



Centre for Energy and
Environmental Markets

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THE UNIVERSITY OF NEW SOUTH WALES
SYDNEY • AUSTRALIA



Public Perceptions: Nuclear power & Alternatives

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Issues for the stationary energy sector

- Challenges for decision-makers:
 - Climate change & other environmental risks
 - Energy security & cost (price volatility for fossil fuels)
 - Social expectations (developed & developing world)
 - Imperfect supply-side options & little interest in frugality
- Key questions for the stationary energy sector:
 - How can we manage constrained supply capacity?
 - How can we compare energy supply options?
 - What are acceptable risks and who should bear them?
 - Who should decide?



The energy conundrum

- There are no easy answers:
 - *“There is no energy production or conversion technology without risk or without waste...The use of nuclear power has created a number of concerns, such as the storage or disposal of high-level radioactive waste and the proliferation of nuclear weapons.” (IEA, 2005, Energy Indicators for Sustainable Development, p1)*
- Why is nuclear power special?
 - *“Nuclear energy represents a special case in this context in that the scope of an accident could be potentially large...” (IEA, 2005, p38)*
 - *“A leak of highly radioactive nuclear fuel dissolved in concentrated nitric acid, enough to half fill an Olympic-size swimming pool, has forced the closure of Sellafield's Thorp reprocessing plant” (The Guardian, 9/5/05)*
 - *“...nuclear power stations are now a potential target for terrorist attack” (IEEE Power & Energy Magazine, May/June 2005, p 90)*



Some decision-making procedures

- **Judicial:**
 - Neutral, balanced, informed (in the ideal case)
- **Commercial:**
 - Decentralised self-interest subject to externally assigned (legal) accountability
- **Political processes:**
 - Compromise supported by a sufficient coalition
 - Often based on self-interest (what's in it for me?)
- **Might makes right:**
 - More common than we may like to admit



Generation investment in a restructured electricity industry

- Generation is competitive:
 - Individual corporations bear investment & legal risks
- Future income is not guaranteed:
 - Financial risk can only managed by derivative contracts between generators and retailers or end-users
- Generator companies bear legal risks of their actions:
 - Unless protected by legislation



Properties of electricity generation options

- “Lumpy” investments with long asset lives
- Large externalities (impacts on non-participants):
 - Climate change (fossil fuels)
 - Nuclear fuel cycle risks (nuclear power)
 - Various adverse impacts (renewable energy forms)
- Difficult to quantify uncertainty & risks:
 - Low probability, high impact
 - Non-stationary (history may not be a good predictor)
- Can be classified as ‘social experiments’:
 - Should only be undertaken with informed consent



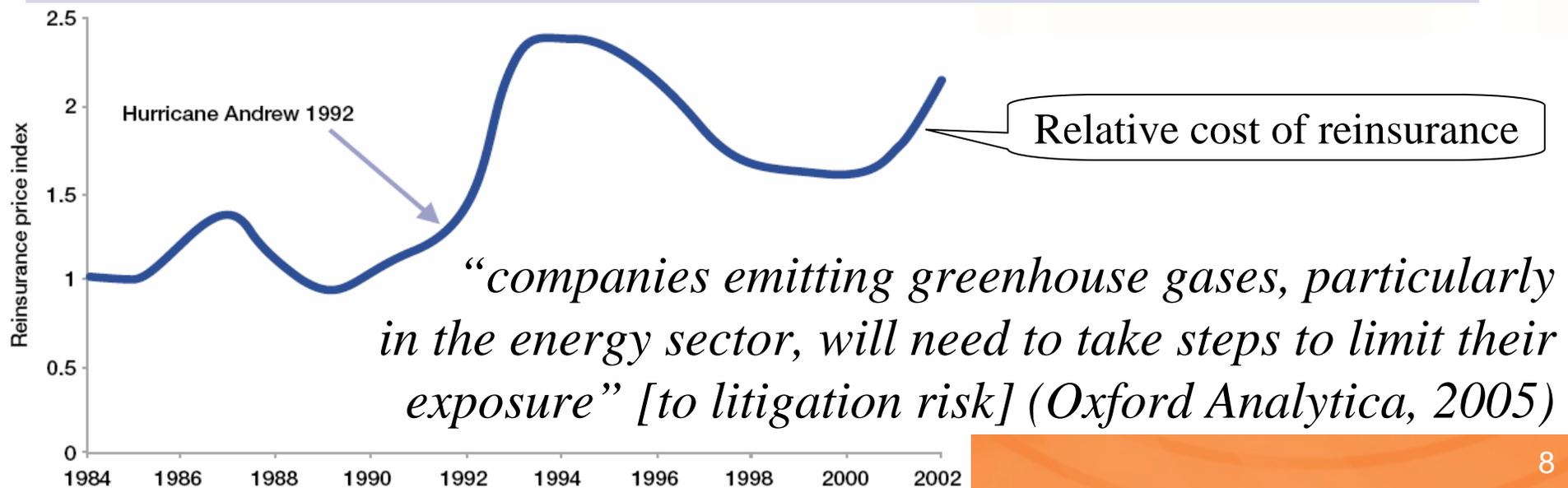
Climate change risks to fossil-fuel based companies (CANA, 2003):

- Operational risk (disruption of company operations)
- Insurance risk (premium cost or non-insurability)
- Regulatory risk (compliance costs)
- Shareholder risk (activism & disruption)
- Litigation risk (claims for damages)
- Capital risk (inability to raise equity capital)
- Competitive risk (loss of economic activity)



Increasing climate change hazards (IAG, 2002)

Hazard	Cause Of Change In Hazard	Resulting Change In Damage/Loss
Windstorm	Doubling of windspeed 2.2 °C mean temperature increase	Four-fold increase in damages Increase of 5-10% in hurricane wind speeds
Extreme temperature episodes	1 °C mean temperature increase	300-year temperature events occur every 10 years
Floods	25% increase in 30 minute precipitation	Flooding return period reduced from 100 years to 17 years
Bushfire	1 °C mean summer temperature increase Doubling of CO2	28% increase in wildfires 143% increase in catastrophic wildfires





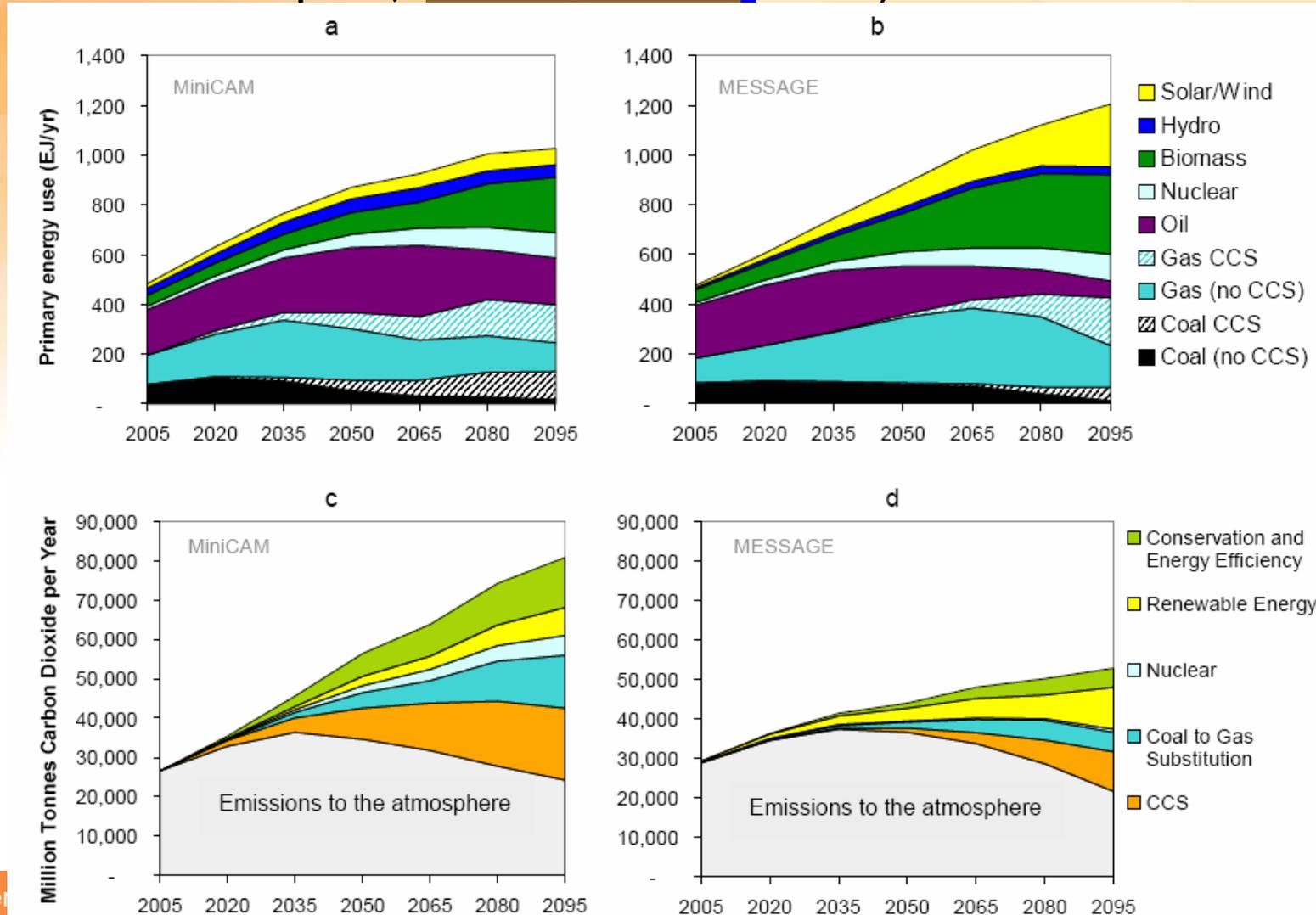
Key findings of IPCC report on Carbon Capture & Storage (CCS) (www.ipcc.ch, 2005)

- Large-scale CCS power plant don't yet exist
- By 2050, 20-40% of fossil fuel CO₂ technically suitable at estimated cost of 13-67A\$/MWh
- Deployment needs CO₂ price of 25-30 US\$/MWh
- CCS might contribute 15-44% of cumulative global mitigation effort to 2100, limited beyond that
- *A portfolio of mitigation measures other than CCS will still be needed*



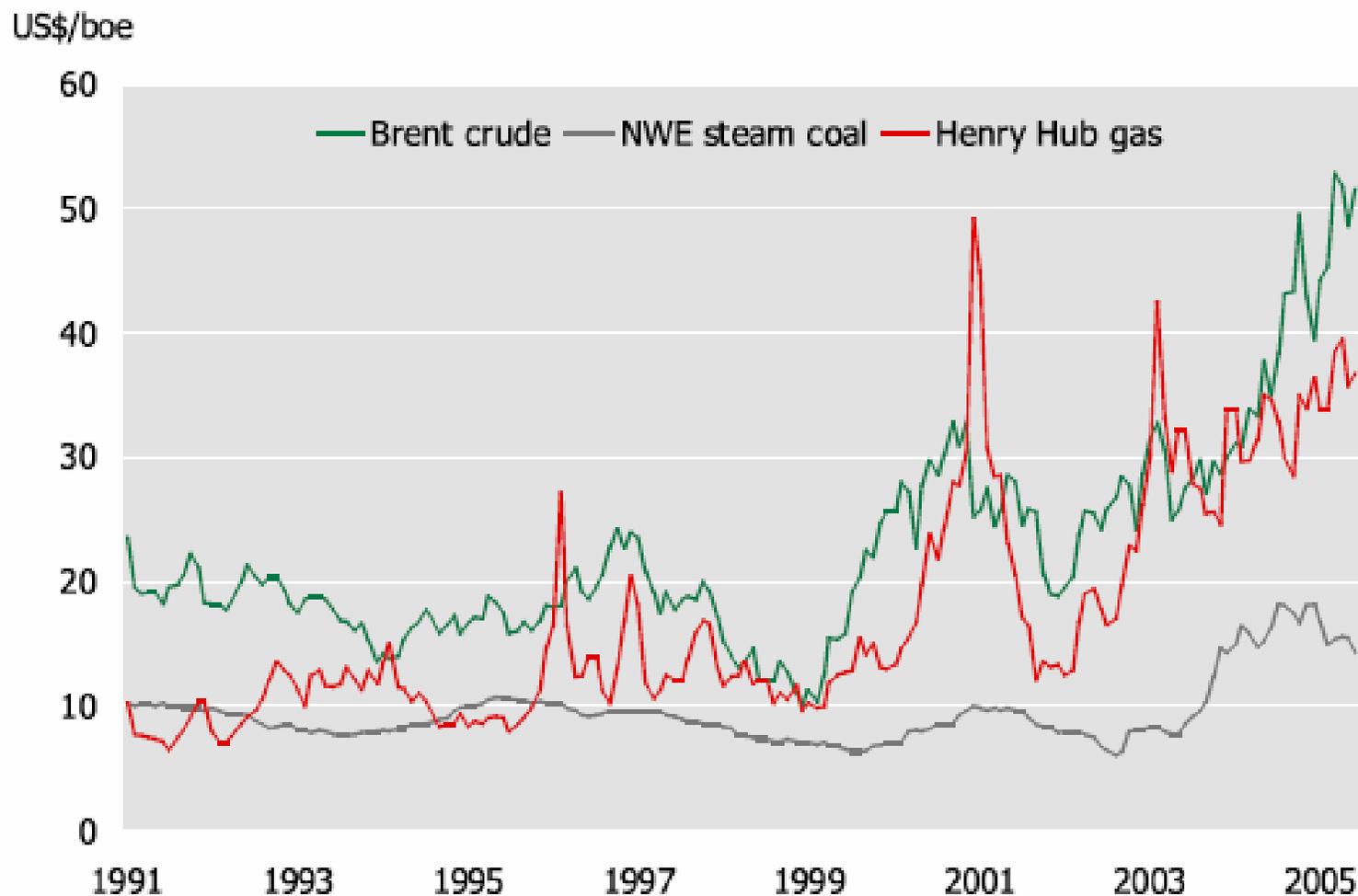
Scenarios of CCS contribution to 2100

(IPCC CCS report, www.ipcc.ch, 2005)





Prices for fossil fuels, possibly reflecting “peak oil” (BP 2005)





Risks associated with nuclear fuel cycle (to companies & societies)

- Operational risk (at each point in the cycle)
- Insurance risk (premium cost or non-insurability)
- Regulatory risk (compliance costs)
- Shareholder risk (activism & disruption)
- Litigation risk (claims for damages)
- Capital risk (inability to raise equity capital)
- Competitive risk (loss of economic activity)
- Resource depletion (uranium ore)
- Terrorism & war (risks to companies & societies)



Senate Committee findings on uranium mining in Australia (ECITARC, 2003)

- That “uranium mining presents unique hazards and risks to both human health and the environment.”
- That “a pattern of underperformance and non-compliance can be shown.”
- That there were “gaps in knowledge and an absence of reliable data on which to measure the extent of contamination or its impact on the environment.”
- That operations of mines “suggests that short-term considerations have been given greater weight than the potential for permanent damage to the environment.”
- That “changes in (sic) were necessary in order to protect the environment and its inhabitants from ‘serious or irreversible damage’ ”
- That “the frequency of leaks and spills is evidence that self-regulation by the mining companies has failed to prevent incidents which have the potential to cause significant environmental damage.”



Opinions on nuclear terrorism & proliferation

- No worries (www.uic.com.au):
 - *“I anticipate that my children's, or perhaps my grandchildren's generation will come to look upon weapons as simply an initial aberration of the nuclear age, rather than a major characteristic of it.”*
- Not so sure (web.mit.edu/nuclearpower):
 - *“Fuel cycles that involve the chemical reprocessing of spent fuel to separate weapons-usable plutonium and uranium ... are of special concern, especially as nuclear power spreads around the world”*
- No thanks :
 - *“The existing [US] security regulations do not provide adequate protection [of nuclear power stations] against known terrorist threat capabilities.”*
(www.ucsusa.org)
 - *“...there's an emerging consensus between left and right, between Washington hawks and the peace movement, that the distinction between peaceful and military uses of nuclear energy is an illusion”*
(www.abc.net.au/rn/talks/bbing/ Background Briefing, 22/5/05)



Failed discussions on the nuclear non-proliferation treaty (Reuters, 27/5/05)

- Mohamed ElBaradei, IAEA; 3 reasons for a treaty:
 - “... the emergence of a nuclear black market, the determined efforts by more countries to acquire technology to produce the fissile material usable in nuclear weapons, and the clear desire of terrorists to acquire weapons of mass destruction”
- Louis Charbonneau, Reuters reporter:
 - “The danger of a nuclear holocaust may never have been greater, yet the 188 signatories to the global pact against nuclear weapons have rarely been more divided, arms experts and diplomats said.”
- 2005 Nobel Peace Prize to ElBaradei & IAEA :
 - “For their efforts to prevent nuclear energy from being used for military purposes” (nobelprize.org)



Nuclear energy & CO₂ emissions: *One perspective* (www.oprit.rug.nl/deenen)

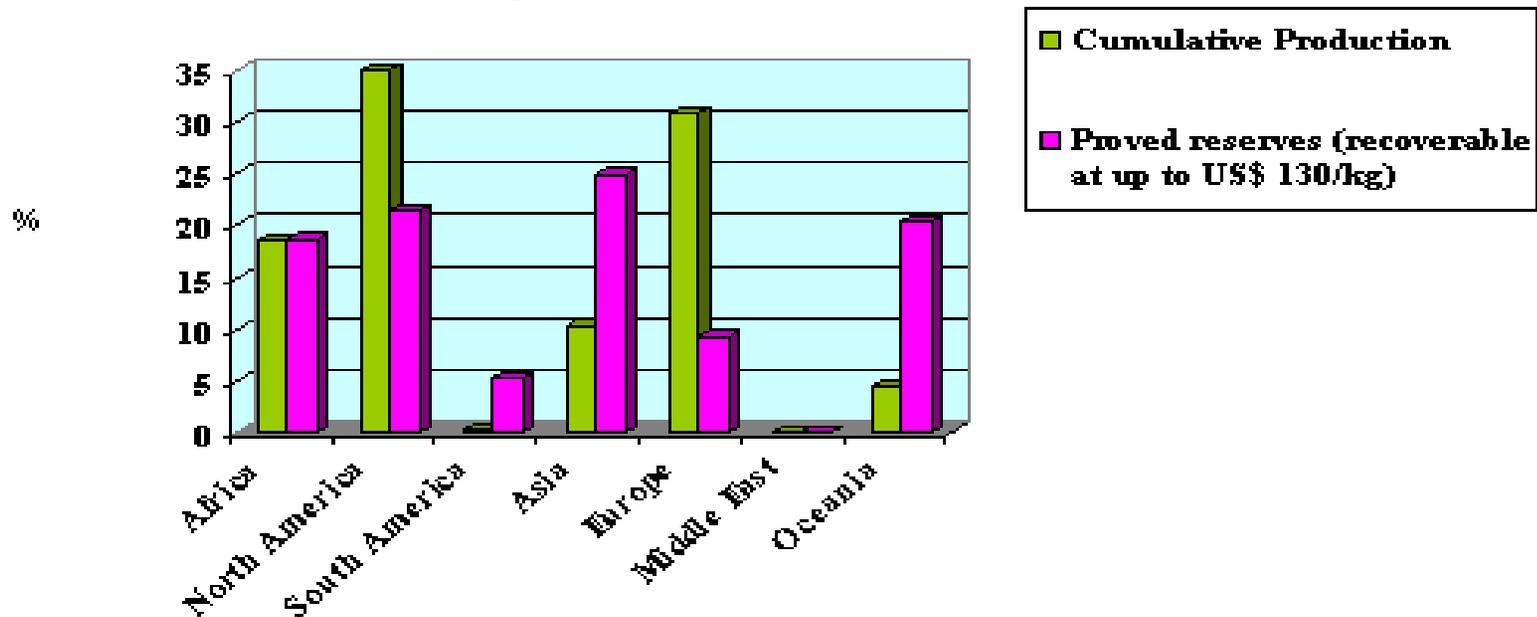
- *“The use of nuclear power causes, at the end of the road and under the most favourable conditions, approximately one-third as much CO₂-emission as gas-fired electricity production.”*
- *The rich uranium ores required to achieve this reduction are, however, so limited that if the entire present world electricity demand were to be provided by nuclear power, these ores would be exhausted within four years.*
- *“Use of the remaining poorer ores in nuclear reactors would produce more CO₂ emission than burning fossil fuels directly.”*

Note: A higher emission coefficient also implies a longer energy payback time

Uranium reserves at end 1999 (www.worldenergy.org)

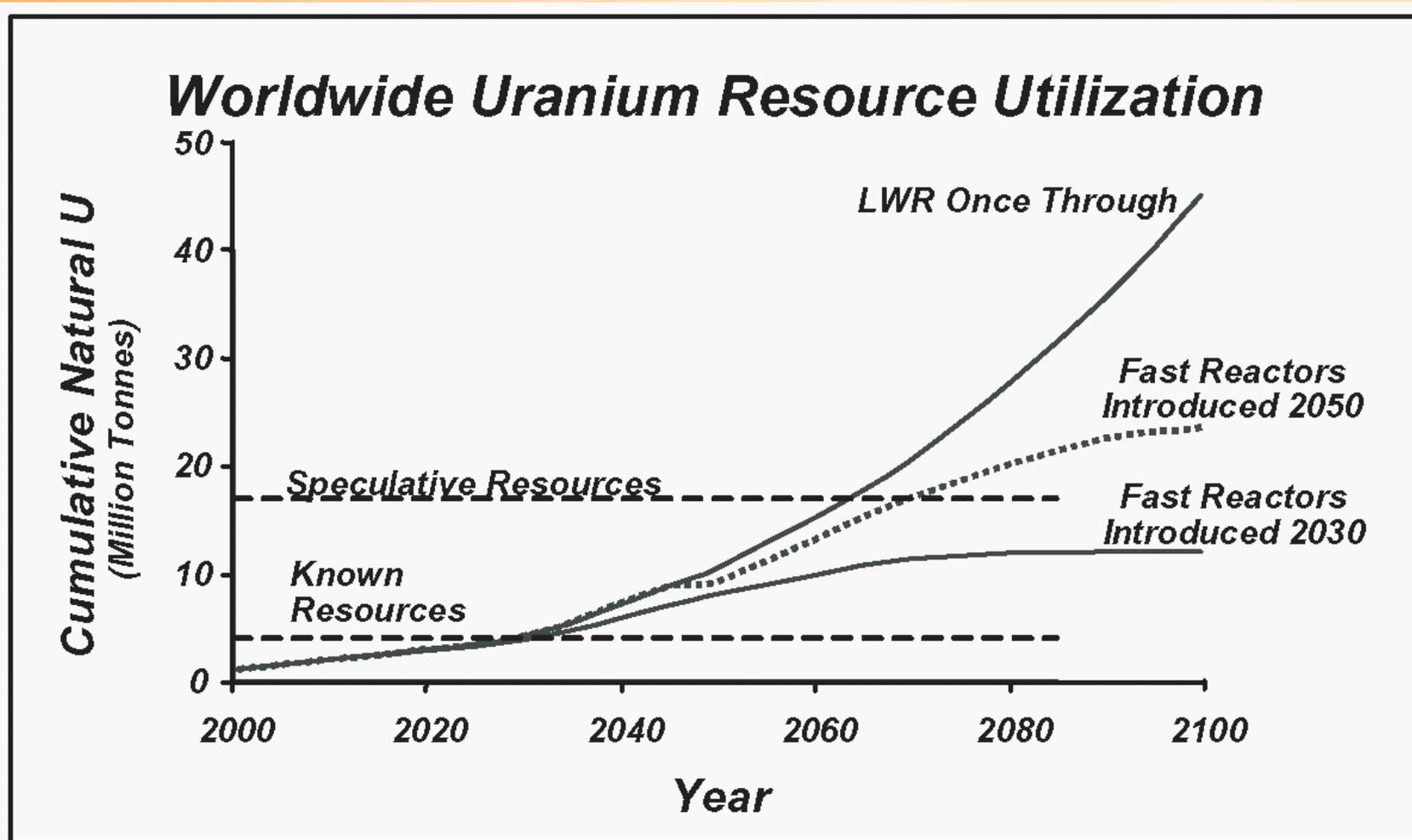
- Reasonably assured @ \$130/kg: 3 MT
- Estimated additional @ \$130/kg: 1 MT
- Estimated annual use in 2015: 0.05-0.08 MT
- Thus < 100 years supply with current technology

Figure 6.1: Cumulative production and proved reserves of uranium at end-1999 - regional distribution





Projected uranium use assuming nuclear retains market share (Gen iv Roadmap, 2002)

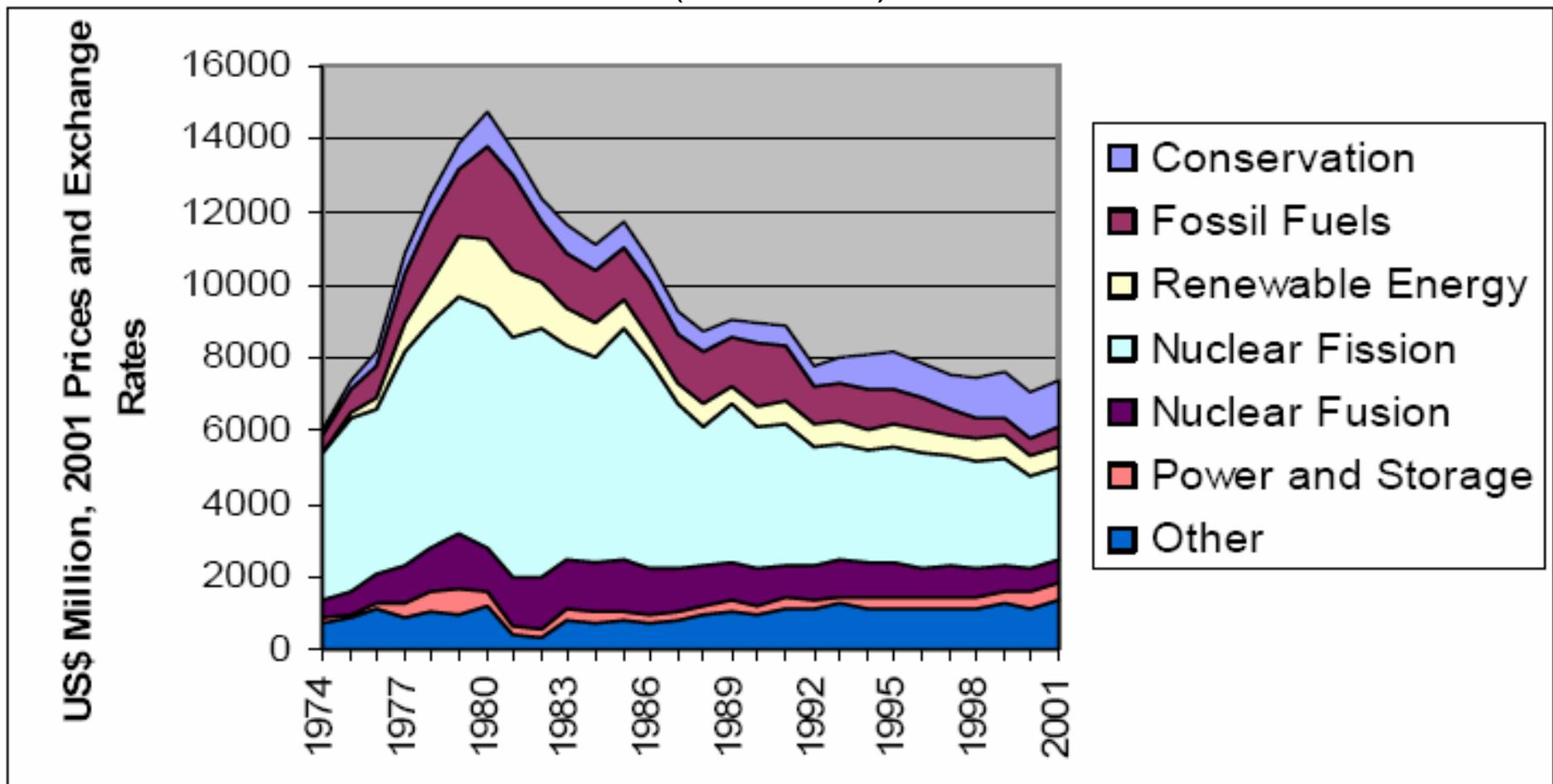




Energy Technology R&D

IEA Government Energy R&D Budgets, 1974-2001

(IEA, 2004)





USA: generation share & subsidy (REPP, 2000)

“In 1998, cumulative subsidies to nuclear power had an equivalent cost of [US]\$1,411 per household.”

Figure 1. 1999 Resource Share of Electricity Generation

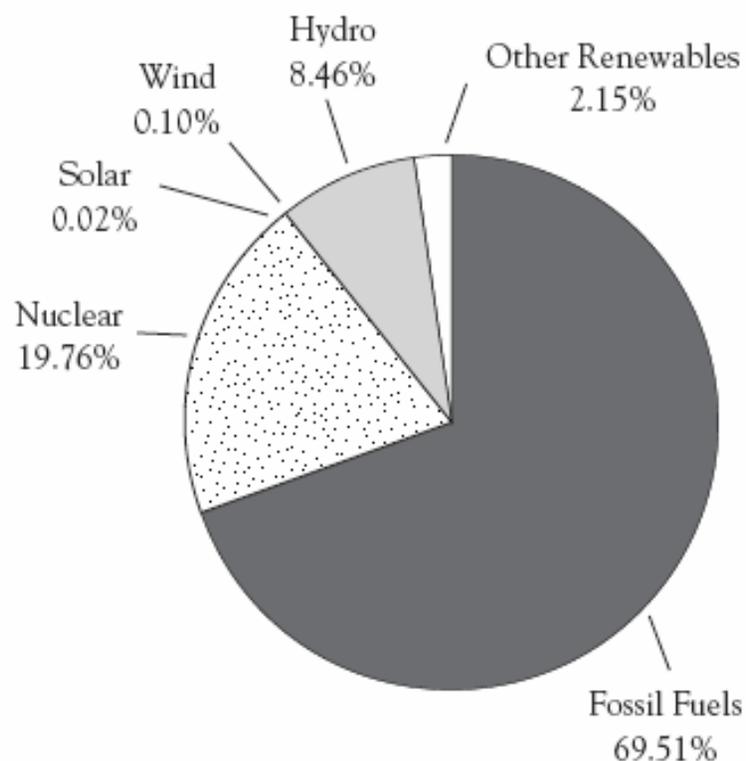
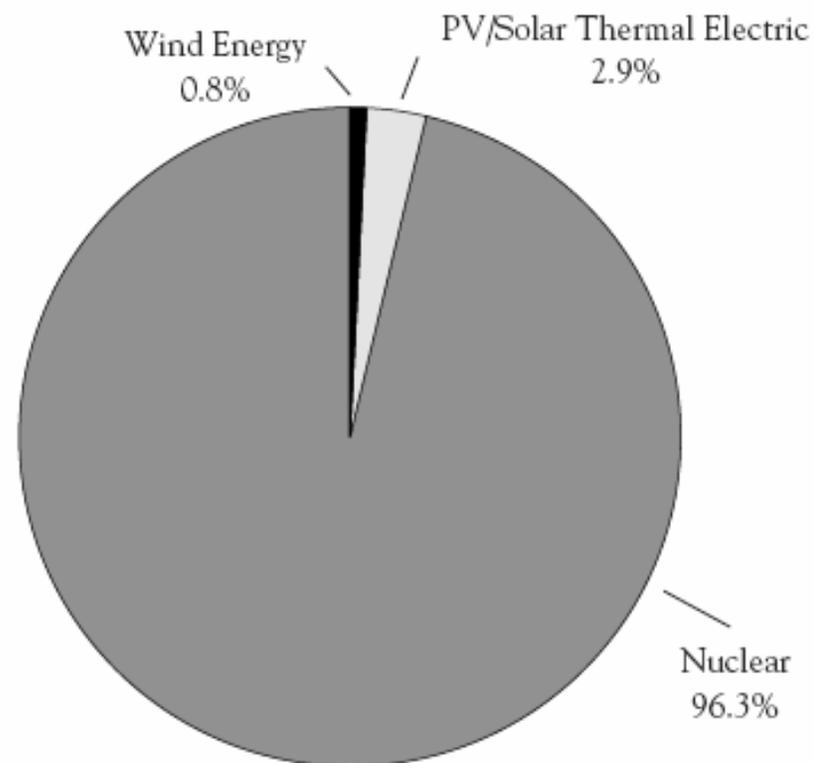


Figure 2. Technology Share of Subsidies





Some Australian opinions on nuclear power

■ No worries :

- *“Australia is probably the only developed country where, when you switch on the light, you are not getting some nuclear electricity to help lighten your way”* (www.uic.com.au)
- *“Nuclear power, not necessarily for nuclear generation in Australia, but nuclear power is the short answer”* Robin Batterham, 19/5/05 (www.abc.net.au)

■ Not so sure:

- *“For a large expansion of nuclear power to succeed, four critical problems must be overcome: cost, safety, waste & proliferation”* (web.mit.edu/nuclearpower)
- *“The world's got to debate whether uranium-derived power is more dangerous than coal”* Bob Carr, 2/6/05 (www.abc.net.au)
- *“The British government viewpoint is that we must focus on renewables and energy efficiency...”* Sir David King, UK Chief Scientist (The Guardian, 11/5/05)

■ No thanks:

- *“Why would you go down the road of bringing in another source of energy like nuclear power, which does have long-term problems and long-term risks?”*
Peter Beattie, Queensland Premier, 6/6/05 (www.abc.net.au)



The nuclear decision requires multi-dimensional societal choice

- MIT report perspective:
 - *“Our audience is government, industry, and academic leaders with an interest in the management of **the interrelated set of technical, economic, environmental, and political issues that must be addressed if large-scale deployment of new nuclear power generating facilities is to remain an option for providing a significant fraction of electricity supply in the middle of this century.**” (MIT, 2003)*
- Such decisions require broad societal discussion & informed consent:
 - The expert’s role is to advise rather than decide



What decision-making procedures might be appropriate for nuclear power?

- Political compromise:
 - Too unstable to address long term issues, including nuclear fuel cycle risks & inter-generational impacts
- Commercial:
 - Difficult to achieve adequate accountability (the critical, high-impact risks are usually underwritten by the State)
- Judicial (*probably the best available option*):
 - The nuclear option has many serious caveats (MIT, 2003)
- Might makes right:
 - Totally inappropriate but all too plausible in this context



The public can be skeptical &/or poorly informed

Cambridge/MIT Study of US public views on climate change, 2004

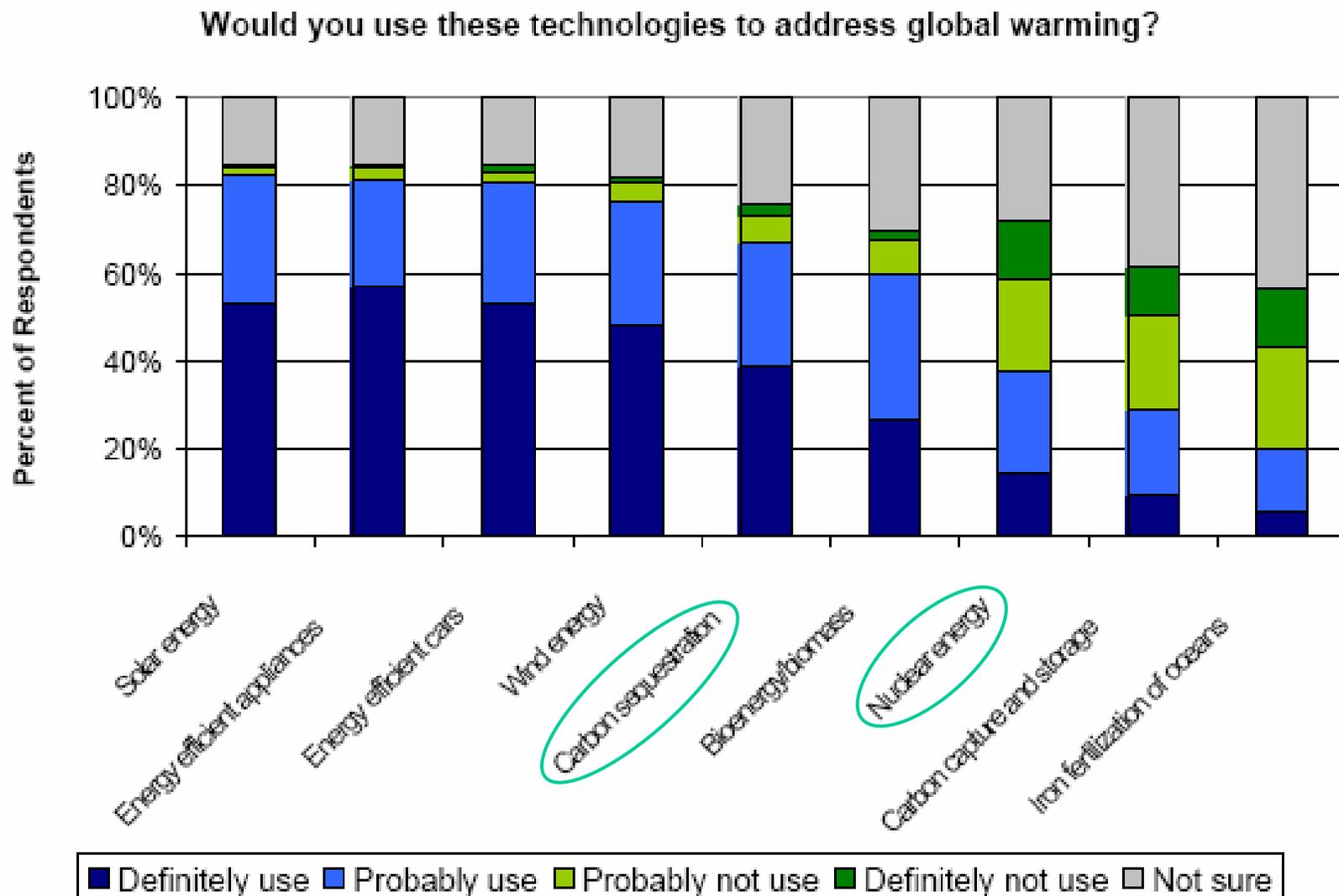




Table 2: Technology assessments

(Australian Govt. 2004)

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 Geosequestration Hot dry rocks Photovoltaics Remote area power systems Coal mining and extraction	Advanced black coal Natural gas Wind Biomass Wave	Hydrogen Tidal Large-scale hydro Nuclear
Energy demand technologies		
Solid Oxide Fuel Cells	Intelligent transport systems Energy efficiency Advanced conventional vehicles Hybrid electric vehicles	Other fuel cells

Assessment criteria & process unclear



One possible comparison of options

Option	Risk scope	Cost	Social Extern	Enviro Extern	Life (years)
Frugality & efficiency	Local	Low	Low	Low	Unlim
Renewable energy	Local	High	Low	Low	Unlim
Natural gas & CCS	Global	High	?	?	~100
Coal & CCS	Global	High	?	?	~100
Nuclear (conventional)	Global	High	?	?	~100



Conclusions

- Nuclear power is one of a number of imperfect options with its own particular concerns:
 - Cost, safety, waste, resource & proliferation
 - *These require very careful consideration of alternatives*
- A basic question asks *how can we do least harm?*
 - *To the global ecosystem including the human population*
 - *Considering risks from the near- to the very long-term*
 - *Assessed judiciously with an informed public debate*
- Given human frailties, risks & constraints, our first response should be frugality & efficient end-use, not supply-side options



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Many of our publications are available at:

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