Centre for Energy and Environmental Markets

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Techno-Economic Modelling of Energy Systems: Possible CEEM contributions

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www.ceem.unsw.edu.au

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CEEM established …

- *to formalise* growing shared research interests + interactions between UNSW researchers
  - Faculties of Engineering, Business, Arts and Social Sciences, Science, Institute for Environmental Studies...
- *through UNSW Centre* aiming to provide Australian research leadership in interdisciplinary analysis + design of energy + environmental markets
- *focussing in the areas* of
  - Energy markets – spot, ancillary and derivatives – within restructured electricity industries
  - Related environmental markets – emissions trading, renewable obligations, Greenpower…
  - Wider policy frameworks and instruments for achieving overall energy and environmental objectives

Some potentially relevant CEEM research efforts

- CEEM/AGO project on facilitating wind integration in the NEM
  - Part of Australian Govt. Wind Energy Forecasting Capability (WEFC) Initiative
- Renewable energy policy support options in restructured industries
  - MRET, Victorian RET, proposed NSW RET
- Emissions trading options for Australia
  - Proposed State and Territory Scheme under development
  - Experimental economics studies on market design
- Technology assessment for developing effective, coherent sustainable energy policy frameworks
  - Energy efficiency, gas and cogeneration, renewables, CCS, nuclear options
- Forthcoming CEEM/CSIRO project on economic modelling of Distributed Energy

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*

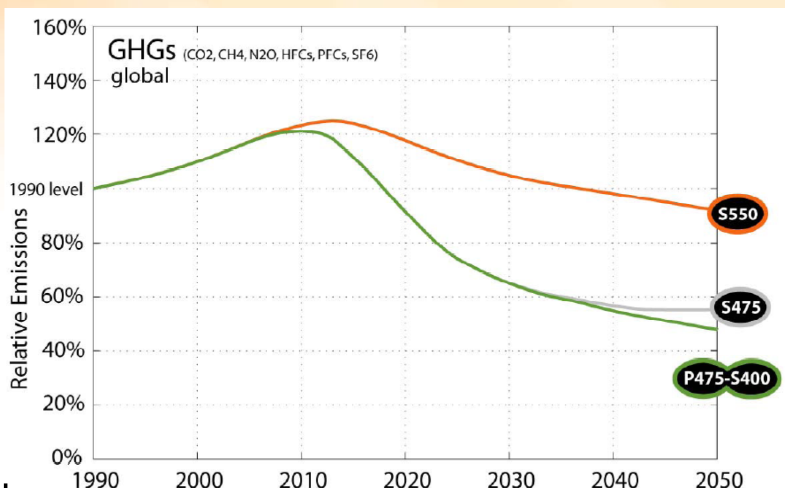
Guidance for assessing future - tools

- Formal assessment of desired objectives
  - eg. likely emission reductions required to avoid dangerous global warming much greater than typically modelled
- Analysis of existing systems
  - What exists is possible, what doesn't yet exist only *may* be possible
- Risk-based technology assessment
- Formal management of uncertainty in modelling
  - Choices of scenarios
  - Sensitivity analysis
  - Probability distributions

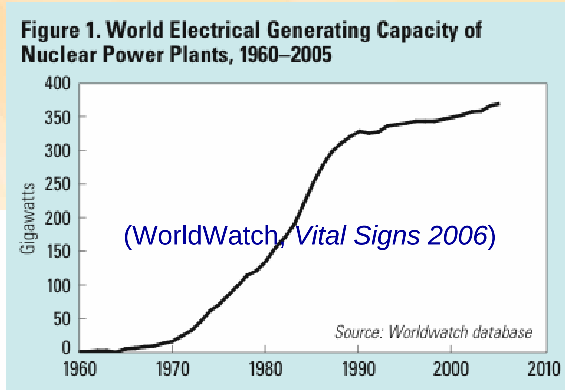
Objectives: To avoid dangerous warming

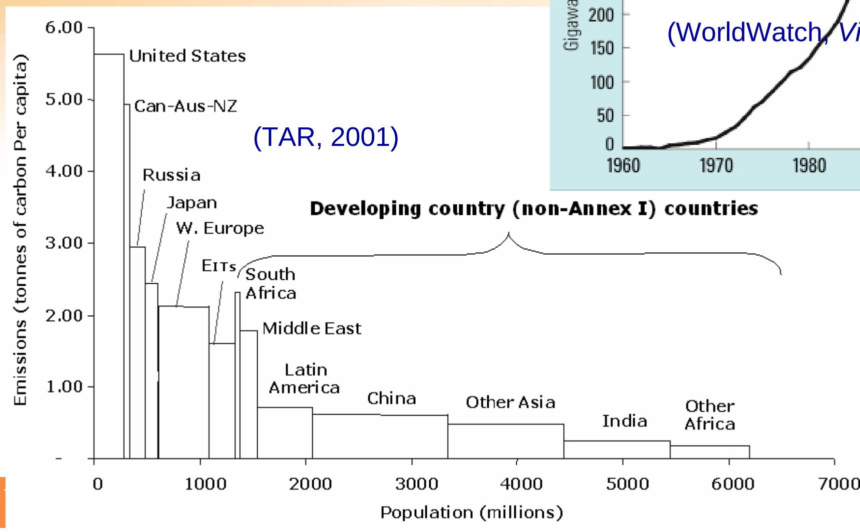
(Meinshausen, Avoiding Dangerous Climate Change, 2005)

- 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



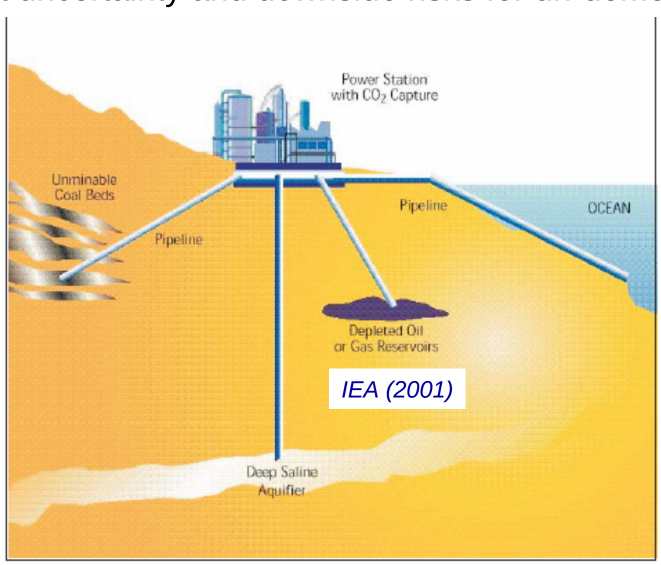
What exists is possible… at least in a context





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
  - Costs wrt uncertainty and downside risks for un-demonstated techs.

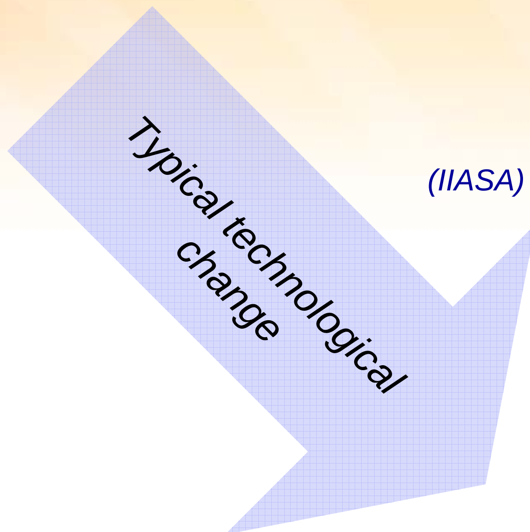


… and technology innovation involves uncertainties and hence risks – *societal choice is final test*

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

Technological innovation

Invention
↓
Commercial-isation
↓
Diffusion/adoption



(IIASA)

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)

Tools for exploring future - forecasting

- "Prediction is difficult, especially about the future"

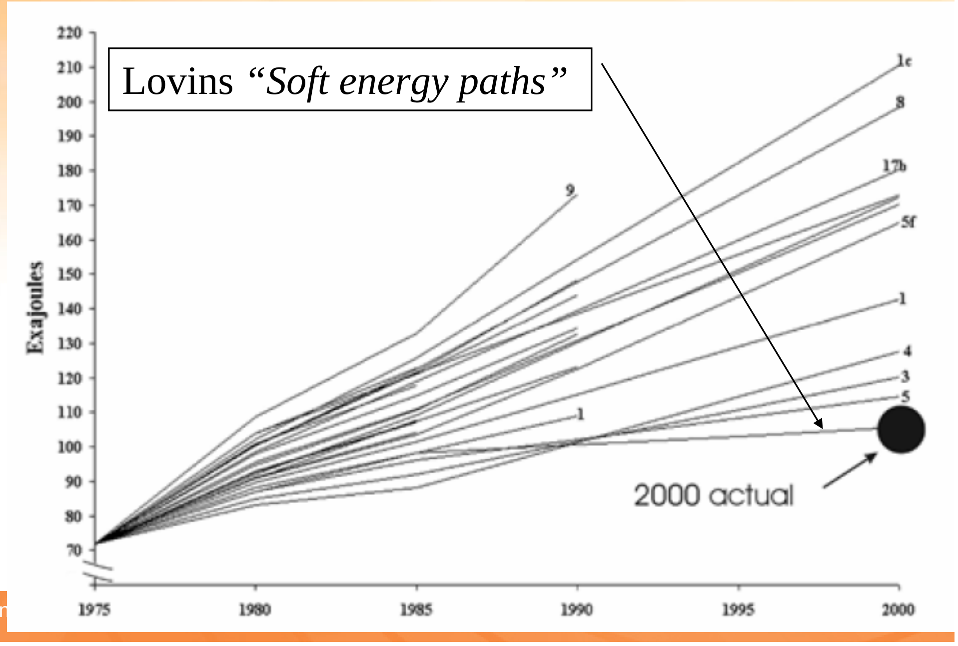
  (attributed to Niels Bohr)
- because
  - Science is based on disprovable hypotheses:
    - A currently accepted hypothesis has yet to be proved wrong
  - Facts are required to test a hypothesis
  - A fact is what has happened, not what may happen:
    - There are no facts about the future, only predictions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



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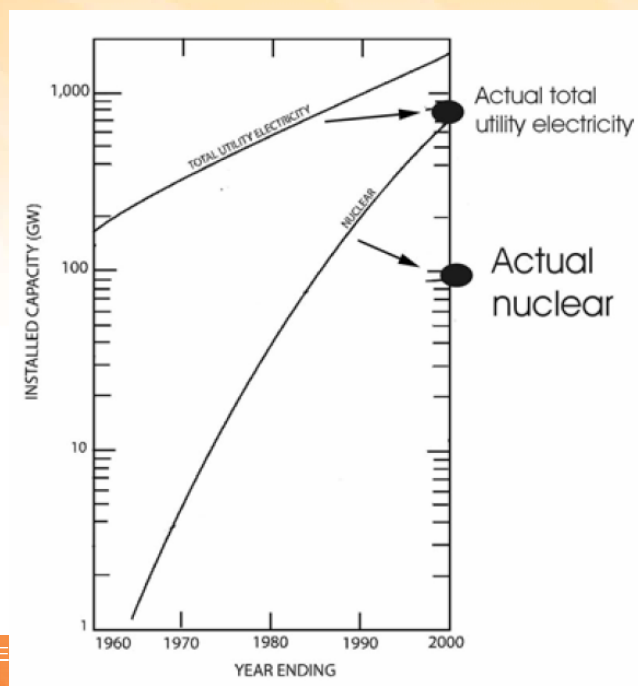
Forecasting as techno-optimism / sales pitch

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

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

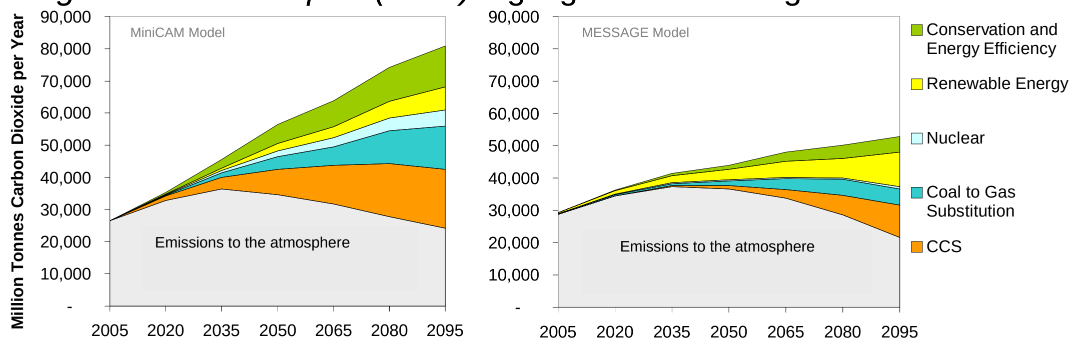
In practice there were no new orders from 1980 due in part to cost blowouts in earlier plants and Three Mile Island.



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



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