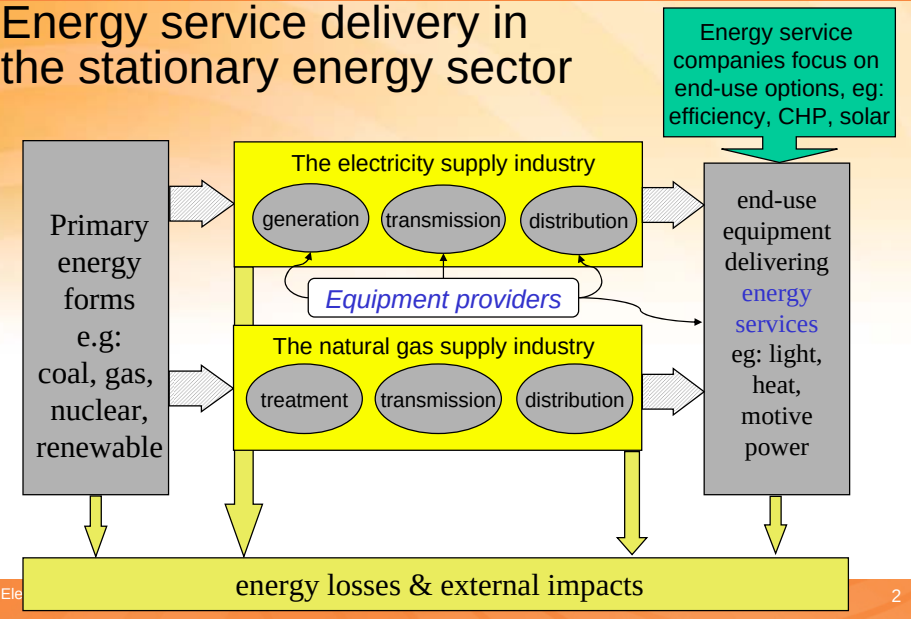
Centre for Energy and Environmental Markets

UNSW

Electricity industry restructuring overview:

economic, commercial & regulatory perspectives

Energy service delivery in the stationary energy sector



Comparison of car & electricity industries

Cars

- Can be touched seen, & stored, last for years
- Consumer choice promotes competition:
  - Each consumer can buy a specific car
  - Each manufacturer can control product quality
- Spatial separation of buyer & seller not a serious issue

Bilateral trade works well:

- *Can use normal commercial framework*

Electricity

- Intermediate energy form:- invisible, ephemeral, fungible - a *flow* industry
- A consumer receives a mixed flow of energy from all power stations:
  - A consumer can't choose a power station
  - A power station can't control quality of delivered energy at another location
- Location matters because of network losses & constraints - the key issue is:
  - *Continuity & quality of flow of electrical energy arriving at end-use equipment*

Bilateral trade does NOT work well:

- *Must design & implement an industry framework that works for electricity*

Infrastructure industries

- A definition of infrastructure:
  - Essential elements forming the basis of a system
- Examples of infrastructure industries:
  - Communications, electricity, gas, water, transport
  - Provide inputs to products or services
  - Often capital intensive with long investment lead times & asset lives
- An infrastructure industry is essential (to a product or service) if:
  - A particular product/service can't be made without it
  - No alternative product/service can be made without it

"Natural monopoly" industries

- Definition:
  - Most efficient if production undertaken by a single firm to meet demand when price=SRMC
    - Always true for "increasing returns to scale", ie average cost decreases as production increases
- Some infrastructure industries may be both essential & natural monopolies, eg:
  - Electricity transmission and/or distribution networks
- However, electricity generation & end-use are not natural monopolies

Traditional models for infrastructure industries: *centralised decision-making*

- Britain, Australia, etc:
  - Statutory authorities supervised by a Minister:
    - Usually vertically integrated monopolies
  - Decision making political, "behind closed doors":
    - Politicians negotiate tradeoffs
- USA (in some cases):
  - Regulated private monopolies
  - Politically appointed regulatory boards
  - Formal public hearings

Five perspectives on accountability of an agency (Hodge et al, 2004, p 200)

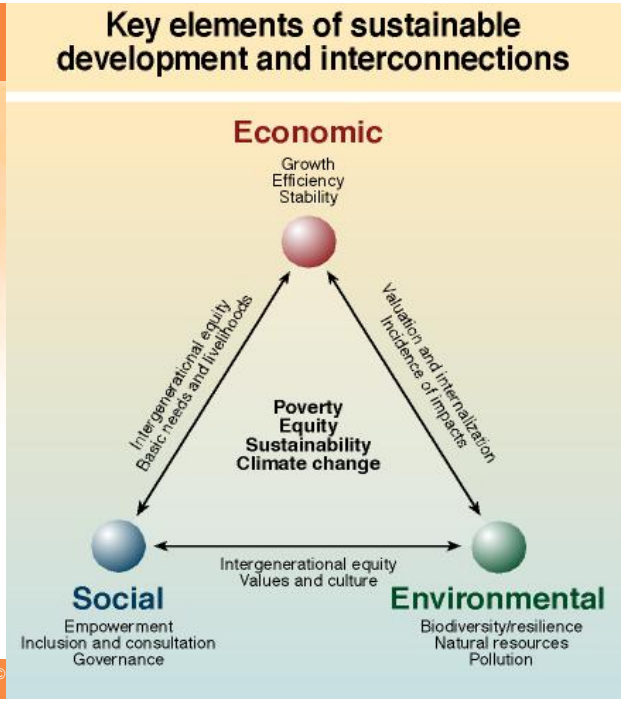
Parliamentary control	Accountable to a Minister
Managerialism	External control strategic rather than detailed
Judicial & quasi-judicial review	Formal, reviewable decision-making
Constituency relationships	Public hearings; advisory bodies; ombudsmen
Market processes	Requires meaningful consumer choice

Electricity industry restructuring objective: *decentralised decision making*

- Improve economic efficiency by facilitating competition & new entry, which assumes:
  - Effective markets & 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
- Release government funds by asset sales:
  - Creates a moral hazard for politicians

The broader context of sustainability that electricity industry restructuring should address
(IPCC COP7)

Engineering criteria must also be met: availability & quality of supply



Economic efficiency objectives

- Allocative efficiency:
  - Appropriate choice between goods & services:
    - For example, electricity versus gas
- Technical or productive efficiency:
  - Cheapest method to produce a good or service:
    - Best available technology & work practices
- Dynamic efficiency (crucial in electricity industry):
  - Support innovation & response to change:
    - R&D & technological change
    - Environmental impacts, social expectations, etc.
  - Efficiently manage both short- & long-term risks

Other drivers for change in infrastructure industries

- Improving theoretical understanding:
  - Imperfect regulation versus imperfect markets
  - A theory of electricity spot pricing from 1979
- Evolving political context in western world:
  - Emphasis on individual choice/accountability
- Challenging conditions for central planning:
  - Slow & uncertain growth in demand
  - Technological progress creating new options:
    - Eg metering, communications & demand-side options
  - Growing climate change concerns

Microeconomic reform

- *Objective* - to improve economic efficiency
  - Particularly challenging for infrastructure:
    - Potential for natural monopolies in essential goods & services
- *Means* - reduce barriers to competition, eg:
  - Remove monopoly franchises & introduce competition
  - Break-up large state-owned enterprises
  - Privatise state-owned enterprises
  - Improve strategies for industry regulation
- *Assumptions:*
  - The key public interest issue is economic efficiency
  - The best mechanism is competition
  - Participants act as profit-maximising economic agents
  - Sound legal framework in which restructuring can occur

Evolution of competition policy in Australia

- Development of COAG process in late 80's
  - Formal interface between federal & state governments may foster rational policy development
- National Competition Policy,1993 Hilmer Rpt:
  - Facilitate competition where effective & pro-competitive regulation where not
  - Treat public & private firms equally
  - Apply universal & uniform market rules of conduct
    - Specific codes only if shown to be in the public interest
  - Develop access regimes for essential facilities

Evolution of competition policy in Australia: Competition Reform Act, 1995

- Amended Trade Practices Act, encompassed Prices Surveillance Act
- Established Australian Competition & Consumer Commission (ACCC):
  - Neutral, economy-wide, open process
  - Decisions can be appealed to Aust.Competition Tribunal
- Implements the principles of competition policy
  - Assumes primary public interest is in economic efficiency and other objectives are secondary
  - Assumes civil society, equity, etc.

The electricity industry restructuring process

Issue	Transition	Key challenges
Industry structure	*From* monopoly *To* competing firms *Plus* system operator(s)	Cultural change; Adequate competition; legal framework *Accountability*
Commercial framework	*From* cost recovery *To* market prices	Market power; legal framework Market design fidelity; *Accountability*
Industry regulation	*From* Rate of Return *To* Incentive Regulation	Multiple objectives; Measuring outcomes; *Accountability*
Sustainability	*From* direct cost *To* full costs	Variable RE energy flows End-user participation; *Accountability*

Key issues in the design of a fully restructured electricity industry

- Particular characteristics of electrical energy:
  - A *flow* industry with short-term uncertainty in, & shared responsibility for, location-specific *availability & quality*
- Inherent market incompleteness & inefficiency:
  - Temporal & locational averaging; important externalities
  - Imbalance between large & small participants; gaming
  - Long-term risks due to asset longevity & capital intensity
  - Large environmental externalities
- Inevitable residual *centralised decision making* by:
  - Policy makers, Regulators, System operators, Network Service Providers
- Unavoidable interaction between:
  - Cooperative (*centralised*) decision making and
  - Competitive (*decentralised*) decision making

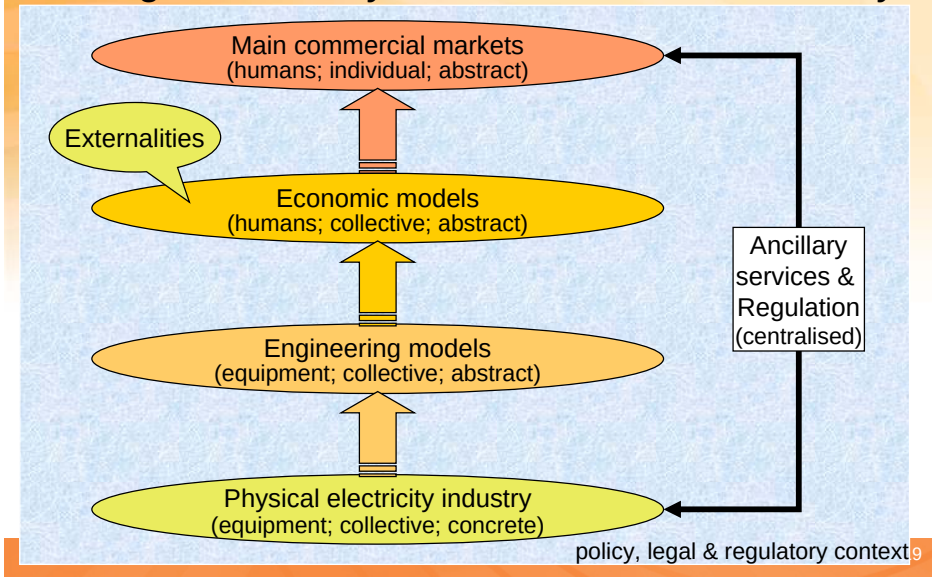
Decision-making regimes for an electricity industry

Governance regime	Formal institutions, legislation, policies & regulation. Informal social contexts that influence decision-making
Commercial regime	Formally designed electricity markets & regulated pricing arrangements. Informal markets that interface to the industry - eg primary energy, equipment, buildings, land.
Technical regime	The set of engineering rules that allow components of an electricity industry, when connected together, to function as a single machine.
Security regime	The task, assigned to one or system operators, of maintaining the integrity of a local or system-wide core of a power system against large disturbances.

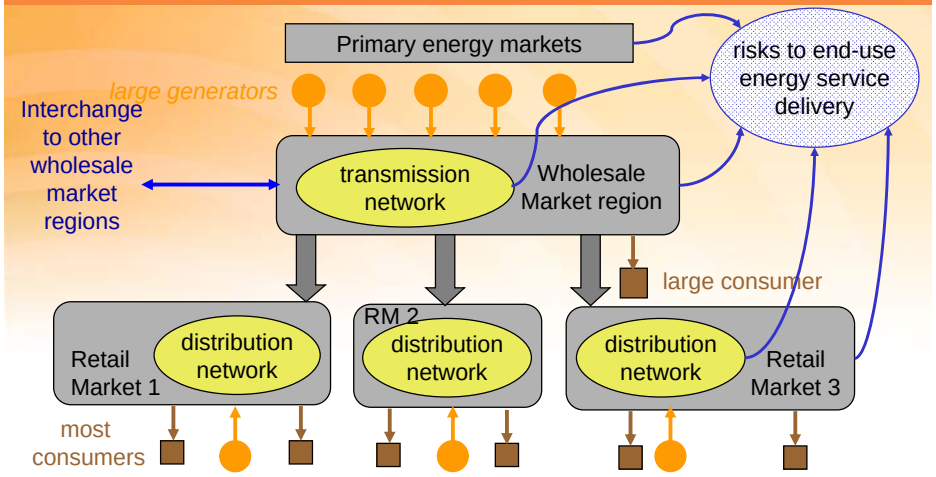
Models of the electricity industry

- Physical reality, e.g. for 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



An electricity trading framework



- *Small consumers, embedded generators & storage should be supported by energy service advisers*

- *Wholesale & retail market designs should be compatible*
  - *Both should include network models*

Some insights from electricity pricing theory #1: temporal issues in pricing

- A single owner of an electricity industry:
  - Could maximise Industry Benefits of Trade (IBOT):
    - if *all* supply costs & *all demand side benefits* were known
- Optimal prices in a decentralised industry:
  - That set of prices that achieves the same IBOT:
    - The incremental cost *or loss of benefit* of delivering an additional unit of energy *at a particular location at a particular time*
  - Standard SRMC definition if no inter-temporal links:
    - Location-specific; time-specific; may be set by loss of benefit (value)
  - Otherwise a set of prices that reflect *future decision options*:
    - Based on best available model of future price behaviour, *including impacts of a specific decision on future prices*

Some insights from electricity pricing theory #2: spatial issues in pricing

- A single owner of an electricity industry:
  - Could maximise IBOT taking into account:
    - Network losses & flow constraints
    - Security: probability & consequence of outages
- Optimal pricing policy in a decentralised industry:
  - Location-specific & time-specific spot prices based on:
    - Local supply/demand balance
    - Network arbitrage subject to losses & flow constraints
  - Location- & time-specific derivative prices based on:
    - Plausible scenarios of future generation & demand
    - Plausible scenarios of future network losses & flow constraints
    - Plausible effects of future decisions

Single owner (centralised decisions): *An engineering optimisation problem*

- Given:
  - An inventory of existing & potential future generation, network & demand side electrical equipment:
  - Technical parameters, operating & capital costs, industry benefits, operating constraints
  - Uncertainties in performance, costs & benefits
  - Ability to control all generation, network & end-use equipment
- Calculate a strategy to maximise IBOT:
  - Solve a stochastic non-linear dynamic optimisation problem for operating & investment decisions in generation, network and demand side equipment

Many owners (decentralised decisions): *An economic optimisation problem*

- A set of location-specific energy spot markets:
  - Each trading energy (that meets QOS criteria) at local spot price in successive short spot market intervals
- A set of location-specific derivative markets:
  - Related to future spot price expectations at that location:
    - Predict aspects of future spot market behaviour
    - Permit reallocation of risks
- Ancillary services:
  - Resources that maintain availability & quality of supply:
    - Some systemic, some location-specific
- Regulatory monitoring of strategic behaviour

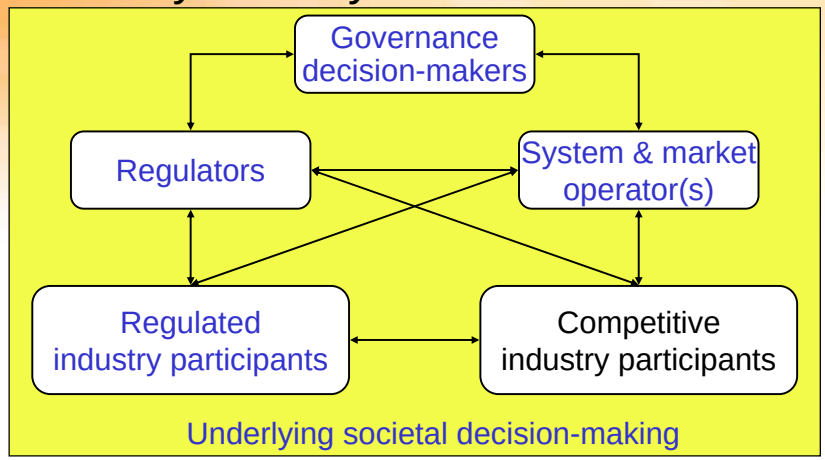
Electricity market models

- Gross pool (eg NEM):
  - All "physical" energy traded in (nodal) spot market
  - Temporal & location risk managed jointly:
    - Ancillary services, spot & derivative markets,
    - PASA, SOO, ANTS
- Net pool (eg UK NETA):
  - Long term & location risk managed bilaterally:
    - Network not modelled in trading arrangements
    - Resource adequacy managed partly as a bilateral issue
  - Imbalance energy traded in "balancing market"
  - Short-term operational risk managed collectively:
    - System operator typically given 1 day's notice of bilateral trades

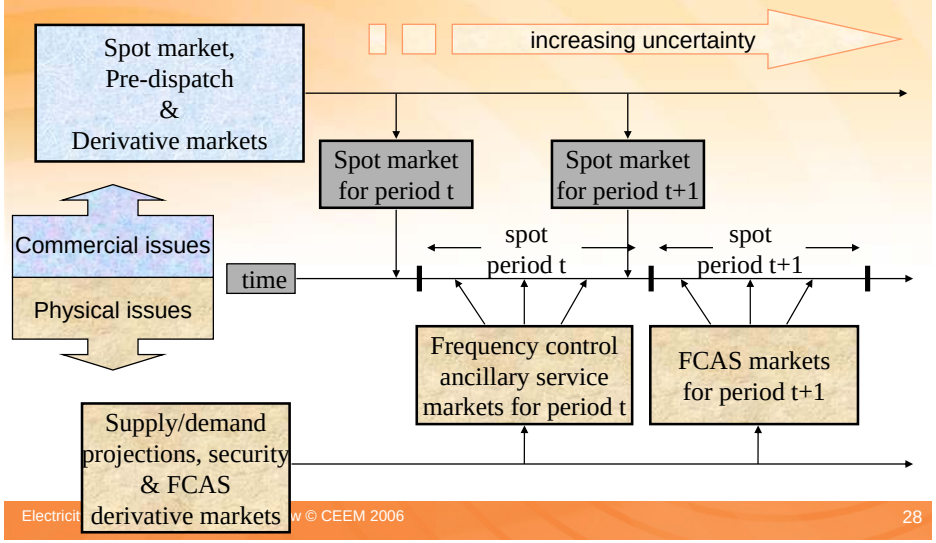
Challenges for a restructured industry

- Consistency between centralised & decentralised processes:
  - *Centralised:* most ancillary services & network services; industry operation; industry design & regulation; government policy for the stationary energy industry
  - *Decentralised:* some ancillary services; spot energy & derivatives
- Sound interface between centralised & decentralised processes:
  - Clear accountabilities & "hand-overs"
- Active involvement of informed end-users:
  - Should take more responsibility for timing of demand, "resource adequacy" & sustainability

Decision making framework for the electricity industry



Managing supply-demand balance in NEM



Uncertainty & risk in electricity trading

Time scale	Issues	Mechanisms
< 30 minutes	• Demand fluctuations • Contingencies	• Ancillary services
30 minutes to several days	• Demand uncertainty • Inter-temporal links, eg • Unit commitment	• Ex-ante spot market • Short term forward market

Weeks to years - *operation*	• Inter-temporal links, eg
	  • Retail tariff setting
	  • Hydro scheduling
		• Long term forward market

Weeks to years Š *investment*	• Optimal investment decisions	• Long term forward market • Policy framework

Ideal spot market trading of electricity

- Use shortest spot market interval consistent with commercial decision making, e.g:
  - Half-hour trading intervals
- Specify locations at which trading occurs:
  - Use multiple locations to partly incorporate network losses & flow constraints
- Active generator & end-user participation:
  - Symmetrical bidding & market clearing price:
    - Express willingness to trade energy
    - Demand & supply side options fully equivalent
  - Allow participants to express voltage quality preferences:
    - Minimise reliance on technical ancillary services

Practical implementation

- Wholesale spot & forward market:
  - Large generators, retailers, large consumers
  - Some representation of networks in markets
- Retail spot & forward market:
  - Retailers, consumers, embedded generators:
    - *In future, wholesale & retail markets might merge*
- Ancillary services (wholesale & retail):
  - Hybrid engineering & commercial arrangements
- Network services:
  - Regulated access regime, administered network pricing, limited competition in some aspects

Metering and communication

- Metering:
  - Interval metering should be provided for all participants:
    - Record 30 minute energy, quality & availability
    - Provide data read-out for participant & market operator
  - Profiling not an adequate option
- Communication:
  - 30-minute energy prices sent to all participants
  - Feeder power flows monitored continuously
  - Participant 30-minute energy collected at appropriate intervals for billing purposes

Conclusions on electricity industry restructuring

- A "designer" process:
  - Industry-specific laws, codes, markets
  - A "social experiment" with risks & ethical issues
- Mix of technical, economic & policy issues:
  - Physical behaviour continuous & cooperative
  - Commercial behaviour individual & competitive
  - Balance between the two is still evolving
- Restructuring is still a learning situation:
  - No complete successes, some disastrous failures, difficult to go back to traditional model
  - Must solve commercial, technical, regulatory & institutional challenges (each aspect must function well)

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