Centre for Energy and Environmental Markets

UNSW



The smart grid:
getting the incentives right

Hugh Outhred
University of New South Wales
National Smart Grids Summit, Sydney 10-11/9/08,

Centre for Energy and Environmental Markets

UNSW

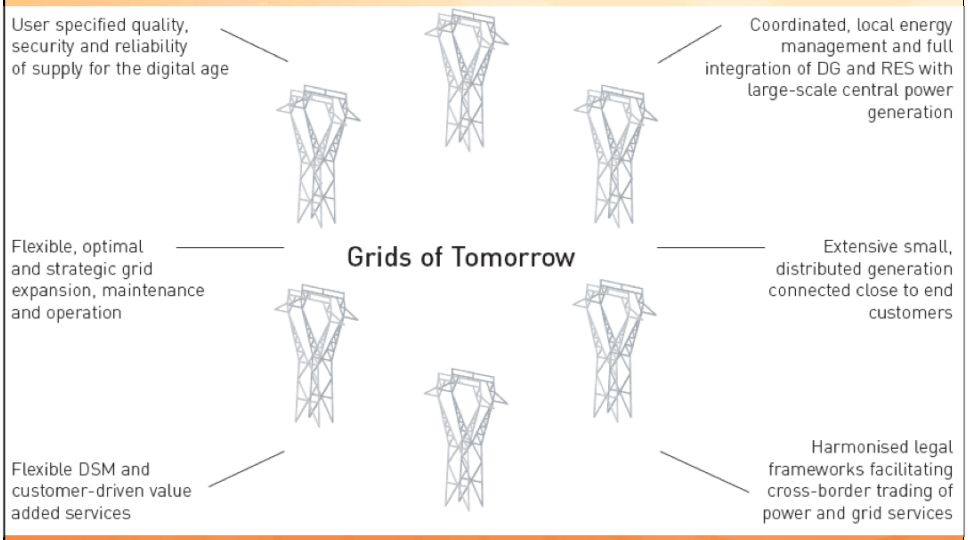
Some smart grid related web sites

en.wikipedia.org/wiki/Smart_grid	http://intelligrid.epri.com
www.oe.energy.gov/smartgrid.htm	www.gridwise.org
www.netl.doe.gov/**moderngrid**	www.smartgrids.eu
www.smartgridnews.com	www.gridweek.com
www.freedm.ncsu.edu	www.galvinpower.org
www.igrid.net.au	www.smartgridaustralia.com.au
www.ceem.unsw.edu.au	

Centre for Energy and Environmental Markets

UNSW

EU SmartGrids Vision (www.smartgrids.eu)



The smart grid: getting the incentives right © CEEM, 2008 3

Centre for Energy and Environmental Markets

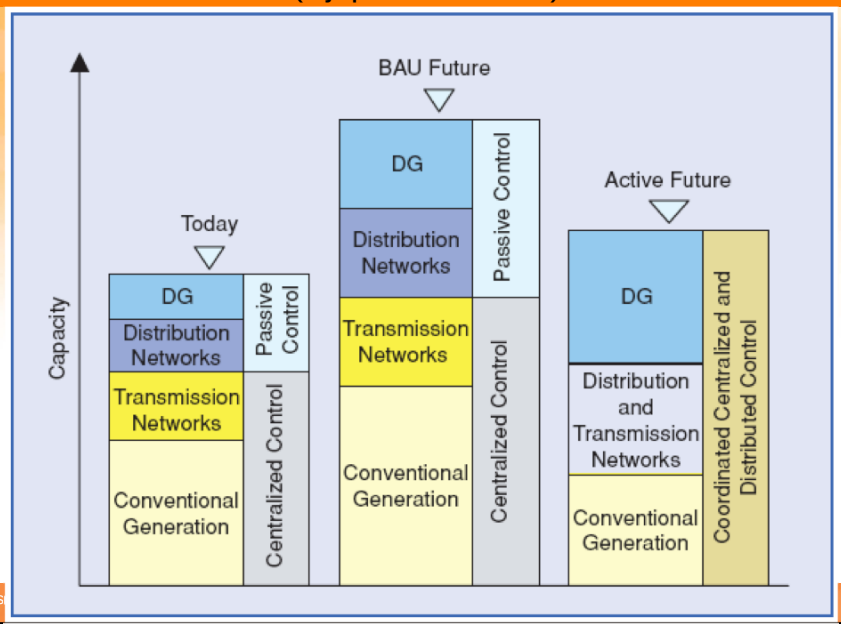
US "modern grid" vision

(www.netl.doe.gov/moderngrid)

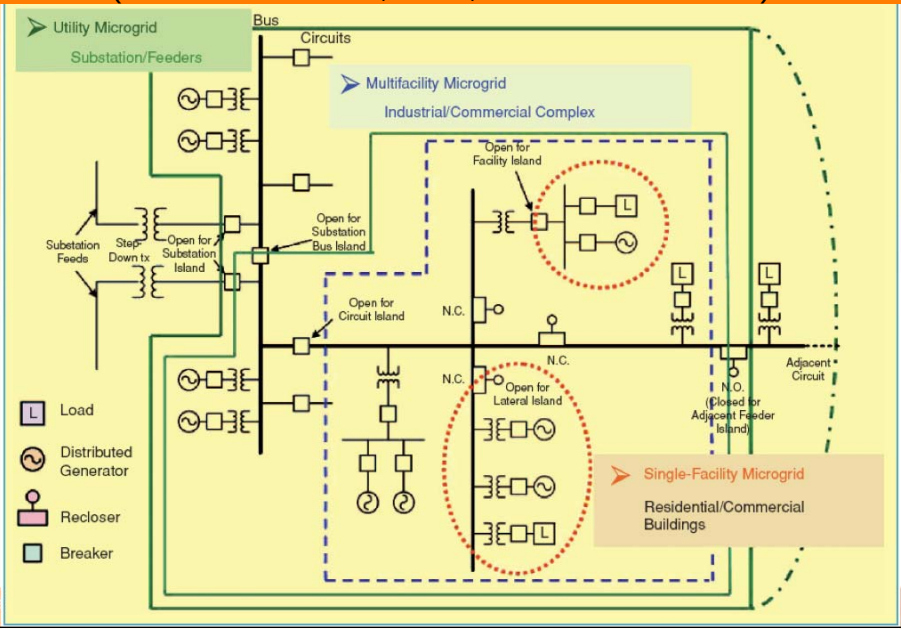
Responds to prevent further damage. Focus is on protection of assets following system faults.	**Self-heals**	Automatically detects and responds to actual and emerging transmission and distribution problems. Focus is on prevention. Minimizes consumer impact.
Consumers are uninformed and non-participative with the power system.	**Motivates & includes the consumer**	Informed, involved and active consumers. Broad penetration of Demand Response.
Vulnerable to malicious acts of terror and natural disasters.	**Resists attack**	Resilient to attack and natural disasters with rapid restoration capabilities.
Focused on outages rather than power quality problems. Slow response in resolving PQ issues.	**Provides power quality for 21st century needs**	Quality of power meets industry standards and consumer needs. PQ issues identified and resolved prior to manifestation. Various levels of PQ at various prices.
Relatively small number of large generating plants. Numerous obstacles exist for interconnecting DER.	**Accommodates all generation and storage options**	Very large numbers of diverse distributed generation and storage devices deployed to complement the large generating plants. "Plug-and-play" convenience. Significantly more focus on and access to renewables.
Limited wholesale markets still working to find the best operating models. Not well integrated with each other. Transmission congestion separates buyers and sellers.	**Enables markets**	Mature wholesale market operations in place; well integrated nationwide and integrated with reliability coordinators. Retail markets flourishing where appropriate. Minimal transmission congestion and constraints.
Minimal integration of limited operational data with Asset Management processes and technologies. Siloed business processes. Time based maintenance.	**Optimizes assets and operates efficiently**	Greatly expanded sensing and measurement of grid conditions. Grid technologies deeply integrated with asset management processes to most effectively manage assets and costs. Condition based maintenance.

The smart grid: getting the incentives right © CEEM, 2008

A "smart grid" vision for distributed control
(Djapic et al, 2007)



Variants on the microgrid theme
(Driesen & Katiraei, 2008, from IEEE P1547.4)



Centre for Energy and Environmental Markets

UNSW

What is a "smart grid"?

- Wikipedia (http://en.wikipedia.org/wiki/Smart_grid):
  - "The term **Smart power grid** may best be defined as using communications and modern computing to upgrade the current electric power grid so that it can operate more efficiently and reliably and support additional services to consumers"
- Hubert Fechner, Arsenal Research, Austria:
  - "A smart grid employs innovative products & services together with intelligent monitoring & control, communication and self-healing technologies…"
- Microgrids: "smart grids" at a local level:
  - With the capability of autonomous operation (islanding)

Centre for Energy and Environmental Markets

UNSW

European SmartGrids Technology Platform Vision (www.smartgrids.eu)

- *"SmartGrids is a new concept for electricity networks across Europe. The initiative responds to the rising challenges and opportunities, bringing benefits to all users, stakeholders and companies that perform efficiently and effectively"*
- *"SmartGrids will use revolutionary new technologies, products and services to create a strongly user-centric approach for all customers"*

Centre for Energy and Environmental Markets

UNSW

What is a "smart grid"? *Australian views*

- iGrid, Australian intelligent grid collaboration:
  - "An 'intelligent grid' is an electricity network that uses energy more efficiently and generates that energy closer to the point at which it is needed"
- Outhred & Schweppe, 1980, *Quality of supply pricing for electric power systems:*
  - "Homeostatic control is a philosophy of approach which exploits advances in communication & computation technology to allow the utility and its customers to participate together in cooperation to control the power system"; "quality of supply pricing is one aspect of homeostatic control"

Centre for Energy and Environmental Markets

UNSW

"Smart grid" is an ambiguous concept

- Key ideas first proposed in 1980:
  - Schweppe, Tabors, Kirtley, Outhred, Pickel & Cox (1980), *Homeostatic Utility Control,* IEEE Transactions on Power Apparatus & Systems
  - Outhred & Schweppe, *Quality of Supply Pricing for Electric Power Systems,* IEEE Power Engineering Society Winter Meeting,1980
- The Australian National Electricity Market has a number of "smart grid" attributes
- This presentation will explore necessary conditions to achieve useful outcomes

Centre for Energy and Environmental Markets

UNSW

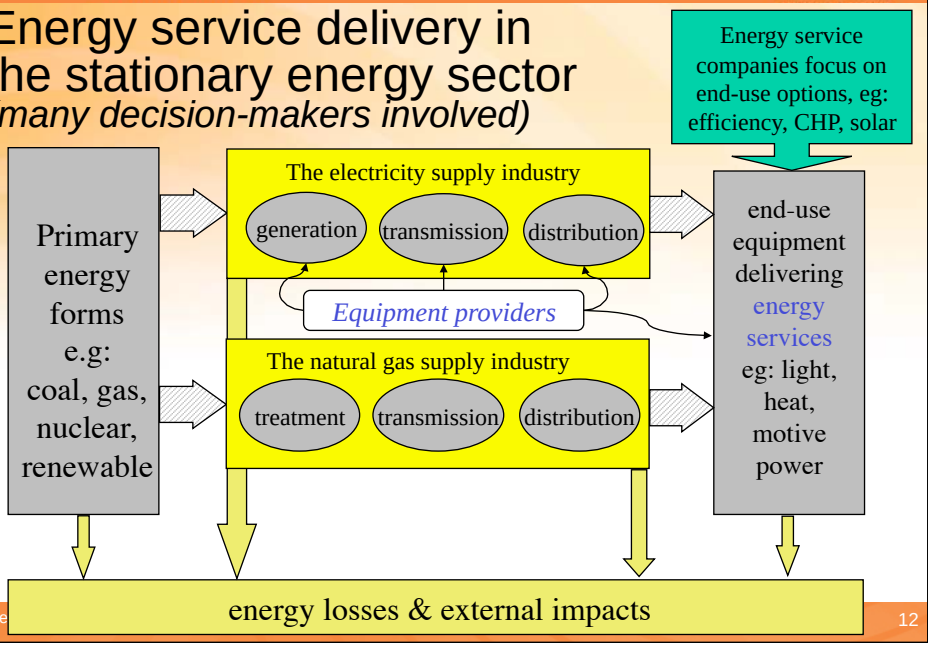
Assumptions used in this presentation

- The key objective for the "smart grid" concept is:
  - Coordinated, decentralised investment in & operation of distributed resources to deliver net societal benefits
- Key requirements in achieving this objective are:
  - A protocol for interfacing "smart grid" elements to create an effective technological system (electricity industry)
  - An associated communications system
  - A formal decision-making framework to allocate authority & accountability to decentralised decision-makers
  - A formal incentive/penalty regime to align the incentives of decentralised decision-makers with societal objectives
  - A robust migration path to a "smart grid future"

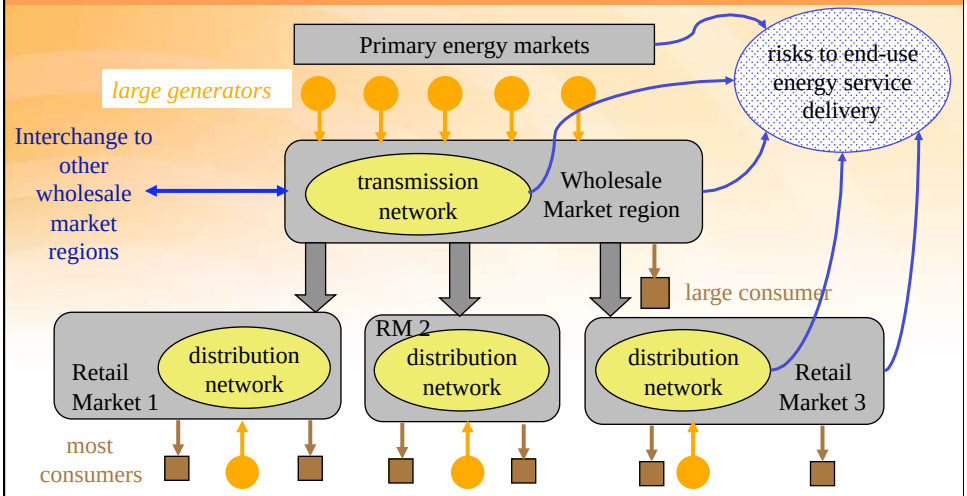
Centre for Energy and Environmental Markets

UNSW

Energy service delivery in the stationary energy sector
(many decision-makers involved)



An electricity industry decision-making framework must work for all resources



- *Small consumers, embedded generators & storage require AMI & should be supported by energy service advisers*
- *Wholesale & retail market designs should be compatible*
  - *Both should include network models*

Electricity industry restructuring 13

Centre for Energy & Environmental Ma

What is technology?

(www.iiasa.ac.at)

Software & orgware are critical for complex technological systems such as electricity & communications

The Art of Knowing and Doing

The study of **technology** concerns *what* things are made and *how* things are made. Technology, from the Greek *science of* (practical) *arts,* has both a *material* and an *immaterial* aspect.

Technology = Hardware + Software + "Orgware"

Hardware:	Manufactured objects (artifacts)
Software:	Knowledge required to design, manufacture, and use technology hardware
"Orgware":	Institutional settings and rules for the generation of technological knowledge and for the use of technologies

Technology's most important characteristic: ***Continuous change >>***

Electricity industry restructuring ove

Centre for Energy and Environmental Markets

UNSW

Decision-making framework for a modern electricity industry

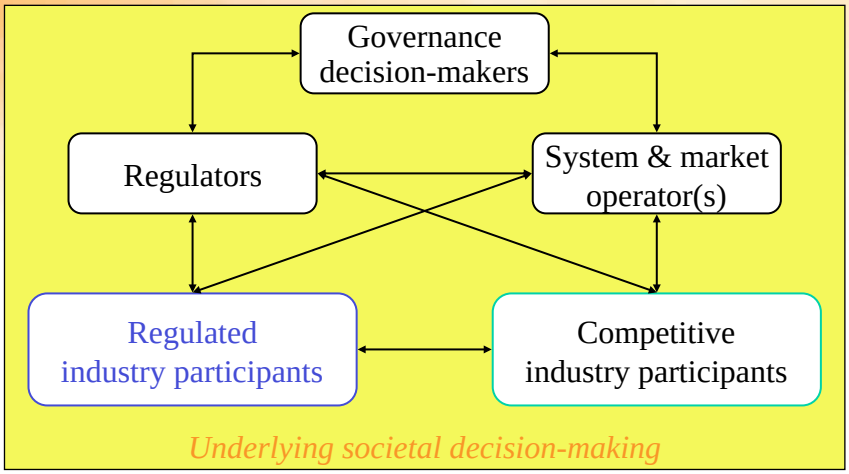
Governance regime	▪ Formal institutions, legislation & policies ▪ *Informal social context including politics*
Security regime	▪ Responsible for core integrity on local or industry-wide basis, with power to override
Technical regime	▪ To allow connected components to function as single, reliable industry-wide machine
Commercial regime	▪ To coordinate decentralised decision-making according to commercial criteria ▪ Includes formally designed markets

Electricity industry restructuring overview © CEEM 2008 15

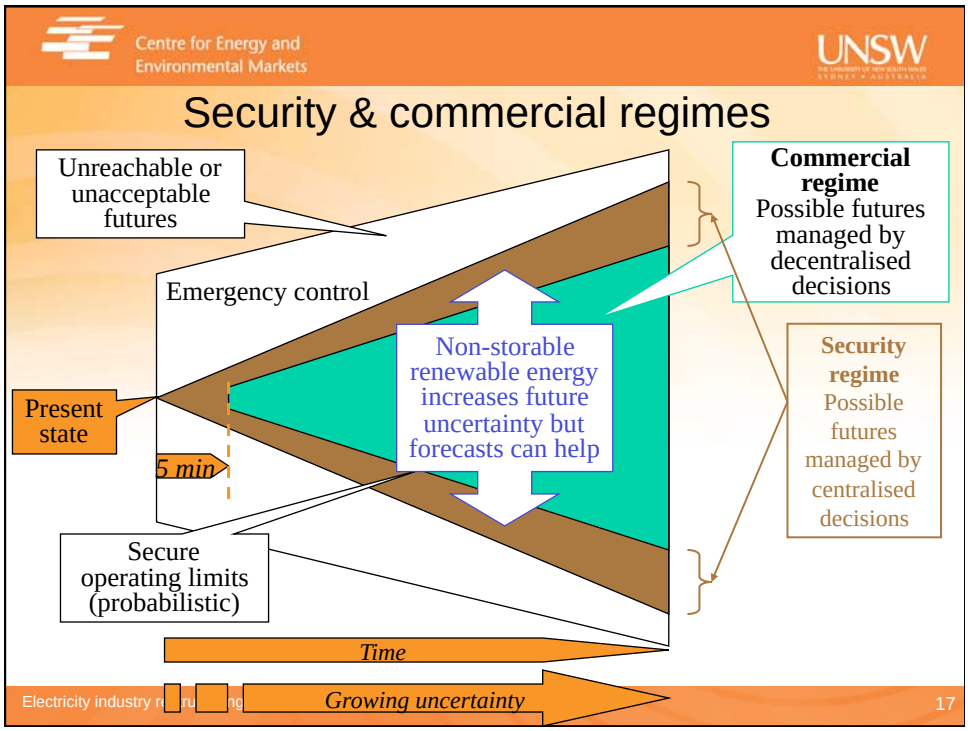
Centre for Energy and Environmental Markets

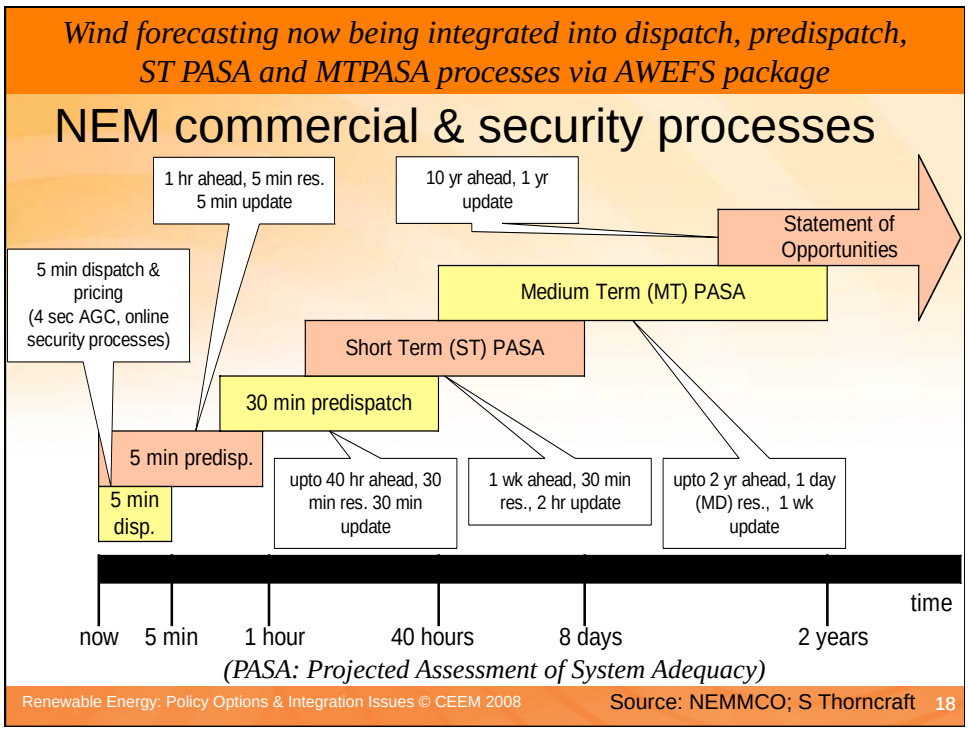
UNSW

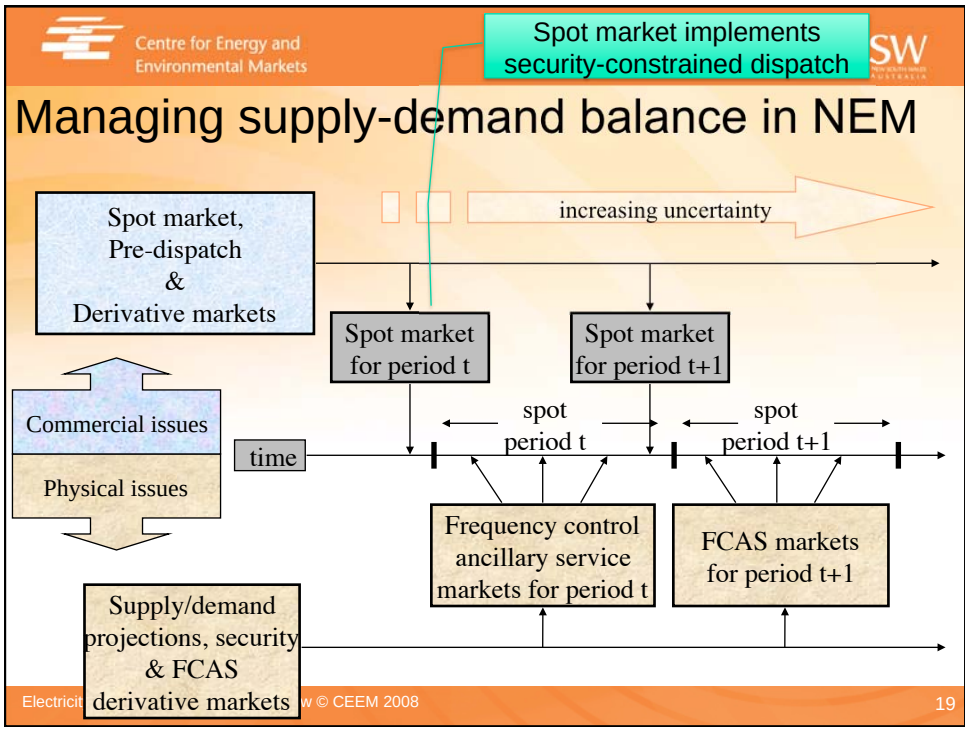
Decision-making framework for a modern electricity industry

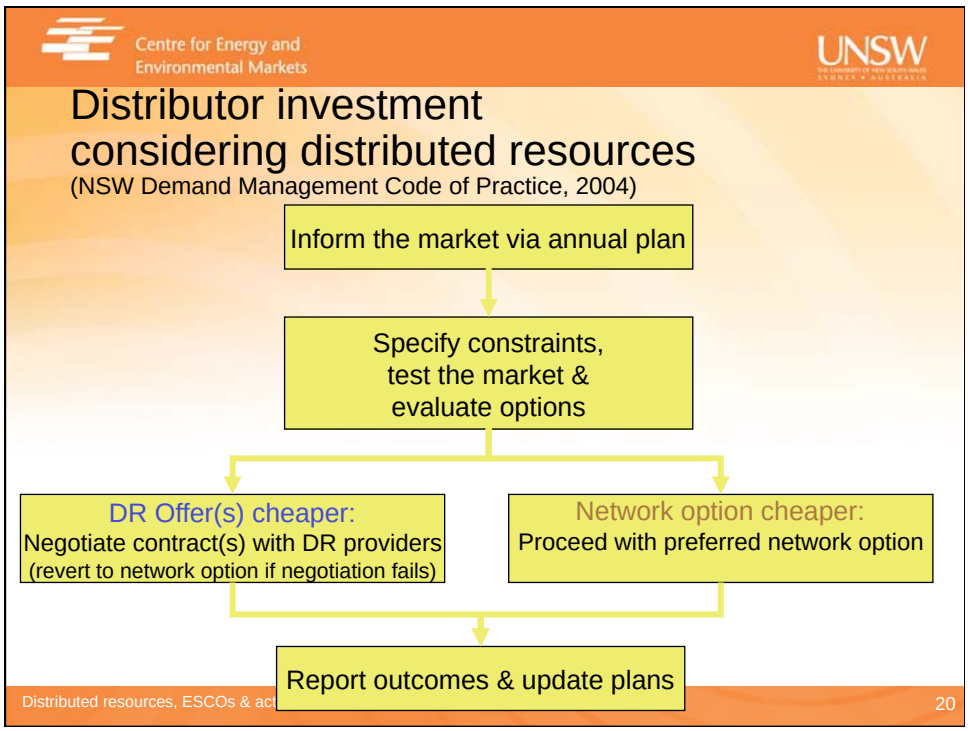


Electricity industry restructuring overview © CEEM 2008 16


Centre for Energy and Environmental Markets
UNSW
Security & commercial regimes
Unreachable or unacceptable futures
Emergency control
Present state
5 min
Secure operating limits (probabilistic)
Non-storable renewable energy increases future uncertainty but forecasts can help
Commercial regime
Possible futures managed by decentralised decisions
Security regime
Possible futures managed by centralised decisions
Time
Growing uncertainty
17


Wind forecasting now being integrated into dispatch, predispatch, ST PASA and MTPASA processes via AWEFS package
NEM commercial & security processes
1 hr ahead, 5 min res. 5 min update
10 yr ahead, 1 yr update
Statement of Opportunities
5 min dispatch & pricing (4 sec AGC, online security processes)
Medium Term (MT) PASA
Short Term (ST) PASA
30 min predispatch
5 min predisp.
5 min disp.
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
time
now
5 min
1 hour
40 hours
8 days
2 years
(PASA: Projected Assessment of System Adequacy)
Renewable Energy: Policy Options & Integration Issues © CEEM 2008
Source: NEMMCO; S Thorncraft
18

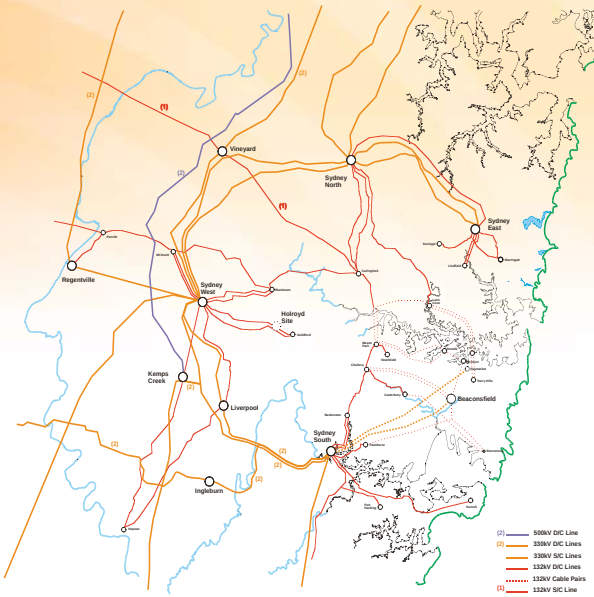

Centre for Energy and Environmental Markets
Spot market implements security-constrained dispatch
Managing supply-demand balance in NEM
Spot market, Pre-dispatch & Derivative markets
increasing uncertainty
Spot market for period t
Spot market for period t+1
Commercial issues
Physical issues
time
spot period t
spot period t+1
Frequency control ancillary service markets for period t
FCAS markets for period t+1
Supply/demand projections, security & FCAS derivative markets
Electricit
w © CEEM 2008
19


Centre for Energy and Environmental Markets
UNSW
Distributor investment considering distributed resources
(NSW Demand Management Code of Practice, 2004)
Inform the market via annual plan
Specify constraints, test the market & evaluate options
DR Offer(s) cheaper:
Negotiate contract(s) with DR providers
(revert to network option if negotiation fails)
Network option cheaper:
Proceed with preferred network option
Report outcomes & update plans
Distributed resources, ESCOs & act
20

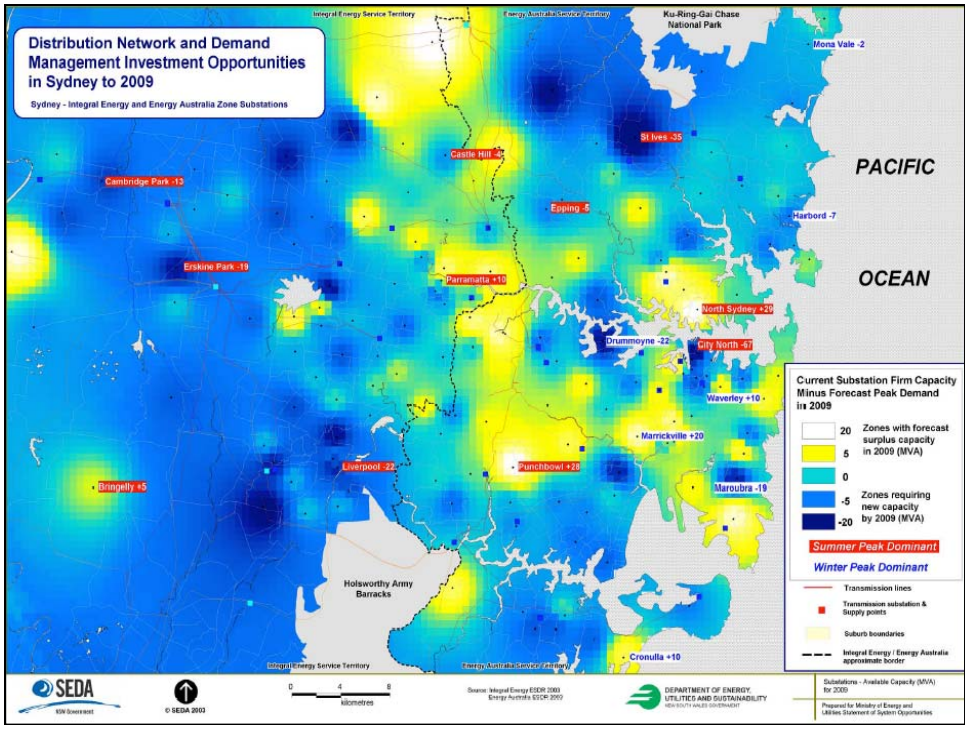
Centre for Energy and Environmental Markets

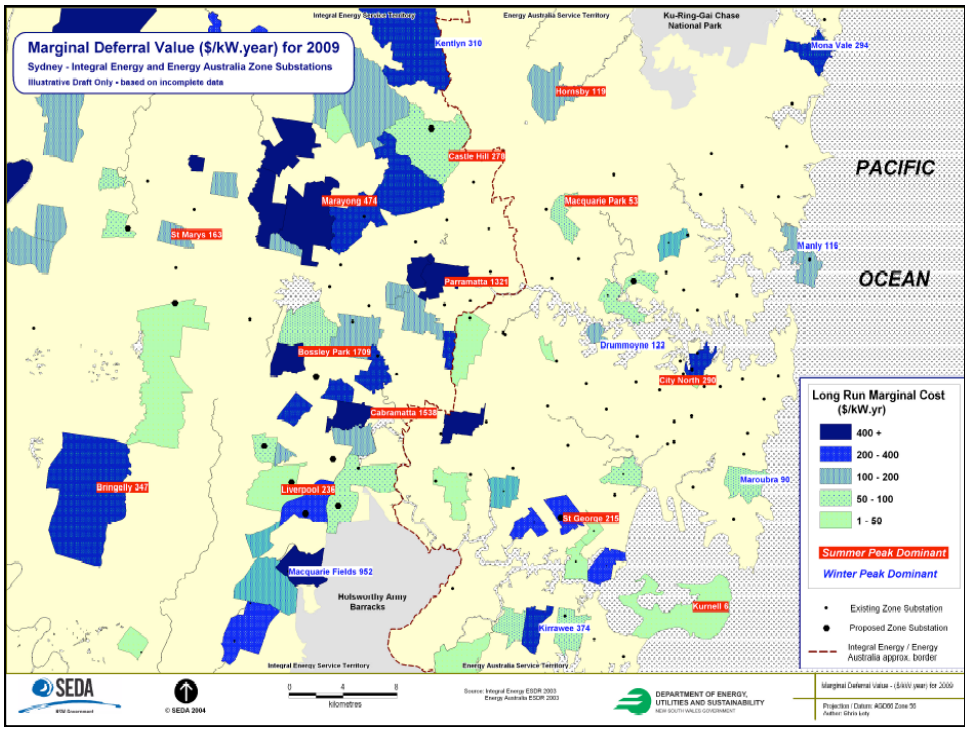
UNSW

NSW transmission network, Sydney region
(M Park, 2005)



Distributed resources, ESCOs & active end-users © CEEM 2007 21

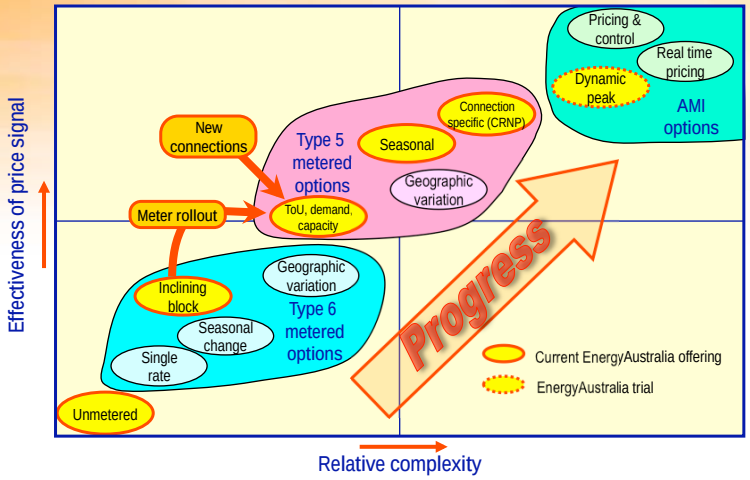




Centre for Energy and Environmental Markets

UNSW

EnergyAustralia vision for network pricing
(Colebourn, 2006)



Distributed resources, ESCOs & active end-users © CEEM 2007 24

Centre for Energy and Environmental Markets

UNSW

EnergyAustralia distributor meter & network tariff strategy (H Colebourn, 2005)

- Only half-hour meters installed since July 2004
- Replacement half-hour meters for most of 25,000 40-160 MWH end-users installed by June 2005
- Replacement half-hour meters for 110,000 15-40MWH end-users by June 2010
- 3-rate TOU network tariff from March 2005
- Seasonal TOU network tariff from July 2005
- Tests of communication systems to support non-predetermined pricing & interruptible loads

Centre for Energy and Environmental Markets

UNSW

Valuing distributed resources (DR)

- Three important issues in valuing DR:
  - Time-varying value of energy should reflect flow constraints
  - Quality of supply, particularly voltage & frequency
  - Obligation to serve on DNSPs *(externalities also important)*
- DR role can be facilitated by coordinated technical & market mechanisms
  - Non-predetermined prices for energy & ancillary services:
    - Value DR improvements to availability & quality of supply
    - Penalise disturbances to availability & quality of supply
  - Communication & interval metering with QOS measurement
  - ESCOs would assist end-users to respond efficiently

Centre for Energy and Environmental Markets

UNSW

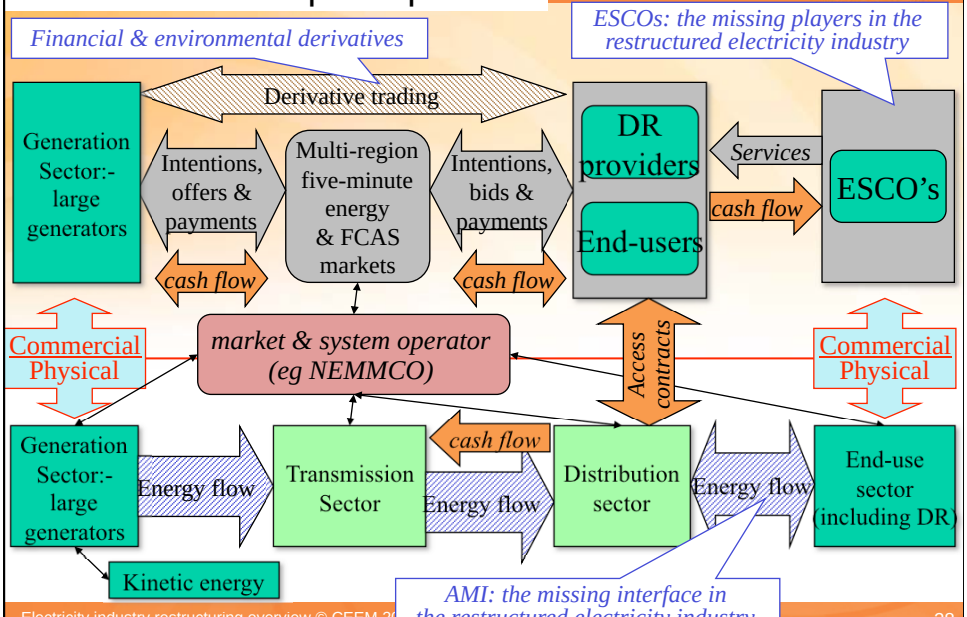
The evolving role of retailers

- The retailer role in an electricity industry is ambiguous:
  - Retailers don't participate in the physical industry
- With interval metering roll-out, retail tariffs may evolve to a spot & derivative contract form:
  - Based on wholesale market energy spot prices
  - Supplemented by NSP flow constraint pricing & ancillary service spot prices
- Retailers may evolve to become ESCOs, providing end-users with products & services

Distributed resources, ESCOs & active end-users © CEEM 2007 27

Enhanced NEM structure with active end-user participation

UNSW



Electricity industry restructuring overview © CEEM 20 28

Centre for Energy and Environmental Markets

UNSW

Conclusions #1

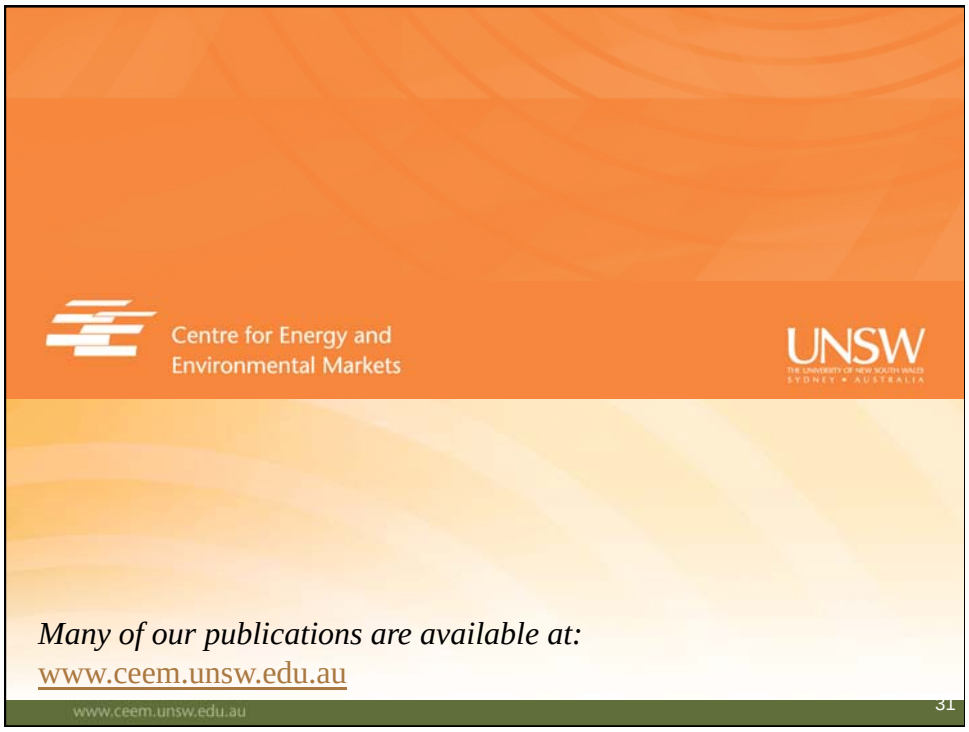
- The key objective for the "smart grid" concept is:
  - Coordinated, decentralised investment in & operation of distributed resources to deliver net societal benefits
- Key requirements in achieving this objective are:
  - A protocol for interfacing "smart grid" elements to create an efficient technological system (electricity industry)
  - A formal decision-making framework to allocate authority & accountability to decentralised decision-makers
  - A formal incentive/penalty regime to align the incentives of decentralised decision-makers with societal objectives
  - A communication system that links all industry participants
  - A robust migration path to a "smart grid future"

Centre for Energy and Environmental Markets

UNSW

Conclusions #2

- The Australian National Electricity Law & National Electricity Rules:
  - Provide a good basis for evolving to a "smart grid"
- But need further development in the areas of:
  - AMI (interval metering & communication)
  - Retail market design (ancillary service, spot & derivatives)
  - Network service operation, investment & pricing
  - End-user engagement
  - Security management
  - Communications standards


Centre for Energy and
Environmental Markets
UNSW
Many of our publications are available at:
www.ceem.unsw.edu.au
www.ceem.unsw.edu.au
31