Towards Zero Emissions
Developing Cost Effective Emission Reduction Options for Australia

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A risk-based technology assessment framework for evaluating our GHG abatement options

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The question…. and our answer up front

- ***The question***

  What role might our different GHG abatement options actually play in a sustainable Australian energy future

- ***And SERGO's view on the answer***

  We don't know yet!

  - … and we need a process to find out that reduces risks and maximises our opportunities through support for a selected *portfolio* of technology options guided by a risk-based technology assessment framework
  - supported by a coherent innovation strategy
  - carefully integrated within a wider energy and climate policy framework

Presentation outline

- Key role of technology innovation in our GHG abatement options in protecting the climate
- Key role of governments in driving this innovation, *risks of trying to 'pick winners' vs need for priorities*
- A possible risk-based technology assessment framework for assessing electricity sector abatement options, considering *technical feasibility, delivered services, possible costs, potential scale of abatement, other societal factors*
- A (very) preliminary assessment of geosequestration, energy efficiency, gas-fired gen and renewables within this framework
- Some thoughts for future innovation policy

Guidance for energy policy development

- Australia committed to meeting Kyoto target
  - modest target + generous **land-use rules** => no major additional policy effort in energy sector required
  - AGO (2003) projects that we are within "striking distance" of Kyoto even with energy emissions up 40% from 1990 – 2010

…and preparing for for the large scale emissions reductions required over coming century

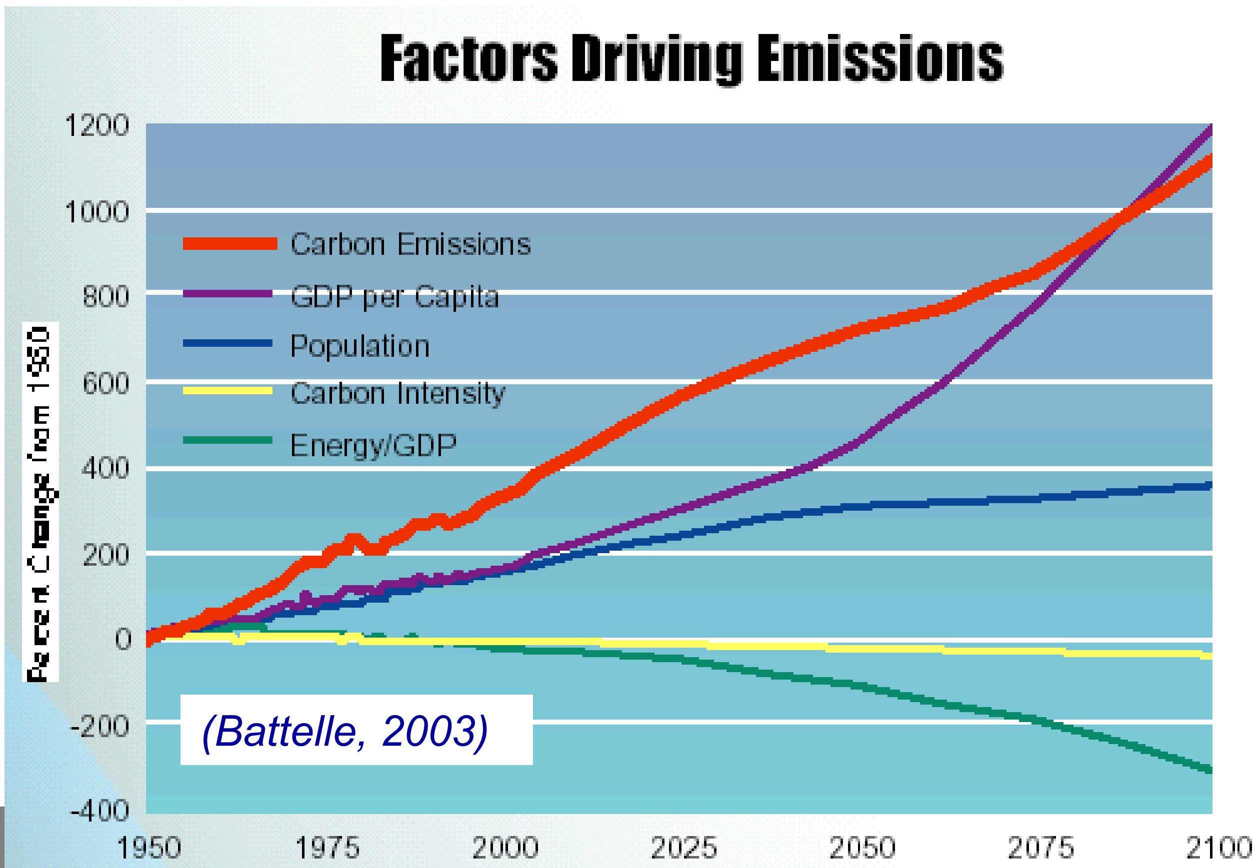
  - Require global 50-60% emissions reduction over century (IPCC, TAR)
  - developed countries potentially obliged to take greater cuts over shorter time frame (UK White Paper)
  - Australian per-capita emissions **2 X** *developed* world average (Australia Institute, Updating per capita emissions for industrialised countries)
- Most reductions must come from fossil fuel emissions (IPCC)

=> Australian electricity sector has a critical role

Climate change and technology

- All technologies are energy technologies (end-use equipment too)
- Present technologies the major part of our climate problem
- Debatable whether current technological change helping or hindering

(Convery et al., 2003)



"Technology a more important determinant of future GHG emissions and possible climate change than all other driving forces put together" (IPCC)

=> *Solving our climate problem requires we change present process of technological change, as well as the technologies themselves*

What technological change is required

- **Effectively** solving our climate problem seems likely to require *(IPCC, 2001)*
  major (60 to 80% from present levels)
  rapid (so that emissions peak within around 30 years) and
  then sustained (emissions must remain very low for millennium)
  reduction in global GHG emissions from our energy technologies..

  ..within context of other societal needs and aspirations, now and future

  ..and given
  present energy systems (options, scale of different technologies), and
  possible technological change of these systems (scale, speed and longer-term sustainability required), and
  possible change to our process of technological change over time

- ***Efficiently*** solving our climate problem achieves above at lowest cost/ max. benefit possible – valuable, but less important than effectiveness *Saving the climate at slightly higher cost than might have been possible with another approach is still likely to be worth it.*

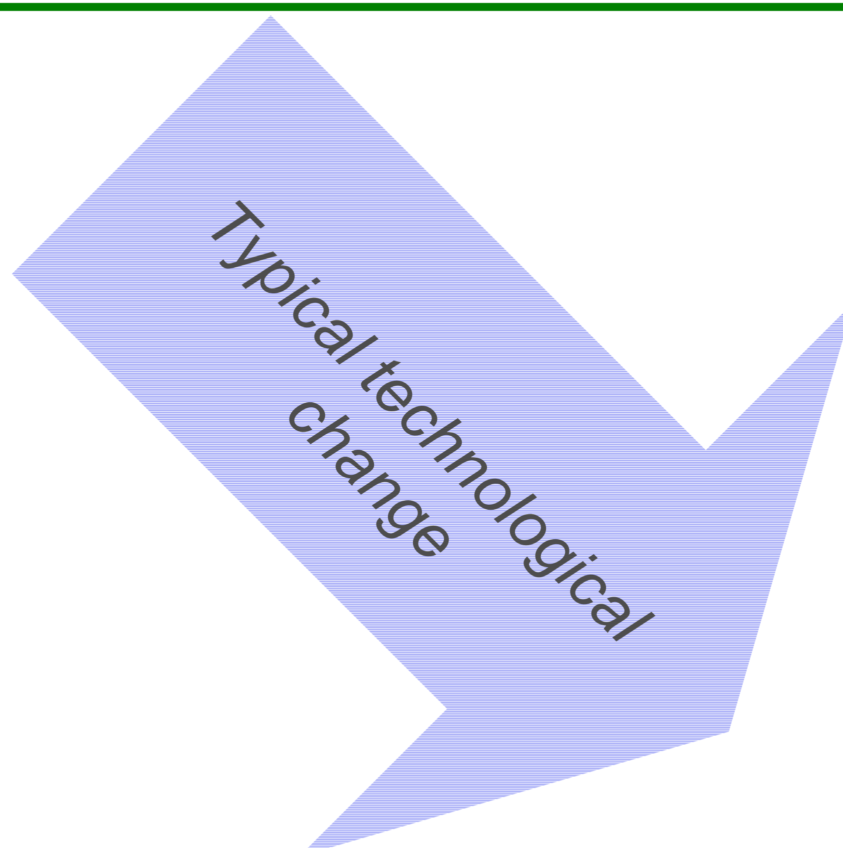
Some dimensions of technological change

Technology *(IIASA)*

‘hardware’ + ‘software’ + ‘orgware’

Technological innovation

Invention
↓
Commercial-isation
↓
Diffusion/ adoption



What drives technological change

- Technical change driven by
  - Markets, and their competitive pressures *(market pull)*
  - Government policy efforts *(make markets reflect societal choices, 'niche' market pull and R&D push)*
  - Technology 'champions' *(largely R&D push)*

- However, successful technology change arises from societal preference (+ what it therefore rewards)

  => its really about *social choice* *(society likely to benefit most from informed social choice – education is key, and governments, industry and the formal education system all have a role)*

The need for innovation policy

- Technological change is too important to leave to:
  - *Imperfect markets*: currently have severe climate *externality* failings, generally under-deliver R&D, more systemic problems too..
  - *Technology 'champions'*: dangers of undue techno-optimism + unaccountable technical elites
- Government policy roles in:
  - *Invention*: support R&D into promising socially beneficial yet unproven technologies
  - *Commercialisation*: support demonstration and initial deployment of promising, technically proven, technologies
  - *Diffusion/Adoption:* ensure markets reflect societal preferences

=> However, many challenges for policy makers…

Government support for R&D + commercialisation

- Govt role because private firms likely to under invest:
  - Public good spill-overs that aren't captured by firms undertaking R&D
  - Markets don't reflect externalities (but is there better way to fix this?)
- Risk + return
  - R&D relatively low cost but high risk, potentially v. high returns
  - Demonstration generally higher cost with lower risk - *Demonstration is not deployment – results necessarily experimental b/c trying new approaches* *(Watson et al., 2001)*
- Current energy related R&D *(EPRI, 2003)*
  - Low + falling worldwide public R&D of $2-3b/yr. Most going to fossils, fusion + fission (>4X funding for renews and EE in IEA over 1974-2002)
  - Energy Industry's own R&D spend ~$5b/yr *(most to incumbent techs)*
  - **Australia** – Govt. spending on energy sector innovation about 5% of science + innovation budget; targeted funding largely to fossil fuels + CCS (3 related CRCs yet none for renews or EE) *(Energy White Paper, 2004)*
- **Public funding necessarily directed to particular technologies – who and how is assessment of priorities to be done?**

Government support for diffusion/adoption

- Govt role b/c many markets don't reflect societal preferences:
  - Externalities + adverse subsidies *(Foxon, 2003)*
  - Systemic challenges – infrastructure, technological/institutional lock-in

  => Governments can create niche markets, transform existing markets
- Risk + return
  - Major deployment involves large $ investments (public or induced private) but (hopefully) relatively low technical risks
  - Some potential to avoid making choices in technology focus (eg. economy wide carbon price) *however* limits because niche markets are designer markets (eg. should renewables compete against tree planting?)
- Current energy related deployment programs
  - Energy very different from key areas where major innovation has been market driven (eg. IT + Telecoms) – driven by concern, not opportunity
  - Examples include Emissions Trading, Green certificates, PV programs
  - Difficult to measure, but far larger amounts of money than R&D involved
  - **Australia:** egs incl. MRET, PVRP, Qld 13% Gas, LPG excise exemptions
- **Many effective programs require technology focus – who + how**

Guidance for policy makers

- Uncertainties in innovation mean risks in *picking winners*
  - Governments often pick losers (eg. Fast Breeder Reactors)
  - Even if chosen technology eventually succeeds to some extent, support may have been far better spent elsewhere (eg. nuclear?)
- *Yet*, limited public resources require some prioritisation

⇒ Valuable formal risk management strategies include
diversification – a portfolio approach
flexibility – choices that don't preclude other choices at later time

However, priorities still have to be established *(its not enough to say everything should be supported)*

=> important role for **risk-based technology assessments**

Technology assessment for GHG abatement options

- A range of abatement options, of varied status + promise
  - *Improved end-use energy efficiency*
  - *Renewable technologies*
  - *Lower emission fossil fuel technologies* – eg. CCGT, CHP
  - *Ecological sequestration*
  - ***Lower emission fossil fuel techs through CO2 capture and storage***

=> A possible risk-based technology assessment framework
  - *Technical status* – unproven => mature, emerging => widespread
  - *Delivered energy services and benefits* – **GHG emission reductions**, flexibility, others… eg. dispatchability, network requirements
  - *Present costs* where known – and possible future costs *(MacGill, 2003)*
  - *Potential scale of abatement* – possible technical + cost constraints
  - *Potential speed of deployment* – time required to achieve scale
  - *Other possible societal outcomes* – eg. other env. impacts, energy security

Preliminary assessment – technical status

Energy Efficiency	Very wide range of end-use technologies; many proven EE options available + some emerging ones
Renewables	Wide range of technologies; some very mature (large hydro), others increasingly deployed (PV + wind), some others not demonstrated or pre commercial (HDR, wave)
Lower emm fossil-fuel techs	Proven USC coal plant, demonstrated IGCC, CCGT mature + widely deployed, larger-scale CHP mature
Ecological Sequestration	The most 'mature' technology, but our understanding of potential abatement is limited
Carbon Capture + Storage	CO2 capture commercial in oil + chem. industries, coal-fired elec. likely to req. 'advanced' pre-commercial IGCC gen techs. 'new' CO2 storage not yet demonstrated, although some injection underway, with exp. in EOR, very limited exp. with ECBM + saline aquifers *(Proving security of storage will take decades to centuries)*

Preliminary assessment – delivered energy services

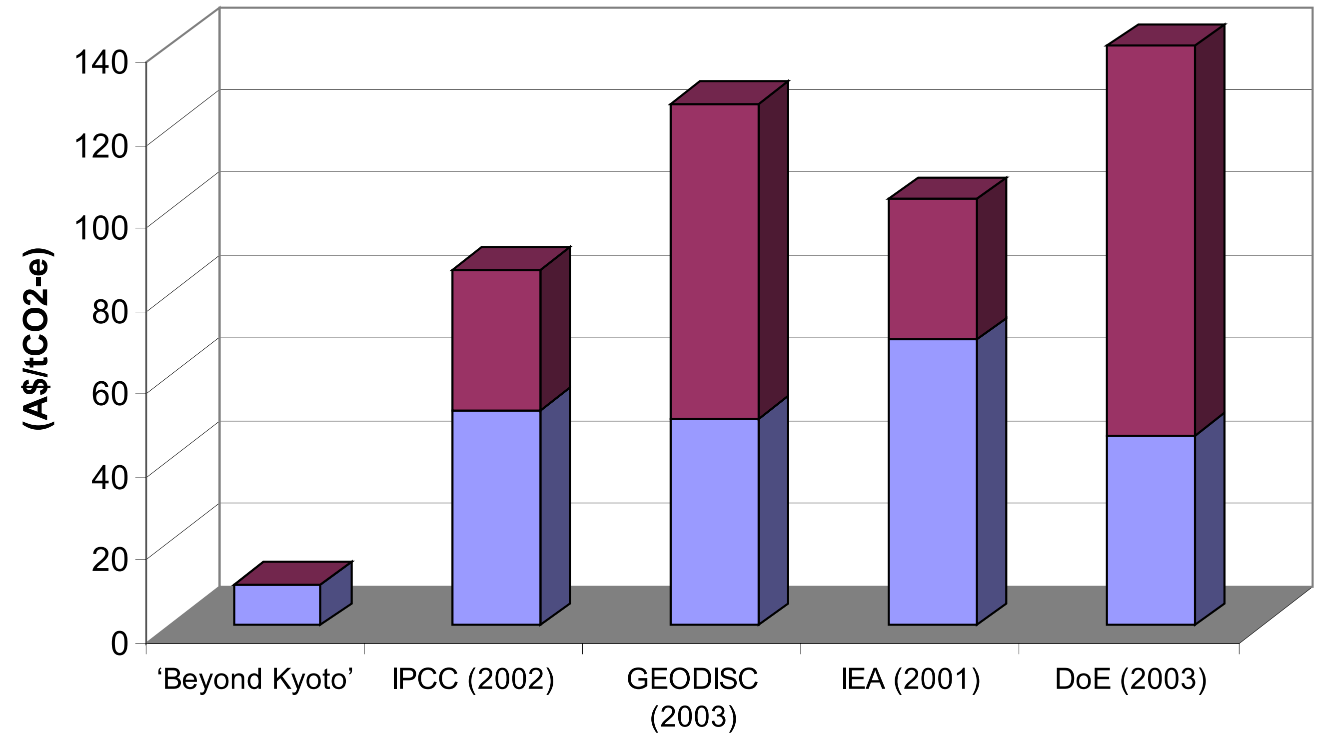
Energy Efficiency	Abatement depends on supply-side emissions, some rapid capital stock turnover offers flexibility, distributed benefits
Renewables	Very secure CO_2 abatement (as fossil fuels)' distributed benefits, high flexibility, intermittency issues for diff. techs
Lower emm fossil-fuel techs	Limited abatement with advanced coal gen but CCGT emissions about ½ of coal plant, all good fit with existing infrastructure, CHP distributed benefits, CCGT block flexible –run on natural gas or coal IGCC with some mods.
Ecological Sequestration	Doesn't directly deliver energy services (except where combined with biomass gen)
Carbon Capture + Storage	IGCC+CCS 1/5 emissions of conventional coal plant but long-term storage needs to be proved, good fit with existing centralised infrastructure

Preliminary assessment – costs.. now + future

Energy Efficiency	Many options offer net cost savings independent of abatement value
Renewables	'new' biomass + wind costs falling but still significantly more expensive than conv. supply, PV much higher costs but potl. distributed value. High uncertainty for HDR.
Lower emm fossil-fuel techs	Costs of gas plant very dependent on gas prices – not cost competitive for baseload in Australia
Ecological Sequestration	Can be very low or even negative (from other env. benefits, but what exactly are you paying for?
Carbon Capture + Storage	Gas project costs may be quite low, CCS for elec. gen has highly uncertain + potentially variable costs depending on capture + sequestration. Some potential for cost reductions with learning (as with many emerging technologies)

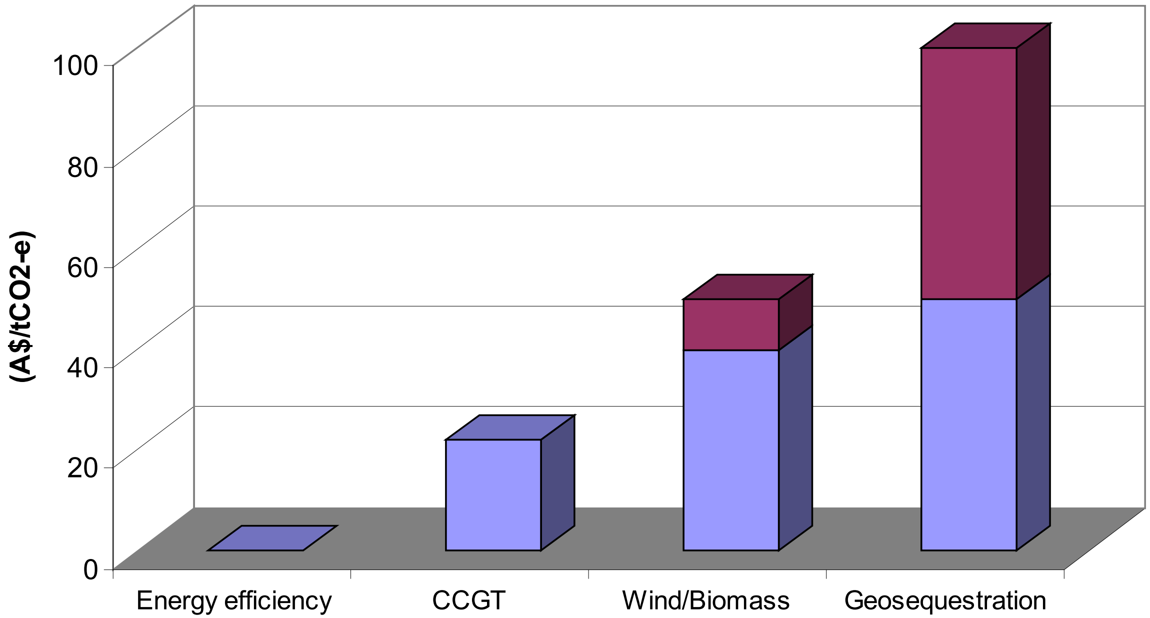
Possible CCS Costs

– Many challenges in cost estimations for CCS… particularly for technology systems that don't yet exist
  - technology not yet demonstrated integrated + at scale
  - some methodological choice critical, eg. NPV vs Levelised
  - can be very project specific, most assume IGCC + near sequestration site
  - possible 'learning' effects outweighed by present uncertainties (IEA, 2003)



Comparing abatement option costs

- Many challenges (provisos) in making comparisons…
  … some possible Australian estimates
  (Abatement costs c.f. conv. coal plant - no-regrets EE measures; CCGT, wind + biomass costs as per CoAG (2002), IGCC+CCS costs averaged from Intn'l. studies)



Preliminary assessment – potential scale

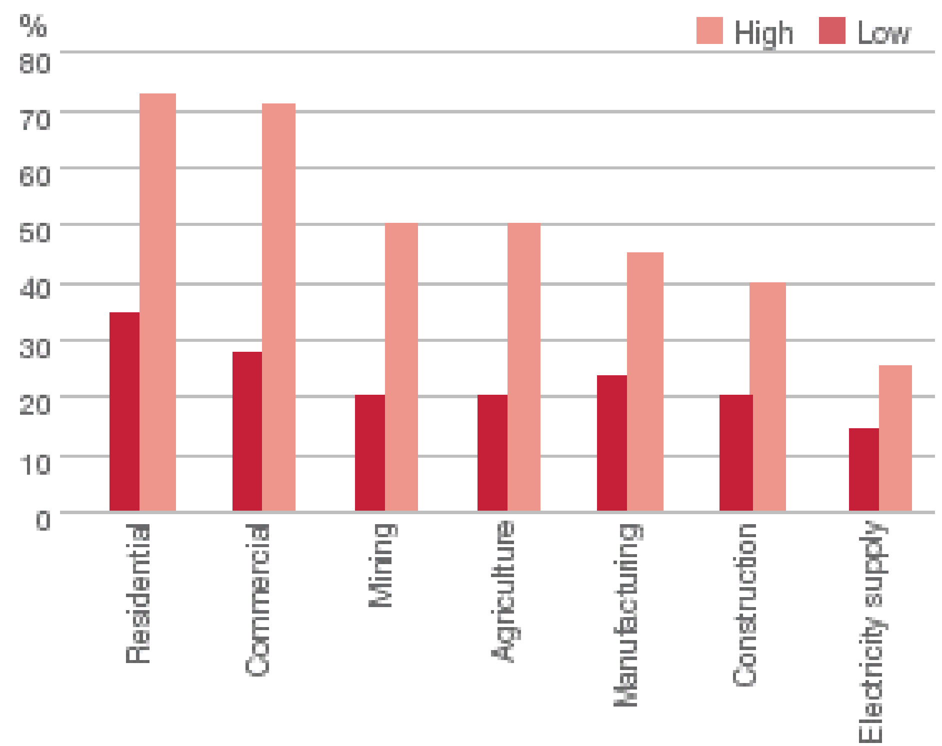
Energy Efficiency	Potentially very large (eg. some argue Factor 4), but inherently limited + competing against econ. growth
Renewables	Most individual technologies limited by available fuel supply (hydro, biomass) or face important intermittency issues (wind, PV). In combination, however, potentially large. High present uncertainty for HDR.
Lower emission fossil-fuel techs	Potential for CCGT driven by likely available gas supplies (possible issues in Eastern Australia), CHP has high penetrations (40%) in some countries
Ecological Sequestration	Limited by available land + potentially competing uses
Carbon Capture + Storage	Potentially very large, although difficult to estimate given present uncertainties on long-term storage – particularly in saline aquifers

Estimates of Australian cost-effective EE potential

- Estimates have high uncertainty however potential clearly very large (NFEE, 2003).

…and this is cost-effective EE with paybacks of 4 or 8 years – what is the potential scale of abatement at $40/tCO2 avoided?

Figure 4: Percentage cost–effective energy consumption reduction potential across different sectors.



Preliminary estimates of CCS abatement potential in Australia

GEODISC

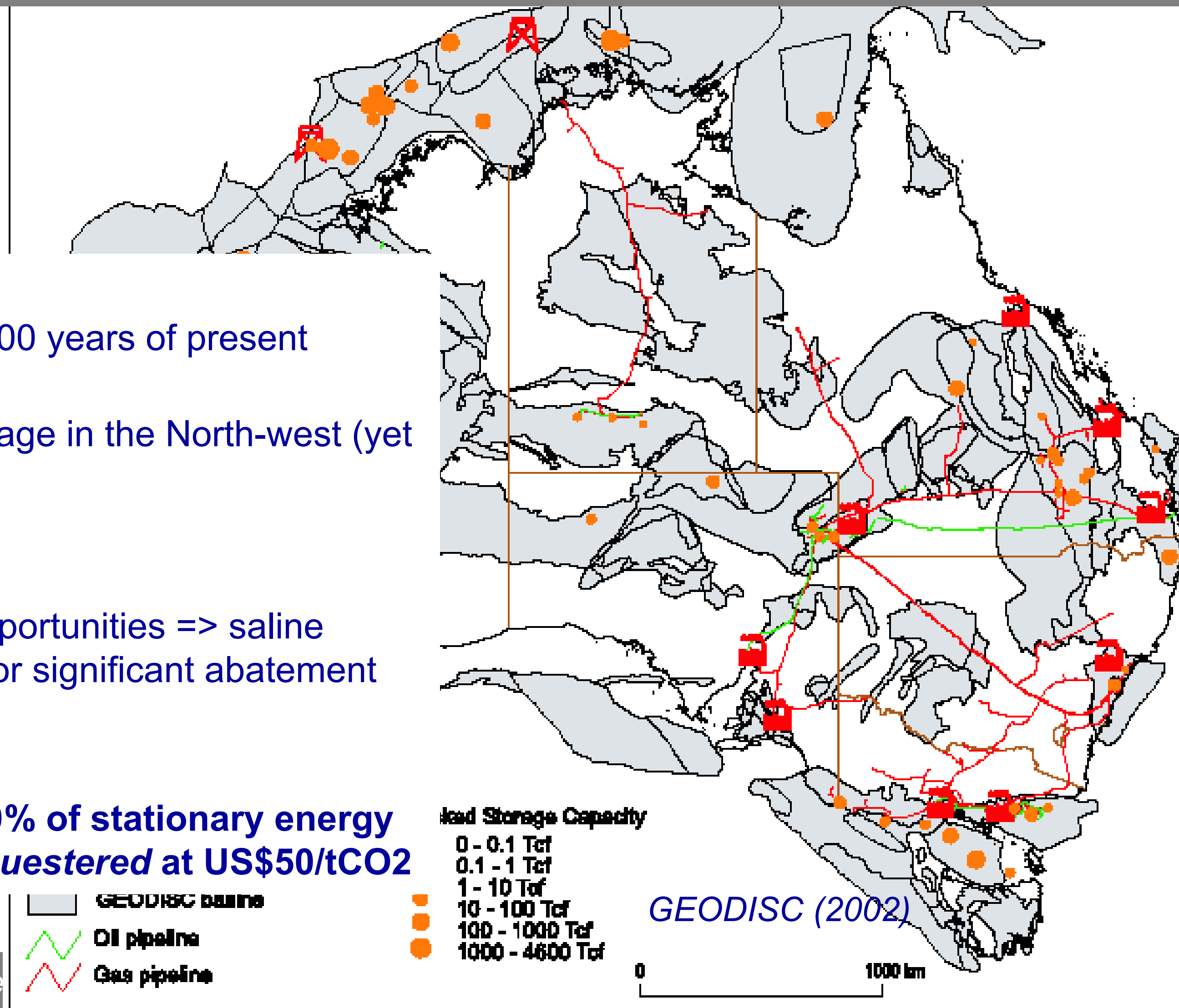
Very large potential resource (1600 years of present emissions)

But, most identified potential storage in the North-west (yet most emissions in South East)

Around 95% is saline aquifer

Very limited EOR, Coal Seam opportunities => saline storage the only realistic option for significant abatement (IEA, 2003)

Still, GEODISC estimates 50-70% of stationary energy sector emissions might be *sequestered* at US$50/tCO2



GEODISC (2002)

Preliminary assessment – potential speed of deployment

Energy Efficiency	Fast for some end-use techs with fast capital stock turnover, potentially slow for built environment (eg. building shells)
Renewables	Wind power the fastest growing energy source in the world, PV restricted by present high costs, biomass faces range of barriers, HDR still has to be demonstrated, commercialised.
Lower emm fossil-fuel techs	Very fast for proven mature technologies. CHP uptake potentially slowed by existing institutional barriers
Ecological Sequestration	Potentially as quickly as chosen biomass type can grow
Carbon Capture + Storage	Appears possible now for gas projects eg. Gorgon. CCS for coal gen still has to be demonstrated, then commercialised. Integration, application + scale can take decades. Proving injection = storage may take decades or more + be site specific - this creates risks for deployment

Preliminary assessment – other societal outcomes

Energy Efficiency	Very promising employment + investment opportunities. Low societal risks, no env. impacts.
Renewables	Promising employment + investment opportunities, including regional areas for many techs. Some env. impacts for some techs – eg. biomass. Land-use issues for wind
Lower emm fossil-fuel techs	A range of direct air, water + land env. impacts with fossil fuels. Energy security a possible issue with gas for many countries, coal with some countries
Ecological Sequestration	A range of other env. Issues can be addressed – eg. salinity, regional development.
Carbon Capture + Storage	Direct env. risks from sudden or slow escape of CO2 to atmosphere or ground waters. Coal an important contributor to Aust. economy + high energy security

Some key themes from preliminary assessment

- *Technologies with present uncertainties have associated risks* that need to be considered – potential upside along with downside *(but downside is what matters for risk averse decision making)*
- *Cost estimates difficult* – particularly where techs not yet commercialised, but also into future (possible learning) + with scale (economies but also potential resource limits)
- *Demonstration + (hopefully) commercialisation of new techs likely to take considerable time*, and this slows potential speed of deployment
- *Capital stock turnover of energy supply infrastructure is slow*, so need to start ASAP – deployment of proven techs has a key role
- *Energy efficiency is probably highest priority* – many proven techs offering considerable abatement at low risk and cost. Requires supply constraint, or it may just fire up more growth *"The cheapest, cleanest and safest way of addressing all our [energy] goals is to use less energy" UK Energy White Paper*
- *CCGT is a highly flexible supply option* – large emission abatement cf with coal, can be fuelled by natural gas initially but incorporated into coal-fired IGCC (with some mods), may also be suitable for direct CCS

Some thoughts on GHG abatement policy needs

- Need a coherent technology strategy that:
  - Establishes priorities subject to scale, speed + long-term sustainability that appears required to protect climate
  - Doesn't rely on technological magic
  - Uses technology push + market pull in tandem: *either type of policy alone is far less effective than when combined* *(IEA, 2003)*
  - Focuses particularly on market-pull to drive rapid deployment of established technologies: *our quickest possible emissions reductions*
  - Doesn't permit delay (delay is victory for incumbents)
  - Fosters competition between options and innovators where appropriate
  - Works to reduce information asymmetry and enhance societal decision making roles
  - Works to counter institutional/technological lock-in with fossil fuels
- all embedded within wider, coherent, climate policy framework

Some thoughts on Australian GHG abatement policy

- **Little evidence of coherent abatement + innovation strategy**
  - *Energy White Paper* focuses largely on technological push (eg. innovation fund), rather than market pull (eg. enhanced MRET, strong EE regulation) *this is very unlikely to be optimal policy approach*
  - Seeming lack of balance in public R&D support – very coal focussed
- For the different abatement options
  - *Renewables* – needs R&D but, critically, deployment support eg. 5% MRET. Emerging techs like HDR need demonstration support
  - *Energy efficiency* – has been woefully neglected, needs R&D yet, critically, targeted (mainly regulatory) deployment support
  - *Gas generation* – present immature Aust. gas market needs to be strengthened (CoAG, 2002), policy support for base-load NGCC, also CHP
  - *Geosequestration* – an important area for R&D + demonstration that should focus on key question of storage uncertainty + site specificity. Best place to start probably with existing high-purity CO2 streams like gas projects. Large incumbent industry should be making major contribution to expense of this

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