Electricity Industry Restructuring in Australia: experience to date and emerging challenges

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Joint Director, CEEM

IIT Seminar
Madrid, May 2008
CEEM established …

– *to formalise* growing shared research interests + interactions
  – Faculties of Engineering, Business (Economics and Management), Arts and Social Sciences, Science, Institute for Environmental Studies...

– *through UNSW Centre*
  – aiming to provide Australian research leadership in interdisciplinary analysis + design of energy and environmental markets

– *Current research efforts (grant and consultancy funding)*
  – Facilitating wind integration in the NEM
  – Renewable energy policy support options in restructured industries
  – Market design for restructured electricity industries – new focus on retail mkts
  – Emissions Trading Schemes + options for Australia
    – Interactions between emissions trading and the Australian NEM
  – Technology assessment for sustainable energy options
    – including energy efficiency, cleaner fossil fuels, renewables, nuclear & **CCS**
  – Sustainable energy services delivery in developing countries
  – Economic modelling of Distributed Energy – demand-side participation & DG
  – Energy efficiency policy – regulation, financial mechanisms
Some of the CEEM Team....
The Australian energy context

- Large, low cost + high quality coal, gas and U reserves
- Major energy exporter – World #1 Coal, #2 Uranium, #5 LNG
- An energy intensive economy c.f. other industrialised nations
- Amongst the world’s highest per-capita greenhouse emissions

<table>
<thead>
<tr>
<th>% of Global...</th>
<th>Population</th>
<th>GDP</th>
<th>Energy Production</th>
<th>Energy Consumption</th>
<th>Fossil-fuel GHG emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>0.3</td>
<td>1.3</td>
<td>2.3</td>
<td>1.0</td>
<td>1.3</td>
</tr>
<tr>
<td>China</td>
<td>21</td>
<td>5.4</td>
<td>14</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>India</td>
<td>17</td>
<td>1.7</td>
<td>4.2</td>
<td>5.1</td>
<td>4.1</td>
</tr>
<tr>
<td>United States</td>
<td>4.6</td>
<td>31</td>
<td>15</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>Japan</td>
<td>2.0</td>
<td>14</td>
<td>0.9</td>
<td>4.8</td>
<td>4.6</td>
</tr>
<tr>
<td>Korea</td>
<td>0.8</td>
<td>1.8</td>
<td>0.3</td>
<td>1.9</td>
<td>1.7</td>
</tr>
<tr>
<td>Germany</td>
<td>1.3</td>
<td>5.6</td>
<td>1.2</td>
<td>3.1</td>
<td>3.2</td>
</tr>
</tbody>
</table>

(IEA, *World Energy Statistics 2006*)
Australia’s coal resources

Australian gas resources

(AER, State of the Energy Market 2007)
Australian hydro resources
Australia’s natural gas pipelines
(www.aga.asn.au)
Electricity demand, Tx and generation

Av. load 5600MW
Gen Capacity 11,300MW

Av. load 1500MW
Gen Capacity 3700MW

Av. load 1600MW
Gen Capacity 3500MW

Av. load 8500MW
Gen Capacity 12,500MW

Av. load 5700MW
Gen Capacity 8800MW

Av. load 1200MW
Gen Capacity 2700MW

Locations are indicative only.
Current NEM generation mix

Figure 1.7
Regional generation capacity by fuel source, 2007

(AER, State of the Energy Market 2007)

Note: Excludes power stations not managed through central dispatch.
Data source: NEMMCO
Australia’s coal dependence for electricity generation

Table 1: Percentage of electricity generated from coal in selected countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Percent of electricity from coal</th>
<th>Trend since 1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poland</td>
<td>2000</td>
<td>96</td>
<td>Steady at saturation</td>
</tr>
<tr>
<td>South Africa</td>
<td>2000</td>
<td>about 92</td>
<td>rising slightly towards saturation</td>
</tr>
<tr>
<td>Australia</td>
<td>2000</td>
<td>78</td>
<td>Steady</td>
</tr>
<tr>
<td>PR China</td>
<td>1999</td>
<td>75</td>
<td>small increase over the decade</td>
</tr>
<tr>
<td>India</td>
<td>1999</td>
<td>75</td>
<td>small increase</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>2000</td>
<td>73</td>
<td>Steady</td>
</tr>
<tr>
<td>Germany</td>
<td>2000</td>
<td>53</td>
<td>fallen slightly</td>
</tr>
<tr>
<td>USA</td>
<td>2000</td>
<td>52</td>
<td>Steady</td>
</tr>
<tr>
<td>Denmark</td>
<td>2000</td>
<td>47</td>
<td>big decline as gas and wind increase</td>
</tr>
<tr>
<td>Korea</td>
<td>2000</td>
<td>42</td>
<td>big increase</td>
</tr>
<tr>
<td>UK</td>
<td>2001</td>
<td>37</td>
<td>big decline since 1986</td>
</tr>
<tr>
<td>Japan</td>
<td>2000</td>
<td>22</td>
<td>big increase</td>
</tr>
<tr>
<td>Thailand</td>
<td>1999</td>
<td>18</td>
<td>small decrease</td>
</tr>
<tr>
<td>Vietnam</td>
<td>1999</td>
<td>12</td>
<td>big decrease</td>
</tr>
</tbody>
</table>

(WWF, Coal-fired electricity and its impact on global warming, 2003)
Terminology – its uses and abuses

- Is the Australian EI undergoing?
  - A Market reform
  - B Deregulation
  - C Restructuring
  - D Privatisation
  - E Liberalisation
Evolution of EI restructuring in Australia

- Development of COAG process in late 80’s
  - Formal interface between Federal & State governments

- National Competition Policy, *1993 Hilmer Report*:
  - Facilitate competition where effective & pro-competitive regulation where not; Treat public & private firms equally; uniform market rules of conduct where possible; access regimes for essential facilities
  - **Highlighted potential value of energy industry ‘reform’**

- Competition Reform Act, 1995
  - Amended TPA + new Competition & Consumer Commission (ACCC):

**Now well over a decade of energy industry restructuring**

- *National Electricity Market (NEM) incorporating NSW, QLD, VIC, ACT, SA (+ now TAS) established in 2000*
- More limited changes in Gas industry
- A mix of national + jurisdictional (State + Territory) roles
## Decision-making framework for a restructured EI

| Governance regime | ▪ Formal institutions, legislation & policies  
▪ *Informal social context including politics* |
<table>
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<tbody>
<tr>
<td>Security regime</td>
<td>▪ Responsible for system integrity on local or industry-wide basis, with power to override</td>
</tr>
<tr>
<td>Technical regime</td>
<td>▪ To allow connected industry components to function as industry-wide machine</td>
</tr>
</tbody>
</table>
| Commercial regime | ▪ To coordinate decentralised decision-making according to commercial criteria  
▪ Includes formally designed markets & interfaces for regulated participants (NSPs) |

*Key challenges – gaps & overlaps (no / blurred accountability)*
The Australian NEM

- Queensland
- New South Wales & ACT
- Victoria
- South Australia
- Tasmania

NEM regions indicated: boundaries need not be on state borders
Governance arrangements

- Council of Australian Governments (COAG):

  - Monitors energy markets & regulates Network Service Providers

  - Manages rule change for electricity & gas markets
  - Undertakes investigations for MCE

- Australian Energy Market Organisation (AEMO):
  - Enhanced version of National Electricity Market Management Company (www.nemmco.com.au) that will implement national electricity & gas markets & associated security regimes
The (new) overall objective for the NEM

- **NEL Section 7:**
  - The national electricity market objective is to promote efficient investment in, and efficient use of, electricity services for the long term interests of consumers of electricity with respect to price, quality, reliability and security of supply of electricity & the reliability, safety and security of the national electricity system.

- Possible short-comings of this objective:
  - Emphasises electricity rather than end-use energy services
  - Fails to mention sustainability - in 1991, COAG said the NEM should be efficient AND sustainable
  - What about technology + participant neutrality?
Features of National Electricity Rules (NER)

- NEM covers all participating states:
  - A multi-region pool with intra-regional loss factors
  - Spot market 5/30 min
  - Ancillary services market (<5 min)
  - No capacity market or equivalent; participants determine unit commitment through energy spot market bidding strategy
  - Centralised projections – ahead one day, week, 2 years and 10 years
  - Operated by NEMMCO (owned by states)

- Compulsory participants in NEM:
  - All dispatchable generators & links > 30 MW
  - Network service providers & retailers

- Over-the-counter + exchange derivative markets
  - Outside formal NEM market law, rules & formal arrangements
Spot market offers & bids

- Generators, retailers & consumers:
  - Price-quantity curve (sell/buy) for each half hour:
    - ≤ 10 daily prices, quantities changeable until dispatch
    - Can also bid in ancillary service capabilities into one or more of 8 FCAS markets; regulation raise/lower, contingency raise/lower 6s, 60s, 5 min
  - Demand forecasts ‘bid in’ at $10000/MWH (VoLL)

- Bids & offers ranked to give dispatch stack:
  - Considering loss factors & inter-tie constraints
  - co-optimised with ancillary service capabilities dispatch
  - 5 minute prices set by economic dispatch:
    - Half-hourly averages are calculated in ‘real time’
Each offer is for one 5-minute dispatch period; must be submitted 1 day ahead but then changeable until ~1 minute before dispatch period

Offer price may be as low as -1,000 $/MW

A simplified representation of bids from a 600 MW generating unit that indicates the capacity the generator is willing to offer to the NEM at a range of prices.

(NEMMCO, NEM Briefing 2007)
NEM regions
(NEMMCO SOO, 2006)
NEM regional spot market model
(Based on NEMMCO, 1997)

Queensland

NSW

750 MW

1000 MW

Victoria

850 MW

Snowy

3,000 MW

South Aust

Murraylink
220 MW DC
(MNSP converted to TNSP, 2003)

250 MW

1,100 MW

500 MW

Victoria

1,500 MW

Tasmania

600 MW pk
Basslink

600 MW

thermal or stability flow limits

Directlink
180 MW DC
(MNSP converted to TNSP, 2005)
Commercial & security/reliability processes

- Now: 5 min dispatch & pricing (4 sec AGC, online security processes)
- 1 hr ahead: 5 min res., 5 min update
- 10 yr ahead: 1 yr update
- Medium Term (MT) PASA
- Short Term (ST) PASA
- 30 min predisp.
- Upto 40 hr ahead: 30 min res., 30 min update
- 1 wk ahead: 30 min res., 2 hr update
- Upto 2 yr ahead: 1 day (MD) res., 1 wk update

Statement of Opportunities

Pre-dispatch, PASA & SOO processes are advisory only & have no commercial significance

PASA: Projected Assessment of System Adequacy

Prices for the next 5 minutes are the only commercial prices
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Present state

Growing uncertainty

Unreachable or unacceptable futures

Emergency control

Secure operating limits (probabilistic)

Time

NEM security & commercial regimes

Commercial regime
Possible futures managed by decentralised decisions

Security regime
Possible futures managed by centralised decisions

5 min
NEM Tx level reliability target, spot market mechs & intervention to meet it
(AEMC Reliability Review, 2006)
Industry structure & decision-making in the NEM

- Generation Sector: large generators
- Transmission Sector
- Distribution sector
- Retail sector
- End-users

Derivative trading (cashflow?)

Intentions, offers & payments
Multi-region five-minute energy & FCAS markets
Intentions, bids & payments

NEMMCO: market & system operator

Cash flow

Energy flow
NEM value chain

Generation ~40%  
Transmission 132kV - 500kV ~10%  
Distribution 415V - 66kV ~40%  
Retailing 240V ~10%

Competitive  
Regulated Natural Monopoly with “open access”  
Competitive

(TRUEnergy, Market Briefing 2006)
NEM spot prices (Quarterly volume weighted, www.aer.gov.au)
NEM frequency control ancillary services prices
(Quarterly volume weighted, www.aer.gov.au)
NEM exchange traded base derivative prices
(www.aer.gov.au)
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New generation investment

(AER, State of the Energy Market 2007)
PASA projections

- Primary role is to drive commercial responses
- Have seen a number of market interventions due to forecast reserve shortfalls <6 months out

(NEMMCO, MTPASA 2007)
NEM demand vs capacity – past & projected

Figure 1.12
NEM peak demand and generation capacity

Figure 1.13
Demand and capacity outlook to 2011–12

(AER, State of the Energy Market 2007)
Some existing & emerging challenges

- Energy constraints in hydro & thermal plant due to drought
- Dysfunctional retail markets
- Immature emerging gas market(s)
- Structural reaggregation of retailing & generation by private ‘gentailers’
- Integration of variable & somewhat unpredictable renewable energy
- Climate change
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Managing potential energy constraints

- Derivative mkts responded to drought however little foresight
- Current PASA projects capacity, not energy constraints
  - eg. Hydro, cooling water for thermal plant
  - NEMMCO to now provide energy adequacy projections

Prices apparently reflecting the impact of drought on coal & hydro power stations (may also be affected by speculation)
Present retail market design in Australia

- Retail market design for large end-users:
  - Competitive retail market (not yet mature)
  - Regulated network pricing (not yet mature)

- Retail market design for small end-users:
  - Regulated or partially competitive retail market
  - Simplified tariff structure; immature metering; profiling
  - Network charges usually passed through retailer
  - Little support for informed end-user decision making

- Some social policy objectives internalised
- Some environmental objectives internalised
- Limited opportunities for embedded generation
Distributed Energy options

- **Technical options within Dx system that actively participate in EI decision making**
  - renewable energy sources including solar thermal, photovoltaics (PV) smaller-scale wind, biomass
  - small-scale fossil fuelled generation, combined heat and power (CHP) plants powered with engines, gas turbines or fuel cells,
  - direct energy storage; chemical ‘battery’ technologies, superconducting magnetic systems, flywheels
  - electrical end-uses that actively respond to changing conditions; eg. ‘smart’ buildings that control heating & cooling to exploit their inherent thermal energy storage
  - End-use energy efficiency

(Dunstan, Developing Demand Response in NSW, October 2005)
Typical measures of competition not very useful

- Retail transfers? Data limitations, relevance
- Price spreads? Can mean competition, or market failure
- .... an important reason there is effective competition ... is “Because the provision of energy is viewed as a homogenous, low engagement service...” AEMC, *Effectiveness of Competition in Vic., 2008*

![Figure 6.8](image1)

Cumulative monthly switches as percentage of small customers—New South Wales, Victoria and South Australia


![Figure 6.9](image2)

Customers not with their host retailer at 31 December 2006—New South Wales, Victoria and South Australia

Sources for table 6.5 and figures 6.8–9:
Meanwhile, decision making in the real world
(Washusen, 2005)

Pay particular attention to the steady slope of this line.
... and network investment

Figure 4.9
NEM-wide transmission investment


Figure 6.13
Composition of a residential electricity bill
Victoria

Figure 5.3a
Allowed revenues—Victoria, South Australia and Tasmania

Figure 5.3b
Allowed revenues—New South Wales, the Australian Capital Territory and Queensland
Current developments

- **Advanced Metering Infrastructure (AMI) rollout**
  - Including 2-way communications, direct load control options, quality of supply measurement, DG connection support

- **Network investment**
  - Arrangements to test augmentation options against possible DE options

- **Forthcoming removal of retail price regulation**
  - Subject to jurisdictions and likely sequentially
Immature gas markets

- Questions of long-term reserves for NEM however major CSM coming on line
- Little transparency in gas prices – most traded via confidential long-term contracts
- New gas gen raising challenges – Scale & peakiness with OCGT

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- Emerging trio of major gentailers
- Possible privatisation of NSW Govt. retailers & generators


**Figure 2.11**
Number of price intervals above $5000 a MWh

(AER, *Weekly Market Analysis, March 2007*)

**Figure 2:** 7 day rolling cumulative price and CPT

Data source: NEMMCO
The Australian wind resource
(Simple estimates of background wind – Australian Greenhouse Office)
Current status of Australian wind generation

Estimated state average load, total installed generation capacity and wind installed or under construction (ausWEA, ESAA)

Transmission lines and generators

Av. load 5600MW
Gen Capacity 11,300MW
Wind 12MW

Av. load 1500MW
Gen Capacity 3700MW
Wind 480MW +160 U/T

Av. load 8500MW
Gen Capacity 12,500MW
Wind 17MW

Av. load 5700MW
Gen Capacity 8800MW
Wind 325MW +165 U/T

Av. load 1600MW
Gen Capacity 3500MW
Wind 200MW

Av. load 1200MW
Gen Capacity 2700MW
Wind 140MW

Locations are indicative only.
Wind penetrations set to rise significantly

- Current Australian wind gen ~ 1GW & 1% energy penetration
- New Renewable Target of 20% by 2020 might see 5-10GW installed
- Most current projects in SA and Victoria rather than NSW & Qld
A challenging context for climate policy

- Energy-related emissions climbing – 70% of total
  - Estimated +35% over 1990–2004, projected +56% in 2010
  - ‘On track’ to meet Kyoto 108% target due to ‘land clearing’ hot air

- Electricity generates 35% of total emissions + fastest growing sector.

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New Federal Government commitments

- Ratify **Kyoto Protocol**
- Adopt **Mandatory Renewables Target** of 20% by 2020, 45,000GWh. Target to be phased out 2020-2030
- $500M **Renewable Energy Fund** intended to develop, commercialise and deploy renewable energy.
- Invest $500M under **National Clean Coal Fund** to finance deployment of clean coal technologies. (Energetics, Dec. 2007)
- Range of Energy Efficiency policies
Estimated effect of a carbon price on merit order

NSW/Vic/SA (one node approximation)

srmc ($/MWh)  srmc & $30/t  srmc & $40/t

(Nolles, 2003)
Forthcoming governance arrangements

- **Council of Australian Governments (COAG):**

  - Monitors energy markets & regulates Network Service Providers

  - Manages rule change for electricity & gas markets
  - Undertakes investigations for MCE

- **Australian Energy Market Organisation (AEMO) bringing together**
  - NEMMCO
  - A Gas Market Operator
  - A National Transmission Planner
Enhanced NEM structure with active end-user participation

ESCOs: the missing players in the restructured electricity industry

ESCO’s

Commercial Physical

Market & system operator (eg NEMMCO)

Access contracts

Distribution sector

Energy flow

End-use sector (including DR)

Energy flow

Multi-region five-minute energy & FCAS markets

Intentions, bids & payments

Transmission Sector

Energy flow

Generating Sector: large generators

Energy flow

Kinetic energy

Derivative trading

Commercial Physical

Intentions, offers & payments

End-users

Generation Sector: large generators

Large generators

Large generators

Cash flow

Cash flow

DR providers

ESCO’s

ESCOs: the missing players in the restructured electricity industry

AMI: the missing interface in the restructured electricity industry

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