The outlook for electricity industry restructuring in Australia

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Outline

- Key properties of the electricity industry
- Objectives of electricity industry restructuring
- Challenges in electricity industry restructuring
- Key features of the Australian implementation
- Strengths of the Australian implementation
- Weaknesses of the Australian implementation
- Current developments
- Future prospects
- Conclusions
The stationary energy sector
energy conversion chain

Primary energy forms
e.g: coal, gas, nuclear, renewable

The electricity supply industry
- generation
- transmission
- distribution

The natural gas supply industry
- treatment
- transmission
- distribution

End-use options, eg: efficiency, cogeneration, solar
end-use equipment delivering energy services eg: light, heat, motive power

energy losses & external impacts
Key features of the electricity industry

- Part of the stationary energy sector:
  - In competition with, and dependent on, other energy vectors to deliver end-use energy services

- Significant externalities:
  - Environmental (e.g. climate change)
  - Social (e.g. “essential good”)

- Characteristics of AC electrical energy:
  - Alternating current (AC) electrical energy is:
    - A high quality, secondary energy form:
    - Expensive to make but flexible to transport & use
  - Influenced by many stochastic processes
  - Has specific physical properties
Specific properties of AC electrical energy:
- No cost-effective storage of AC electrical energy
- Instantaneous transmission & distribution
- Energy flows according to network laws:
  - From all generators to all end-use equipment
  - Quality & availability shared by all equipment at the same location

The ultimate “just in time” industry:
- Supply & demand must balance at all times
  - Generator output determined by end-use equipment
  - Supply & demand side options are equally valid
- Cannot assign energy from a particular power station to a particular consumer:
  - ‘pool’ rather than ‘bilateral’ trade
- Wholesale & retail activities not clearly separable:
  - Retailers don’t have a clear role in an electricity industry
Objectives of electricity industry restructuring

- Improve economic efficiency by facilitating competition & new entry, which assumes:
  - Effective markets & clear accountabilities via sound legal & policy frameworks

- Enhance accountability to end-users & society through ‘customer choice’, which assumes:
  - End-users become active participants in the industry
  - End-users are independent agents who make “informed” decisions & efficiently manage the associated risks:

- Implement a market-based approach to social & environmental externalities:
  - Assumes political will to regulate non-monetary impacts

- In some cases, release government funds by asset sales:
  - Creates a moral hazard for politicians
<table>
<thead>
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<th>Issue</th>
<th>Transition</th>
<th>Key challenges</th>
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<tr>
<td>Industry structure</td>
<td>From monopoly To competing firms Plus system operator(s)</td>
<td>Cultural change; Adequate competition; Accountability</td>
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<td>Commercial framework</td>
<td>From cost recovery To market prices</td>
<td>Market power; Market design fidelity; Accountability</td>
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<td>Industry regulation</td>
<td>From rate of return To Incentive Reg’n</td>
<td>Multiple objectives; Measuring outcomes; Accountability</td>
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<td>Sustainability</td>
<td>From direct cost To full costs</td>
<td>Variable RE energy flows End-user participation; Accountability</td>
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Challenges in electricity industry restructuring

- The industry is infused with short & long term risk:
  - A flow industry with short-term uncertainty in, & shared responsibility for, location-specific availability & quality

- Electricity markets are incomplete & thus inefficient:
  - Economic value derives from end-use energy services not electricity
  - Temporal & locational averaging; important externalities
  - Imbalance between large & small participants; gaming
  - Long-term risks due to asset longevity & capital intensity

- Centralised decision making remains, by:
  - System operators, Network Service Providers, Regulators

- There is an unavoidable interaction between:
  - Cooperative (centralised) short & long-term decision making and
  - Competitive (decentralised) short & long-term decision making

- Which results in:
  - Ambiguity in the accountability of industry decision makers
Useful models of an AC electricity industry

- Physical reality, e.g. for AC electricity:
  - Instantaneous voltages, currents & power flows
- Engineering models (a typical example):
  - Balanced 3 phase sinusoidal voltages & currents
- Main commercial models (typical examples):
  - Spot & forward markets; network access regime:
    - *Designed to elicit economically efficient behaviour*
- Ancillary services to manage mismatches:
  - Between main commercial models & physical reality
- Policy & regulatory framework for the industry:
  - Societal objectives & behavioural norms
Trading in electricity: an abstraction from reality

- **Main commercial markets** (humans; individual; abstract)
- **Economic models** (humans; collective; abstract)
- **Engineering models** (equipment; collective; abstract)
- **Physical electricity industry** (equipment; collective; concrete)
- **Externalities**

> **Ancillary services & Regulatory actions**

**Policy & regulatory context**
Interchange to other wholesale market regions

large generators

Wholesale Market region

transmission network

Retail Market 1

distribution network

RM 2

distribution network

Retail Market 3

distribution network

large consumer

- Small consumers, embedded generators & storage should be supported by energy service advisers
- Wholesale & retail market designs should be compatible
  - Both should include network models
Challenges for a restructured industry

- Consistency between centralised & decentralised processes:
  - Centralised power system security: *most ancillary services; industry operation; industry design & regulation*
  - Decentralised market processes: *some ancillary services; spot & forward markets*

- Sound interface between centralised & decentralised processes:
  - Clear accountabilities & “hand-overs”

- Active involvement of informed end-users:
  - Industry economic value derives from end-use energy services NOT electrical energy
### Timescales & mechanisms for risk management
*(centralised power system security & decentralised markets)*

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<th>Time scale</th>
<th>Issues</th>
<th>Mechanisms</th>
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<td>&lt; 30 minutes</td>
<td>• Demand fluctuations</td>
<td>• Ancillary services</td>
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<td>• Contingencies</td>
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<td>30 minutes to several days</td>
<td>• Demand uncertainty</td>
<td>• Ex-ante spot market</td>
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<td>• Inter-temporal links, eg</td>
<td>• Short term forward market</td>
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<td>• Unit commitment</td>
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<td>Weeks to years Š (operation)</td>
<td>• Inter-temporal links, eg</td>
<td>• Long term forward market</td>
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<td>• Retail tariff setting</td>
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<td>• Hydro scheduling</td>
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<td>Weeks to years Š (investment)</td>
<td>• Optimal investment decisions</td>
<td>• Long term forward market</td>
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<td>• Policy framework</td>
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Power system security
(Australian National Electricity Code (NEC) Chapter 4)

- Satisfactory operating state:
  - Frequency “normal” (49.9-50.1Hz), except for brief excursions within 49.75-50.25Hz
  - Voltage magnitudes within specified limits
  - All equipment operating within equipment rating

- Contingencies (equipment outages):
  - Credible, eg single generator or network element (N-1)
  - Non-credible, eg multiple outages except abnormal condns

- Secure operating state:
  - Currently in a satisfactory operating state
  - Would return to a satisfactory operating state following any single credible contingency (consider loss of largest gen / interconnector)

=> Require sufficient FCAS available to cover sudden loss of largest generation unit / interconnector within each NEM region
Centralised & decentralised risk management
(requires adequate location detail & active demand-side involvement)

- Financial instrument (derivative) trading & spot market projections
- Commercial issues (decentralised)
- Physical issues (centralised)
- Forward-looking ancillary service (AS) “acquisition markets” & reliability assessment

- Spot market for period t
- Spot market for period t+1

- Ancillary service “actuation markets” for period t
- Ancillary service “actuation markets” for period t+1

Uncertainty increases looking forward
Frequency control & NEM 5-30 minute spot market

Long term (>5 min) power imbalances resolved by hybrid 5-30 minute spot market

Unresolved disturbances

Offers to sell & bids to buy with ramp-rate limits

Market clearing price & accepted quantities for each participant

Medium term (10 sec - 5 min) power imbalances controlled by centralised AGC

Unresolved disturbances

frequency error

Automatic generation control algorithm distributes raise/lower signals to AGC participants

Power setpoints

Short-lived (<10 sec) power imbalances controlled by decentralised governors (local speed/frequency control)

Unresolved disturbances

Generator with speed governor

Generator with speed governor

Frequency-sensitive load
Scope of the NEM

• Queensland
• New South Wales & ACT
• Victoria
• South Australia
• Tasmania (on connection to the mainland)

NEM regions are indicated, and their boundaries need not be on state borders (e.g. two regions in NSW)
NEM market regions
(Securing Australia’s Energy Future, 2004)

Directlink DC link, currently MNSP

Murraylink DC link, now regulated, formerly MNSP

Basslink DC link MNSP (2005?)
600MW short term rating (north)
Key NEM features

- NEM covers all participating states:
  - A multi-region pool with intra-regional loss factors
  - Ancillary services, spot market & projections
  - Auctions of inter-regional settlement residues
  - Operated by NEMMCO (owned by states)

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

- Contestable consumers may buy from NEM
Electricity industry structure in SE Australia

- **Generation Sector**: large generators
  - Gen 1
  - Gen 2
  - Gen 3
  - Gen X

- **Transmission Sector**:
  - NSW
  - Victoria
  - South Aust.
  - Queensland & possibly Tasmania

- **Multi-region National Electricity Market (NEM)**

- **Financial instrument & REC (emission) trading**

- **Retail sector**
  - Retailer 1
  - Retailer 2
  - Retailer Z

- **Distribution sector**
  - Distributor 1
  - Distributor 2
  - Distributor Y

- **Retail Markets**

- **End-use sector**
  - Embedded generators
  - Contestable end-users
  - Franchise End-users

- **End-use sector**
  - End-use Equipment & Distributed resources

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Dispatch, Pre-dispatch, PASA, SOO & ANTS
(source: NEMMCO)

- **Medium Term PASA (2 yr, daily peak)**
- **Short Term PASA (7 days, 30 min res, 2hr update)**
- **Pre-dispatch, re-bid & final dispatch schedule**

- **0 day 1 day 2 week 1 month 1 year 1 year 2**

  - ST & MT Projected Assessment of System Adequacy support reserve assessment & participant operating decisions. ST PASA projects region demand & reserve for 7 days @ 30 min resolution, updated every 2 hours. MT PASA projects region daily peak demand & reserve for 2 yrs, updated weekly.
  - Statement of Opportunities (SOO) & Annual National Transmission Statement (ANTS) are intended to inform generation, demand & network investment decisions (10 year horizon, issued annually)
Weekly avg. NEM spot prices since market inception  (NECA, 04Q4 Stats, 2005)
Spot price duration curve, SA, Sept-Dec 2004 (NECA, 04Q4 Stats, 2005; half-hour spot prices)
Average weekly price & demand, SA, Q4 2004
(NECA, 04Q4 Stats, 2005)
Flat contract prices, Q4 2004
(NECA, 04Q4 Statistics, 2005)
NEM governance (Allens Arthur Robinson, 2003)
Electricity transmission: ANTS

- An integrated overview:
  - Future constraints on major transmission paths
  - Information on augmentation options
  - Incorporated into SOO & complimentary to projection of supply-demand balance

(www.mce.gov.au)
Conclusions on electricity restructuring in Australia

- Experience to date:
  - A thoughtful & balanced process over a decade produced mostly good results
  - However, there are important weaknesses:
    - Difficulties with network representation and pricing
    - Lack of active demand side participation

- Future prospects:
  - It is not clear that further progress will be made:
    - Complexity; climate change challenges; loss of expertise; political resistance to effective demand-side engagement
A number of our publications on this topic are available at: www.ceem.unsw.edu.au