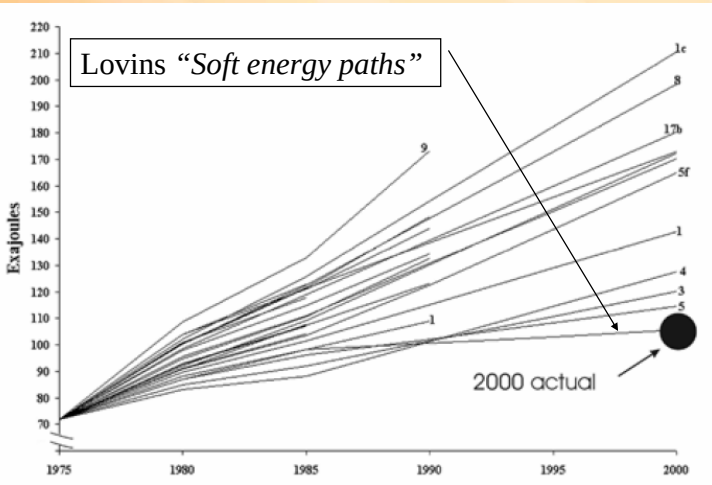
  (attributed to Niels Bohr)
- because
  - Science is based on disprovable hypotheses:
    - A currently accepted hypothesis has yet to be proved wrong
  - Facts are required to test a hypothesis
  - A fact is what has happened, not what may happen:
    - There are no facts about the future, only predictions unless you can control the experiment
- QED: forecasting is Art (opinion-based) and Science

Forecasting as extrapolation of past behaviour

(Craig, "What can history teach us?" *LBNL-50498*, 2002)

Forecasts of US energy use from 1970's *illustrates limitations of extrapolation and BAU assumptions*

Generally fail to capture major technical progress

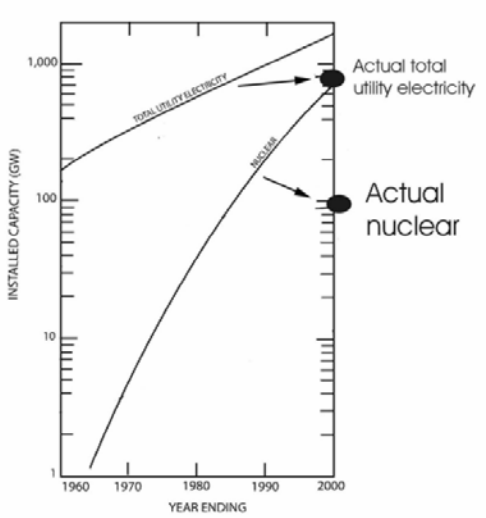


Forecasting as techno-optimism / sales pitch

(Craig, "What can history teach us?" *LBNL-50498*, 2002)

Atomic Energy Commission 1962 forecast of future US nuclear power requirement.

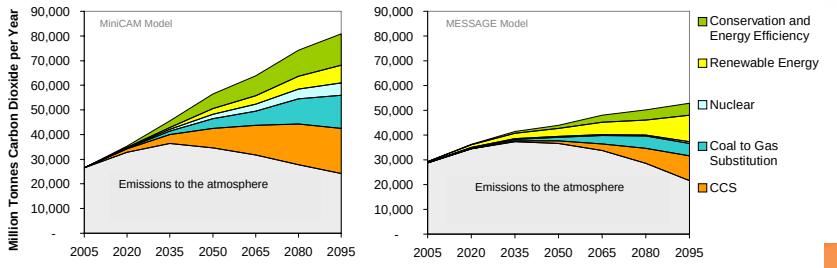
In practice there were no new orders from 1980 due in part to cost blowouts in earlier plants and Three Mile Island.



Managing uncertainties in tech. assessments + forecasts

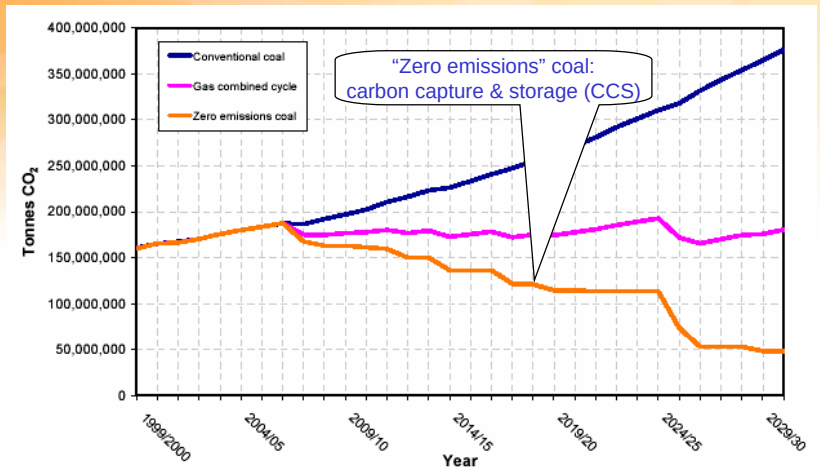
- Reduce complexity
- More thoughtful and modest presentation of results
- Multiple models and use of scenarios
  - Transparent process for development
  - Transparent + justified assumptions - definitions, system boundary..
  - Clear identification of uncertainties

eg. IPCC CCS Report (2005) highlights CCS timing + scale uncertainties



Beware less thoughtful scenarios

(Beyond Kyoto, PMSEIC Report, 2002)



The potential for sustainable energy futures

- International energy tech. assessments + scenarios
  - IPCC Technology Assessments in TAR (2001)
  - IEA Alternative Policy Scenario (2004): *emissions continue to climb*
  - IEA Energy Technology Perspectives (2006) 'deep cuts' scenarios
  - Forthcoming AR4 WGIII review (2007)
  - Wide range of technology specific studies – industry, govts, NGOs
- Australian scenarios
  - ABARE AP6 (2006) scenarios: *emissions continue to climb*
  - Clean Energy Futures (2004):
  - Australian Business Roundtable on Climate Change (2006)
  - AGL / WWF (2006)
  - Wide range of technology specific studies – eg. ANSTO, Coal21
- Question: how do they manage uncertainty

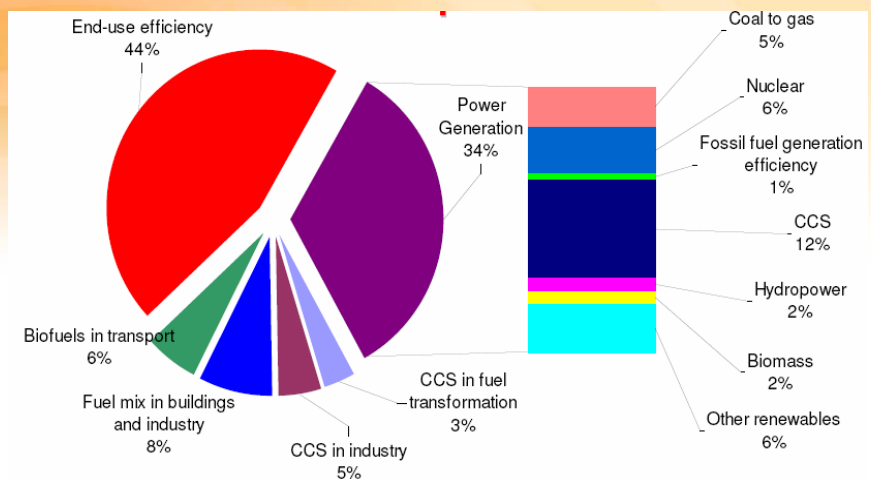
=> A wide range of 'answers' – not all have much value

IEA global 'deep cuts' scenarios

- Assume both 'tech push' R&D&Demonstration and 'market pull' deployment measures

Scenario	Renewables	Nuclear	CCS	H_2 fuel cells	Advanced biofuels	End-use efficiency
Low Renewables	Slower cost reductions					
Low Nuclear		Lower public acceptance				
No CCS			No CCS			
Low Efficiency						0.3% p.a. less improvement
TECH Plus	Stronger cost reductions	Stronger cost reductions & technology improvements		Breakthrough for FC	Stronger cost reductions & improved feedstock availability	

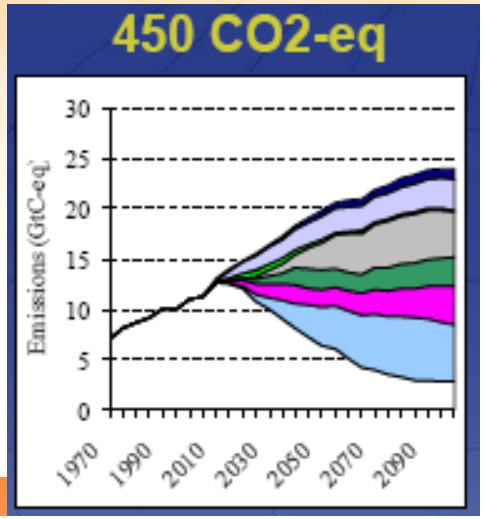
ACT Scenario – technology mix



NEAA Global scenarios

(van Vuuren, Netherlands Environment

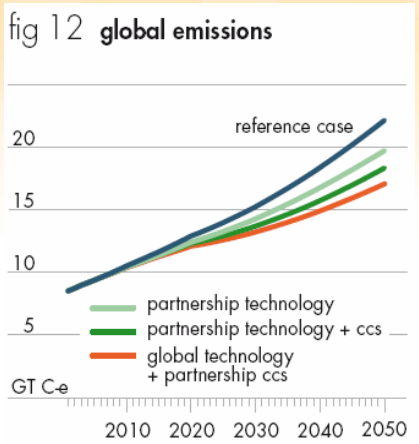
- Main options short term: non-CO2, fuel switch (to NG); efficiency
- Main options long term: CO2 storage; Biofuels, Nuclear, (Efficiency)



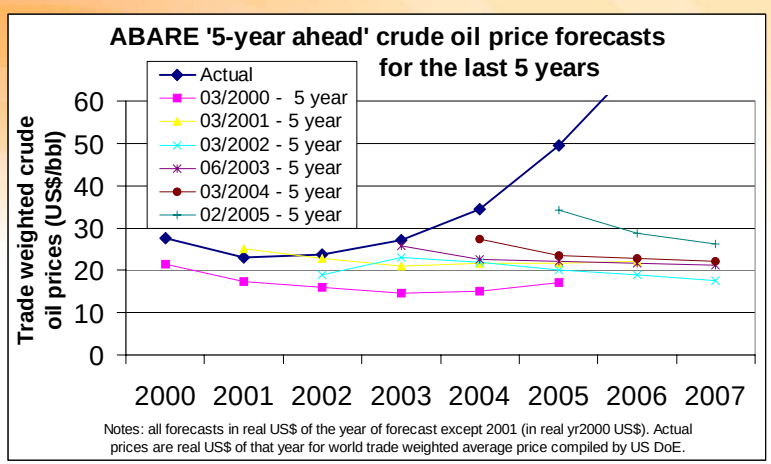
ABARE AP6 Scenarios

(ABARE, *Technological development and economic growth*, 2006)

- Assumes CCS costs of US$25-30/tCO2 (effectively requires ETS/tax)
- "… important to ensure that .. the necessary technologies to substantially reduce emissions actually exist and are capable of deployment before technology 'pull' policies are adopted."

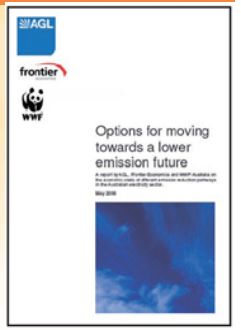


ABARE oil price forecasts



AGL/WWF Scenarios

- 40% reduction in electricity related emissions in 2030



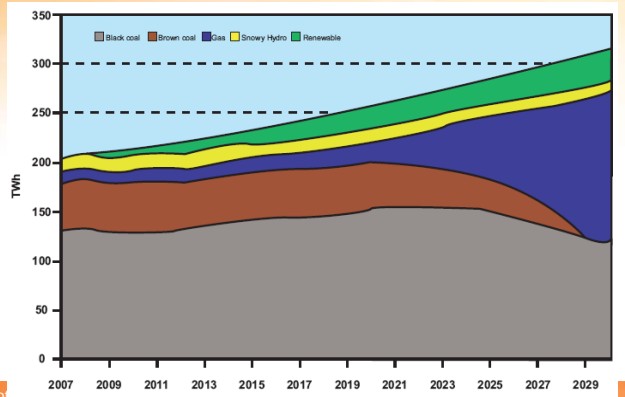
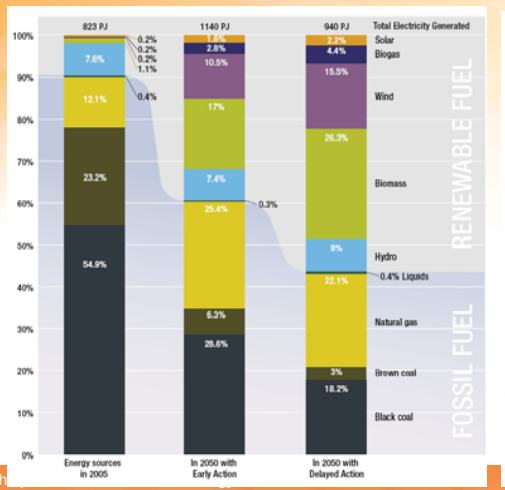
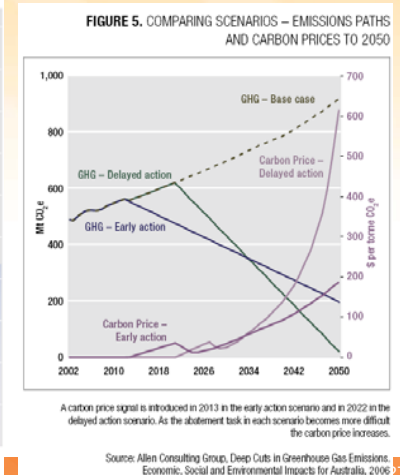


Figure 1: Staged Transition with Energy Efficiency.

ABR scenarios: 60% cut by 2050

(Australian Business Roundtable, The Case for Early Action, 2006)





The policy challenge for Australia

- Possible sustainable energy futures not a matter for speculation but action
- Government policy roles in invention, commercialisation and, most importantly, diffusion
  - Risks in trying to pick winners but need to establish priorities
    - combine technology neutral measures with additional support for portfolio of promising technologies
  - Start now with primary focus on greater diffusion of existing options
    - drives technology innovation via 'learning by doing'; reduces risks of emission intensive technology 'lock-in'
- Current Australian policy framework appears unbalanced
  - Major focus on R&D and demonstration of emerging technologies
  - However, ".. there is no certainty when and to what extent the necessary technologies will be developed." (IEA, 2005)
  - *More support required for existing and possible future options by ETS/Carbon Tax, regulation and targeted 'niche' technology markets*

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