Centre for Energy and Environmental Markets

UNSW

Assessing Nuclear Power Using a Risk-based Framework

Rob Passey, Iain MacGill & Muriel Watt

ANZSES 2006

Canberra, Thurs 14th Sept, 2006

www.ceem.unsw.edu.au

Centre for Energy and Environmental Markets

UNSW

The Energy Challenge

- Governments worldwide face energy sector challenges
  - Energy security
  - Economic development
  - Social equity
  - Climate impacts
- Number of different technologies
  - Supply and demand sides
  - Different characteristics and stages of development
  - R&D requires technology push policies
  - D&C requires market pull policies

2

A Policy Framework

- Required for
  - Assessment of various technology options
  - Development of policies that will allocate limited resources to drive
    - Deployment of existing and acceptable technologies
    - Development of those that may be in the future
  - Minimise short/long-term abatement costs
  - Minimise social, environmental & economic impacts
  - Balance supporting a broad portfolio of options vs picking winners
- Current Australian policy
  - Focus on R&D of promising yet unproven technologies
  - Apparent attempts to pick winners (CCS, nuclear)
  - Comparatively little emphasis on market pull deployment of existing technologies

Prof John Gittus Report for ANSTO
Introducing Nuclear Power to Australia

- "International studies have consistently shown that nuclear generation produces the lowest cost electricity, even without considering the payment of a carbon tax" Ian Smith, Exec Director ANSTO
- "Model forecasts ….. show that nuclear will be continuously competitive with gas and coal [generation] in Australia through 2011" John Gittus
- Two finance plans for 5th copy of a Gen III+ PWR AP1000
- First four AP1000's built in other countries (China, USA)

- Significant risks for government (society)
- Conflicts of interest re safety requirements that could reduce returns
- Waste management and decommissioning costing inadequate

First finance plan

- $38/MWh
- Government takes 56% of construction risks through upfront loan for FOAK costs
- Government takes operational risks of $40.1m per year
- Loan + interest plus insurance premium would be repaid once plant operating
- Issues
  - Repayment from operating profits reduces incentive to reduce energy demand
  - Construction risks include “delay licensing the Plant or refuse Consents and require costly design changes” - conflict of interest re safety etc
  - AP1000 not yet built, FOAK costs may require extra finance, loan not repaid?
  - Operational risks include government increasing safety requirements and premature closure of plant - conflict of interest re safety etc
- Historically construction costs in USA and Europe higher than predicted, in part due to regulatory delays and redesign requirements

Risk-based probability x consequences calculations

- Questionable for a small market
- Eg. changes to market trading arrangements = $2.3m
  - Calculated assuming a 1 in 1000 event with a cost = cost of nuclear plant = $2.3b
  - But with one plant the costs = zero or $2.3b

Nuclear accident costs

- Government agrees to “pay all costs to third parties of most severe nuclear accidents”
- In USA
  - Insurance companies pay up to $US 300m
  - Price Anderson Fund pays up to $US 10b (nuclear power companies)
  - Government pays rest
- Chernobyl about $US 150b according to Ukrainian and Belarusian govs, encasing Unit 4 $US 768m for first 100 years
- In Australia
  - ???

Second finance plan

- Government subsidises 14.3% of construction costs
- Government subsidises 21.41% of operation costs for first 12 years
  - About $1b subsidy assuming FOAK cost savings from other country
- Waste management and decommissioning ~ $190m to $375m
  - Estimates for decommissioning of new UK plant are $550m to $1,100m
- Ongoing waste storage of $6.8m to $9.6m per year (100 yrs)
  - Post 100 yrs not included, presumably discounted away
- Described as a “profitable nuclear power station”
- Much more rigorous analysis required

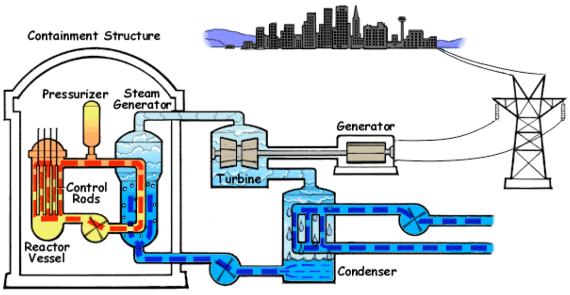
Technical Assessment Framework

1. Technical feasibility
2. Delivered energy services
3. Present and possible future costs
4. Scale of short/long term abatement
5. Other environmental/social outcomes

Centre for Energy and Environmental Markets UNSW

1. Technical feasibility

- Nuclear currently provides 15% to 17% of world electricity
- PWRs, very common, 200 operating
- Passively safe characteristics
  - As coolant heats, less dense, reduces moderating ability, reaction slows
  - Complexity of plant means operator actions also required
- AP1000
  - Not yet built but likely to be safer and cheaper than Gen II plant



9

Centre for Energy and Environmental Markets UNSW

2. Delivered energy services

- Nuclear power is thermal and so supplies baseload
- BAU - baseload needed around 2015
  - Short term baseload needs met by capacity additions and CC gas plant
  - Depends on DSM measures, economic growth, C price, oil price
  - By 2015 may also have geothermal, bioenergy, FF+CCS
- Demand profile
  - Load becoming more ‘peaky
  - Increased penetration of variable output plant (VRET)
  - Increased need for intermediate and peaking plant, not inflexible baseload

10

3. Present and possible future costs

- Very difficult to accurately cost nuclear plant
  - Government owned, shielded from market forces
  - Risks associated with construction costs, operating performance, fuel price changes, and other factors have been borne by government
- Massachusetts Institute of Technology multidisciplinary study
  - assumed that capital and operating costs would be reduced by 25% compared to current plant, commercial and regulatory risks would be reduced to that of conventional fossil fuel plant, zero waste management costs, and a US$50/tonne on CO_2 emissions.
  - concluded that "….it is extremely unlikely that nuclear power will be the technology of choice for merchant plant investors in regions where suppliers have access to natural gas or coal resources. It is just too expensive. In countries that rely on state owned enterprises that are willing and able to shift cost risks to consumers to reduce the cost of capital, or to subsidise financing costs directly, and which face high gas and coal costs, it is possible that nuclear power could be perceived to be an economical choice"

Centre for Energy and Environmental Markets UNSW

Costs (cont)

- Nuclear is mature technology, costs unlikely to decline appreciably
- Slower innovation rate due to longer lead time, shorter production runs, and delays to design changes
  - Learning rates (IAEA); nuclear 0-5%, wind 6-14%, PV 10-15%
  - Wind currently 1% so greater capacity for expansion and 'learning'
- Small proportion of capital expenditure in Australia
  - Coal ~25%, wind 50-80%, nuclear ?
- Thus likely higher cost, and higher proportion of costs go OS

4. Scale of short/long term abatement

- Recent climate science: climate possibly more sensitive to emissions, even moderate warming could cause irreversible damage, possible step changes make incremental increases dangerous
- EU adopted 2°C target, stabilisation at 400-450ppm, emissions peak 2020 then drop by 60% by 2050, any delay increases required rate of reduction
- Oz emissions projected to be 22% higher than 1990 by 2020, energy sector emissions 70% higher by 2020
- Nuclear unlikely in Australia until at least 2015, limited contribution
- SDC concluded than 10GW of nuclear in UK would have limited contribution to abatement by 2020

5. Other environmental/social outcomes

- All energy technologies have impacts but radioactive nature unique
- Mining uranium: mobilises radioactive elements - alpha particles, inhaled or ingested, radon gas problematic - cancer
  - Senate References Committee (2003) found systemic problems in Australian mining industry (leaks, spills and contamination)
- Low probability catastrophic events
  - unlikely, but malevolent actions receiving more attention
  - theft of plutonium for nuclear device, radiological weapons, attack or sabotage of nuclear plant
  - insurance industry fear exposure to any sort of nuclear event
- Radioactive waste
  - produced during enrichment, reprocessing, operation, decommissioning
  - high level waste must be managed for hundreds of thousands of years
  - *Homo sapiens* thought to have appeared 100,000 to 200,000 years ago
  - Finland developing deep disposal, will others?, standard practice rarely best practice
  - current safeguards rely on political stability and knowledge transfer for hundreds of thousands of years, and entirely ineffective if material falls into the 'wrong' hands

Centre for Energy and Environmental Markets

UNSW

Policy implications

- Issues: inflexible form of generation, high yet uncertain costs, delayed contribution to abatement, mining impacts, low probability yet catastrophic events, disposal of radioactive material and proliferation
- Nuclear would absorb resources and so exclude other options, and increase reliance on imported technology and expertise.
- Trying to 'pick winners' is very high risk
- We require innovation through R&D of promising options and through deployment of existing options
- Focus should instead be on the mix of policies and institutional frameworks that will drive development and deployment of abatement technologies and processes with least societal, economic and environmental disruption.

15

Centre for Energy and Environmental Markets

UNSW

Thank you… and *questions*

Many of our publications are available at:
www.ceem.unsw.edu.au

www.ceem.unsw.edu.au

Why nuclear?

- Widespread recognition that climate change is a serious threat
  - IAEA survey identified CC as a driver for support
  - In Australia
    - Nuclear reactor: 38% for, 51% against
    - Enrichment: 25% for, 59% against
    - Exports: 65% for, 28% against
- Energy security concerns (high oil and gas prices)
- Commonwealth support for
  - 'Magic bullet' answers (CCS, nuclear)
  - Mineral exports (coal $17b, uranium $475m in 2004/05)
  - No impact on electricity prices for 10-15 years
  - Energy intensive exports (aluminium $3.63b, iron/steel $10b)