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Network services

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Outline

- Network services - regulated or competitive?
- Ideal - nodal market at each connection point:
  - Ancillary services, spot energy, future risk
  - Network arbitrage versus local resources
  - Active demand-side participation
- Impractical near term, uncertain long term:
  - Complexity, market power, uncertainty
- Practical approaches depend on context:
  - Regional markets & negotiation frameworks
  - Network service, pricing & investment protocols:
    - To allow distributed resources to compete

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Competitive or regulated network services?

more centralised < decision-making > *more decentralised*

- Formally regulated network services
- Negotiation frameworks for network services
- Network services fully represented in ancillary service, spot & derivative markets
- Combinations of the above (hybrid models)

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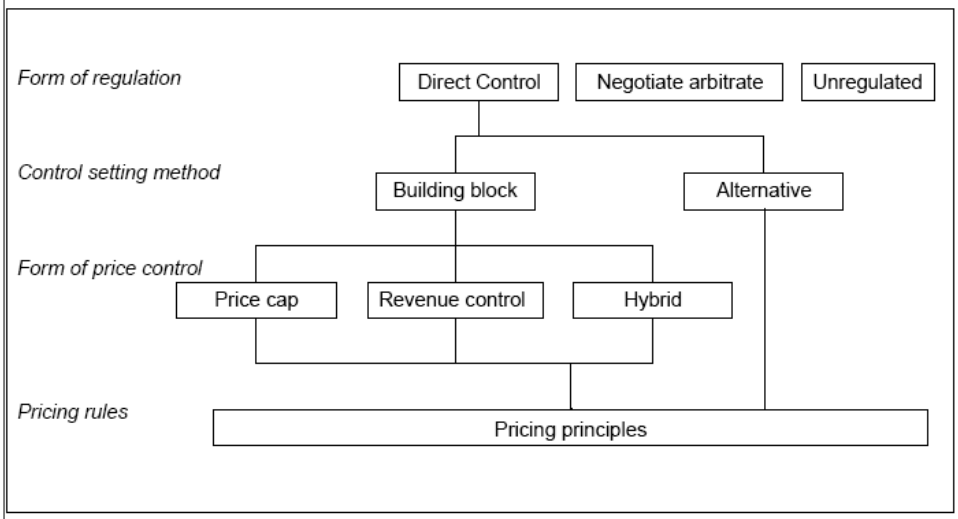
Regulatory taxonomy for network services
(Network Incentives for DSR & DG, NERA, 2007)



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Formally regulated network services

(example: building block model applied at each regulatory review)

Building blocks *(to meet performance standards)***:**
- Value of existing assets at time of regulatory review
- Projected operating costs of existing assets till next review
- Approved expansion plan till next review *(may include DR)*

Issues:
- User benefits
- DR vs network
- Risk allocation
- Sunk costs

Regulatory algorithm *(to mimic competitive industry)***:**
- Annual average price cap (with pre-set annual adjustment)
- Annual revenue cap (with pre-set annual adjustment)
- Combination of the above & possibly negotiation framework

Issues:
- Gold-plating
- Accountability
- Incentives

Tariff-setting rules *(to meet socio-political goals)*:
- Allocation of approved revenue to network user categories
- Tariff types (eg demand/energy; real/apparent power)
- Side constraints (eg max escalation from one year to next)
- Contestability provisions & contracts with DR providers

Issues:
- Efficiency
- Accountability
- Incentives & cost allocation

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Fully competitive electricity industry model:

Nodal ancillary service, spot & derivative markets

- Based on a set of markets at each node:
  - Nodal ancillary service, spot & forward markets
  - Nodal prices set by simultaneous, uniform price auction
- Participants in the set of markets at a node:
  - Generators & end-users connected to that node:
    - Requires advanced metering infrastructure (AMI)
  - Flows between that node & the rest of the network
- Markets solved simultaneously to maximise benefits of trade (network-based arbitrage):
  - To reflect network's physical exploitation of diversity
  - Subject to network losses & flow constraints

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A definition of network services in a fully competitive electricity industry

- Arbitrage between nodal markets
  - In ancillary services, spot energy & future risk
- Subject to *centralised* & decentralised constraints:
  - *Operating limits imposed for system security:*
    - *Influenced by the characteristics of generators, loads & network elements as well as the system operating state*
    - *Matters of judgement rather than objectively set*
  - Availability of network elements
  - Energy losses in network components
  - Maximum ratings of network elements

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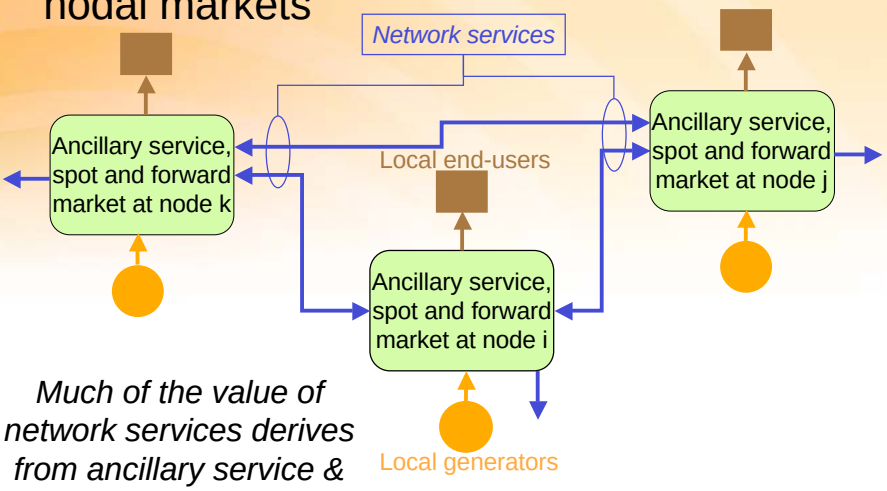
Network arbitrage between nodal markets



Much of the value of network services derives from ancillary service & investment timescales

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Solving nodal spot markets that include a network model

- Single node assumption (or strong network):
  - All sellers & buyers at one location
- Two node model:
  - Sellers at one node, buyers at the other:
    - Constrained line but no losses
    - Unconstrained line with line losses
    - Competing options to relieve a network flow constraint
- Three and five node models:
  - Interaction between lines in a meshed network

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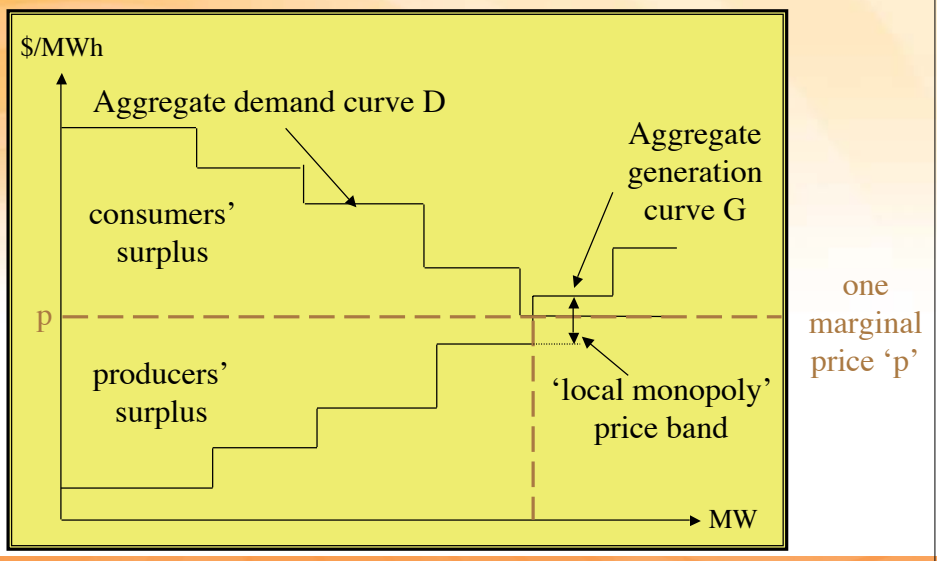
Single node spot market



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Issues illustrated by one node example
(all participants at one location or strong network)

- Buyers & sellers see the same nodal price
- No revenue to network operator:
  - No network-based arbitrage
- The marginal buyer or seller may have a 'local monopoly':
  - The ability to set price within a limited band
  - More likely with fewer participants

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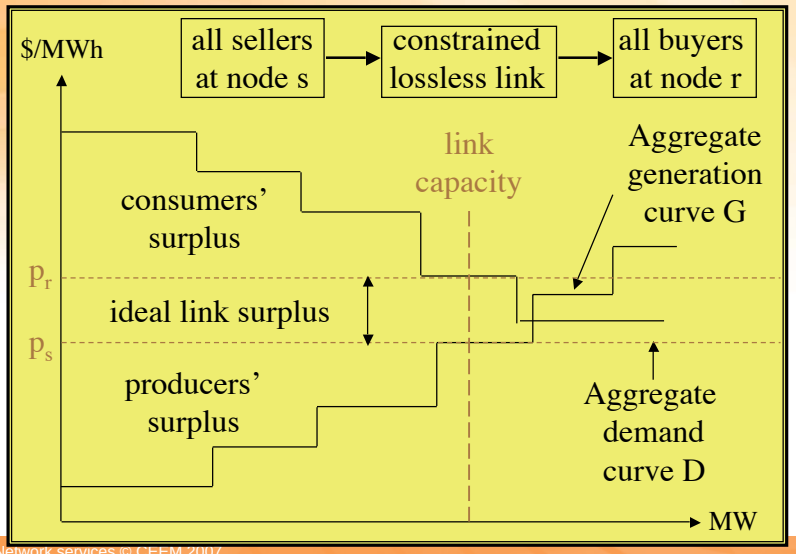
Two-node spot market with



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Issues illustrated by 2 node example: constrained, lossless link

- Nodal prices are set to constrain flow to link capacity (quantity rationing):
  - $p_r > p_s$ (always true for radial case)
  - link outage causes market collapse
- Link owner has a perverse incentive:
  - to constrain link capacity (but not to zero)
- Sellers & buyers may capture some of ideal link surplus due to 'local monopoly':
  - Local market power greater if link constrained

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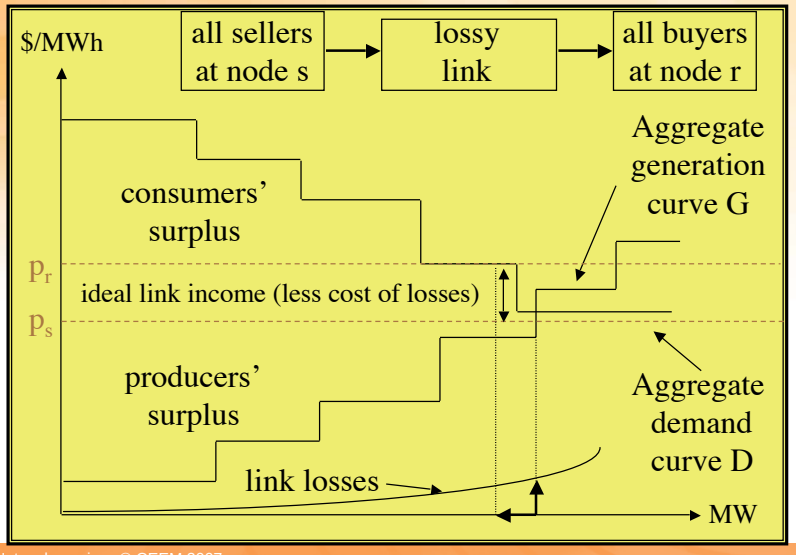
Two-node spot market with unconstrained lossy link



related nodal prices p_r & p_s

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Issues illustrated by 2 node example: unconstrained, lossy link

- Unconstrained, lossy link between all sellers & all buyers
- Link operator buys at sending end, sells at receiving end, increasing link flow until:
  - cost of next increment of flow = its sale value:

    i.e. $p_s(\Delta X+\Delta L) = p_r \Delta X$ [ΔX = sale, ΔL = loss]

    hence: $p_r = (1+ \Delta L/ \Delta X) p_s$
- Thus nodal prices are related by the incremental loss of an unconstrained link

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Relieving network flow constraints

- Link flow constraints can be alleviated by:
  - investment in additional link capacity
  - investment in distributed resources:
    - Appropriately located generation, storage or load
  - relaxation of QOS criteria
- Investment underwritten by forward markets:
  - generator: sell CFD or call option at node ‘r’
  - load: buy CFD or CO at node ‘s’
  - link: buy CFD/CO at node ‘s’ and sell CFD/CO at node ‘r’

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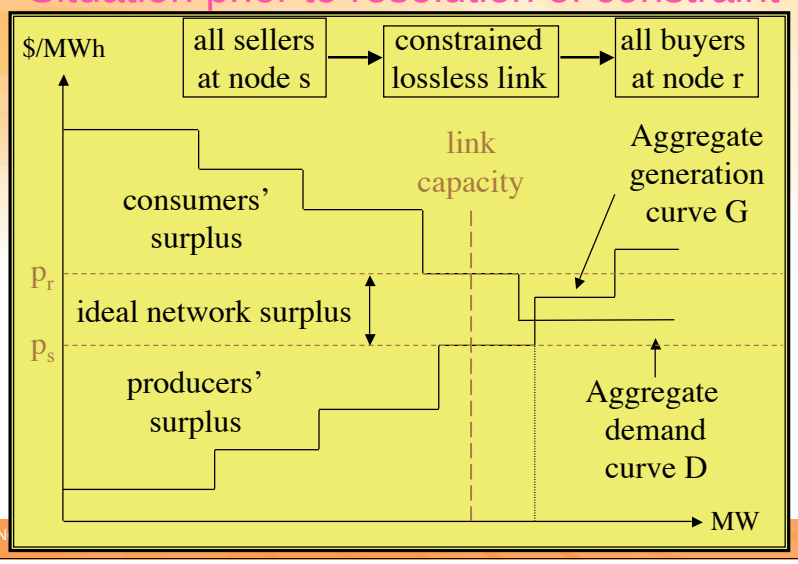
Relieving network flow constraints:
Situation prior to resolution of constraint



two marginal prices p_r & p_s some network surplus

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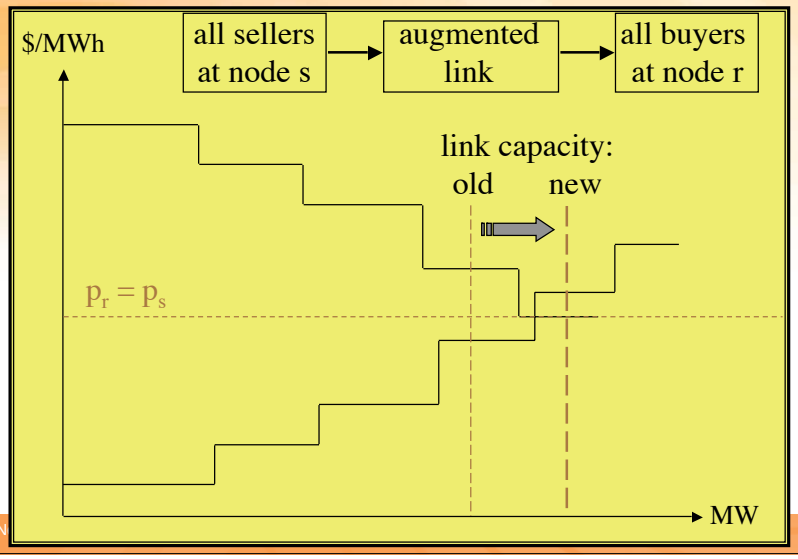
Relieving network flow constraints:
Option 1 - augment link capacity



one marginal price $p_r = p_s$, no network surplus

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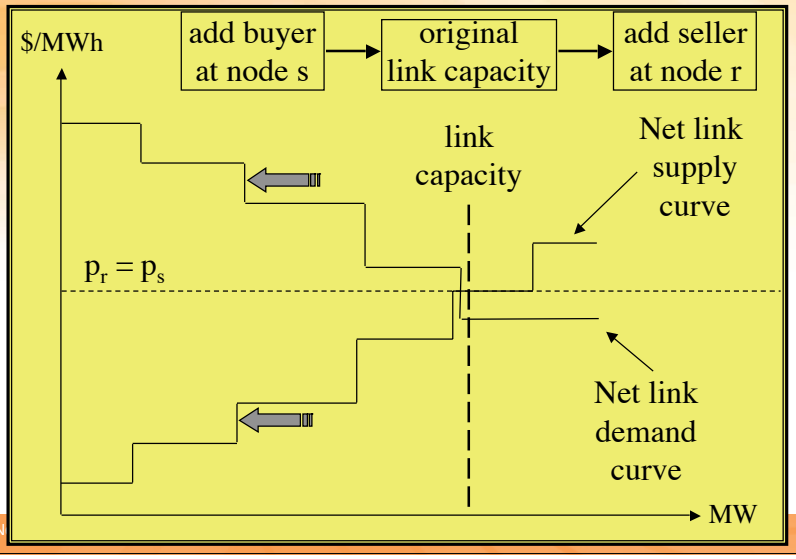
Relieving network flow constraints:
Option 2 - add distributed resources



one marginal price $p_r = p_s$, no network surplus

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Limits to the effectiveness of nodal markets

- For a given network, more nodal markets:
  - Mean fewer participants in each nodal market:
    - Local participants & network owners gain market power
    - Ancillary services, spot energy & risk harder to price
  - Require a more accurate network model
  - *There is a lower limit to the level of network detail that nodal markets can resolve*
- Regional markets provide one option:
  - Place major flow constraints on region boundaries:
    - Models of "notional interconnectors" then required
  - Resolve intra-regional network flow constraints by negotiation under regulatory supervision

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NER treatment of network losses & capital costs

- NER contains NEM rules & access regime:
  - Both address network issues
- National Electricity Market trading rules:
  - Notional regulated interconnectors & associated settlement residue auctions
  - Market network service provider (unregulated intercon)
  - Intra-regional network loss factors & constraints
- Network access and pricing:
  - Revenue cap for regulated network service providers

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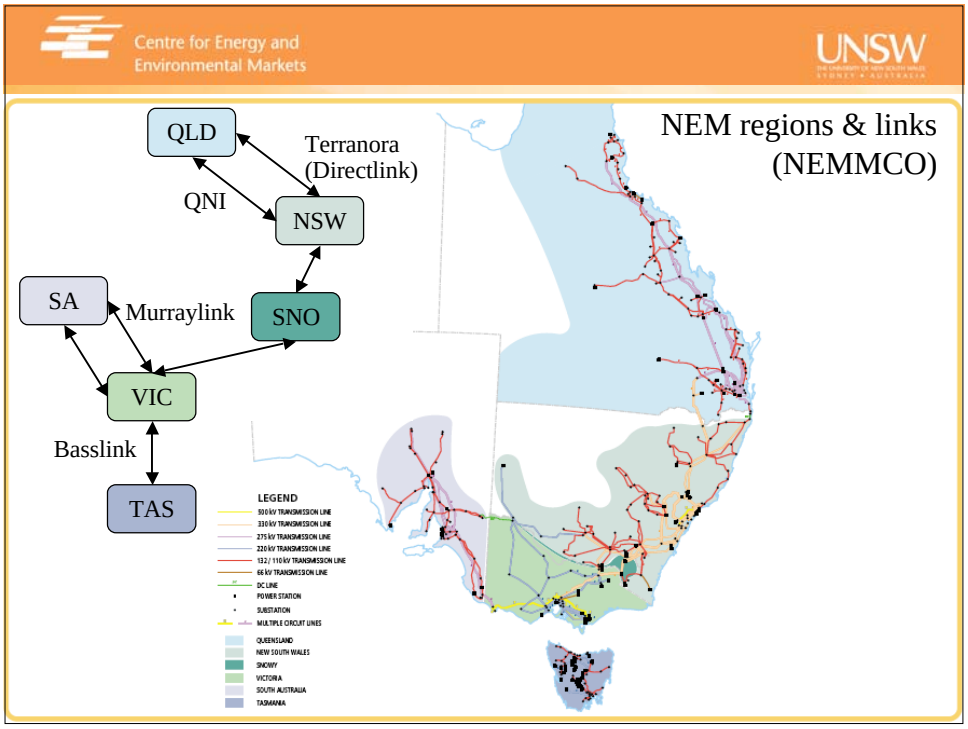
NER treatment of network flow constraints

- NEMMCO documents inter- & intra- regional flow constraints:
  - these are inputs to the dispatch process
- Original concept:
  - Significant transmission constraints appearing 50 hours per year or more:
    - To be placed on market region boundaries where it is practical to reset the boundaries to do so
- Not followed due to opposition by some states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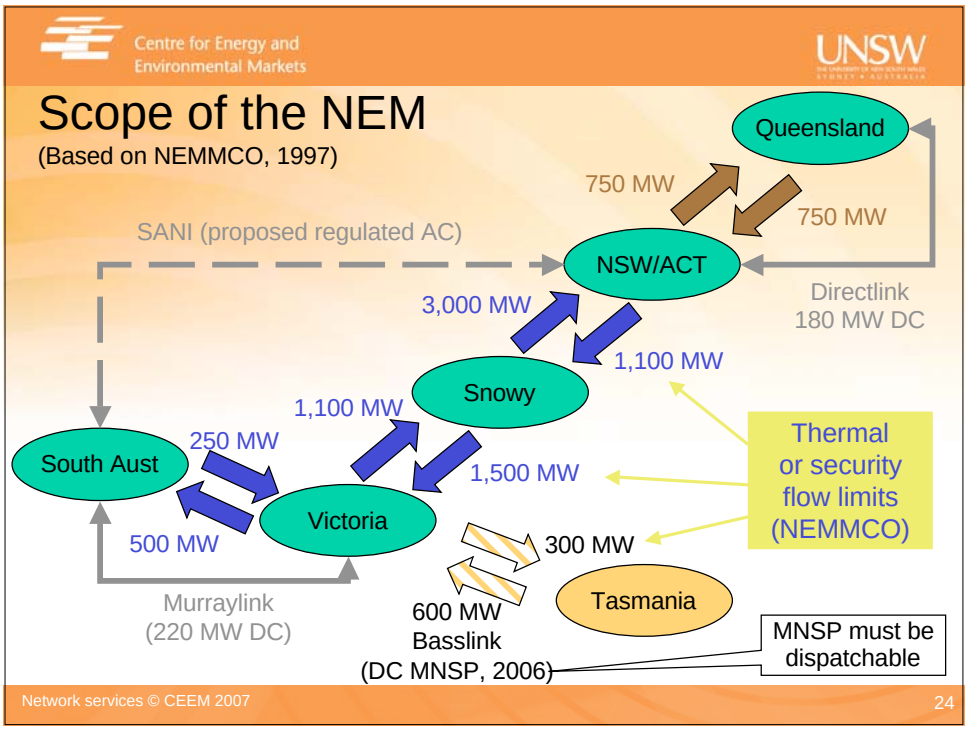
NEM regions & links (NEMMCO)
QLD
Terranora (Directlink)
QNI
NSW
SA
Murraylink
SNO
VIC
Basslink
TAS
LEGEND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Scope of the NEM
(Based on NEMMCO, 1997)
Queensland
750 MW
750 MW
SANI (proposed regulated AC)
NSW/ACT
Directlink
180 MW DC
3,000 MW
1,100 MW
Snowy
1,100 MW
250 MW
South Aust
1,500 MW
Thermal or security flow limits (NEMMCO)
Victoria
500 MW
300 MW
Tasmania
Murraylink
(220 MW DC)
600 MW
Basslink
(DC MNSP, 2006)
MNSP must be dispatchable
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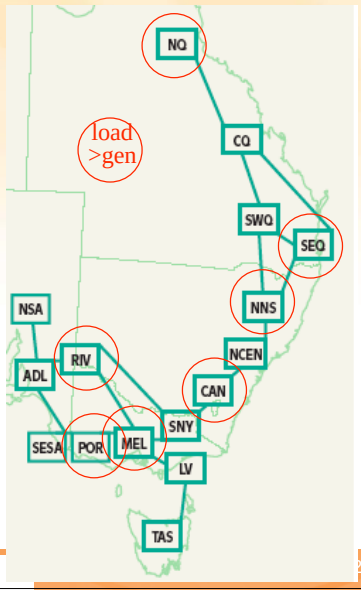
Node	Pk Ld (MW)	Gen Cap (MW)	Net Gen (MW)
NQ	1250	800	- 450
CQ	1900	4150	2250
SWQ	200	2150	1950
SEQ	4350	1450	- 2900
NNS	800	150	- 650
NCEN	10000	11650	1650
CAN	800	300	- 500
SNY	800	3900	3100
MEL	5750	800	- 4950
LV	900	7000	6100
POR	650	0	- 650
SESA	100	150	50
RIV	500	50	- 450
ADE	2100	2250	150
NSA	200	1100	900
TAS	1500	2500	1000

16 region NEM model

(NEMMCO SOO, 2004)



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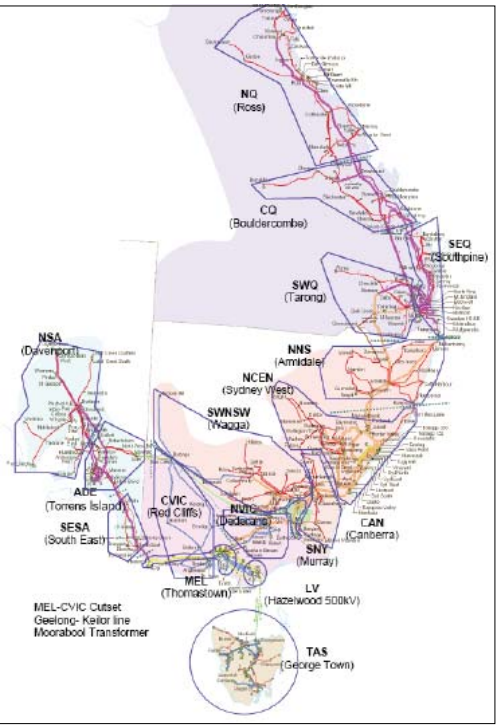
ANTS zones & transmission paths (NEMMCO 2006)



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(Qld Govt, 2006)

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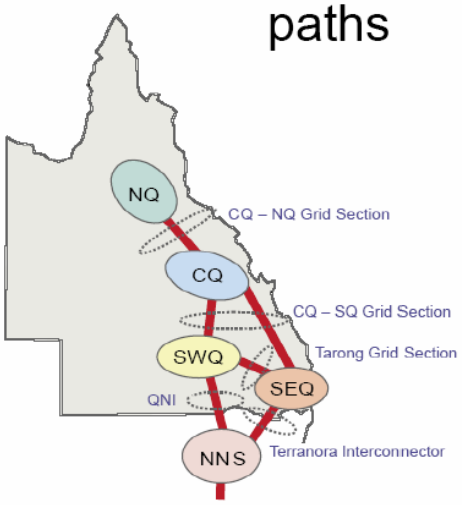
Queensland's major transmission flow paths



Legend

NQ	North Queensland
CQ	Central Queensland
SWQ	South West Queensland
SEQ	South East Queensland
NNS	Northern New South Wales

Queensland Government
Department of Energy

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Inter-regional hedges for regulated interconnectors

- A hedge against differences between regional spot prices for one direction of flow
- Based on interconnector settlement residue:
  - Difference in regional reference prices multiplied by interconnector power flow
    - for each spot market interval
- 3-monthly auctions of settlement residue
  - first offered for South Australia interconnector
- Incomplete hedge:
  - doesn't cover interconnector losses or outages

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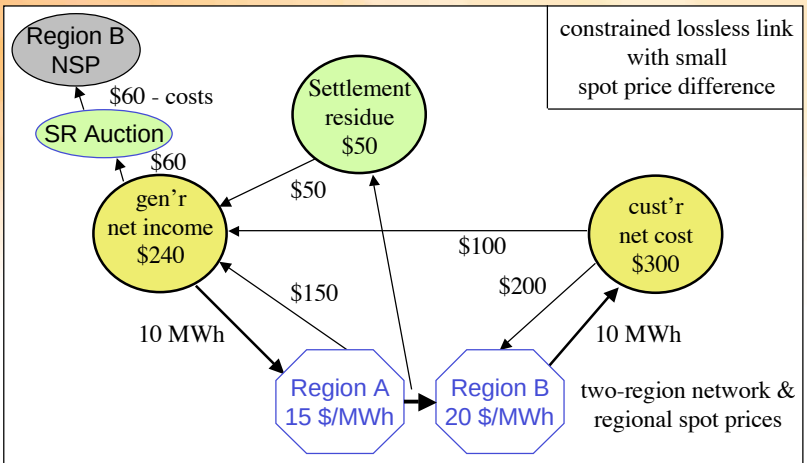
Inter-regional settlement residue example



Generator sells a 10 MWh hedge contract on region B price to customer at $30/MWh & buys a directed 10 MWh hedge (B-A) from NEMMCO SR auction at cost of 6 $/MWh (expected spot price difference between regions)

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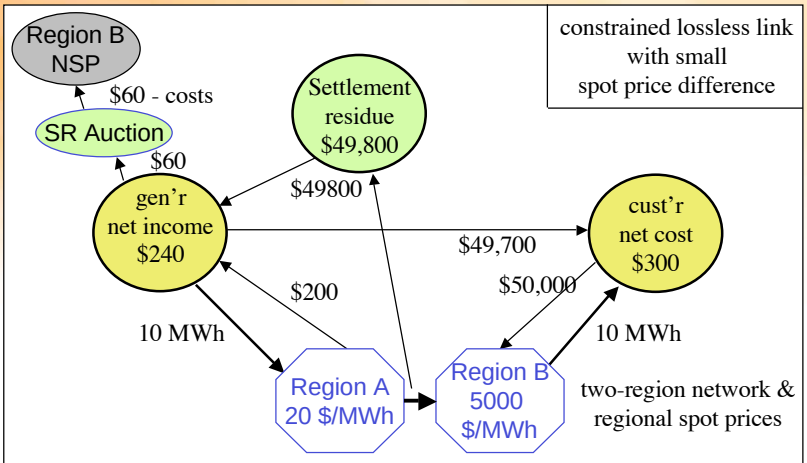
Inter-regional settlement residue example ctd



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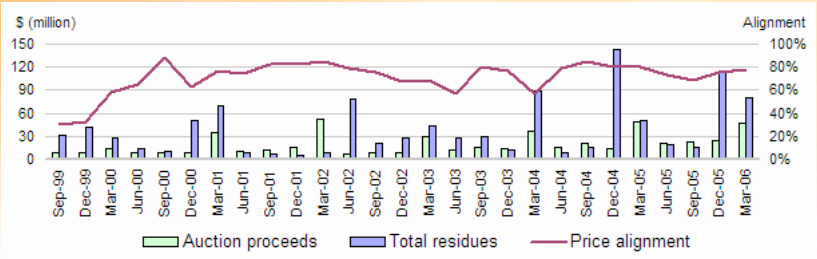
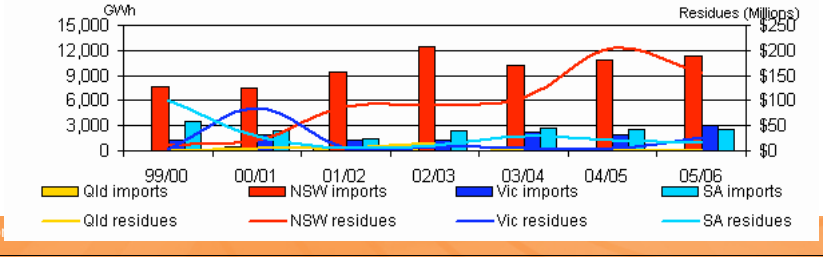
SRA outcomes (AER long term analysis)





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Financial outcomes from Settlement Residue Auctions (NEMMCO, 2006)

Financial Year	Auction Proceeds [$Million]	Residues distributed [$Million]	Profit to SRA Participants
1999/2000	$41	$60	47%
2000/2001	$64	$105	63%
2001/2002	$87	$98	13%
2002/2003	$62	$120	94%
2003/2004	$81	$141	73%
2004/2005	$105	$230	119%
2005/2006	$118	$220	86%
Totals	$558	$975	74%

Less revenue went to TNSPs than if no SRA's - the difference is paid by end-users

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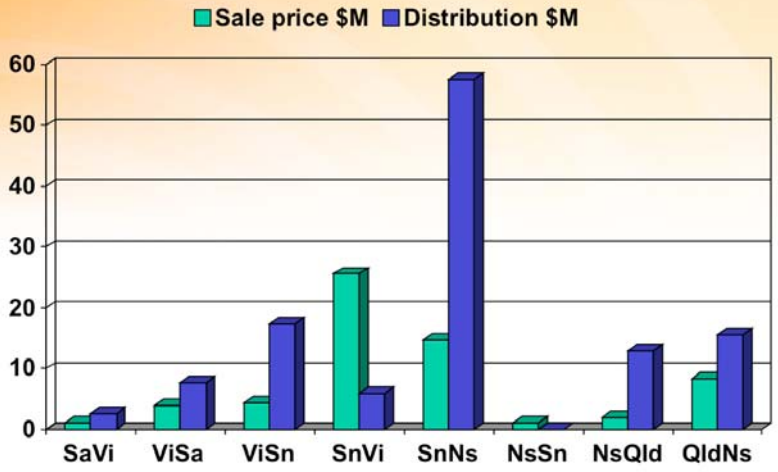
Annual outcomes of NEM SRAS for FY03

(SRC report FY03 see www.nemmco.com.au)



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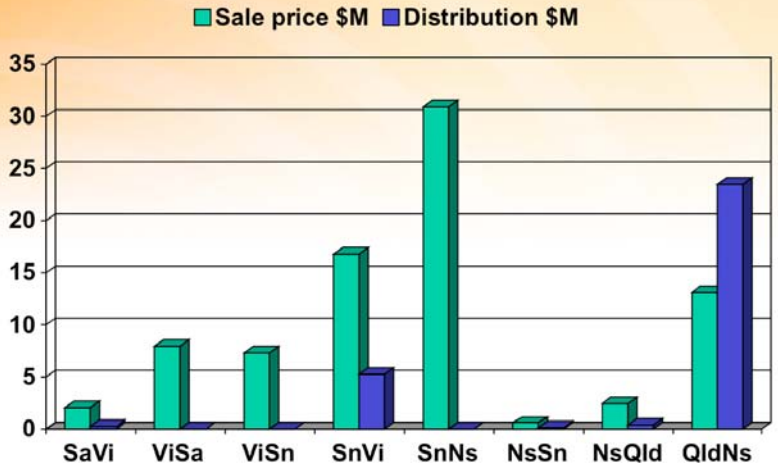
Annual outcomes of NEM SRAS for FY04

(SRC report FY04 see www.nemmco.com.au)



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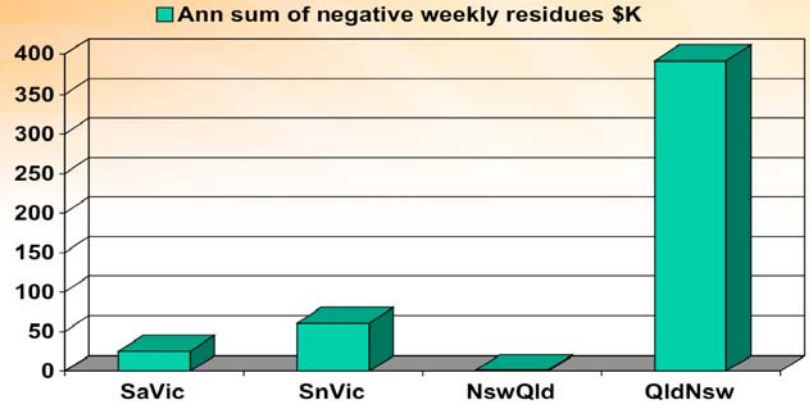
Negative weekly residues for SRAS in FY03
(SRC report FY03 see www.nemmco.com.au)



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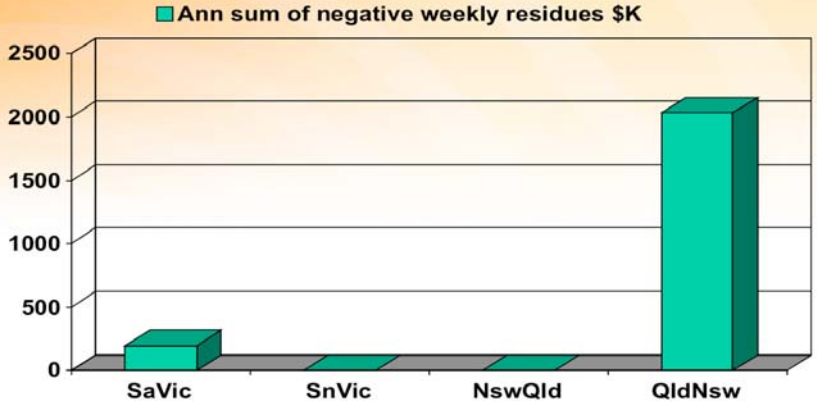
Negative weekly residues for SRAS in FY04
(SRC report FY04 see www.nemmco.com.au)



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Formally regulated network services

(example: building block model applied at each regulatory review)

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Issues:
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Tariff-setting rules *(to meet socio-political goals):*
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Issues:
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- Accountability
- Incentives

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NER Treatment of Transmission & Distribution Pricing (Chapter 6)

- Principles for network pricing:
  - Promote competition in the provision of services
  - Be transparent & non-discriminatory
  - Seek similar outcomes to a competitive market
- ACCC Regulatory test for T&D augmentation:
  - Reliability:
    - Minimises cost of meeting an objective reliability criterion
  - Market benefit:
    - Maximises NPV of market benefit having regard to alternative projects & market scenarios

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Transgrid's interpretation of allowable market benefits (QNI preliminary assessment, 03/04)

Allowable Market Benefits	Description of Benefit
Production Efficiency Benefits	Reduction in fuel consumption of higher-priced sources Reduction in transmission losses Reduction in ancillary services
Capital Efficiency Benefits	Deferral of generation plant that would be required to maintain reliability reserve margins Deferral of generation plant that could be expected to enter the market in response to sustained high pool prices Reduction in capital costs Reduction in O&M costs Deferral of other transmission investments
Consumer Efficiency Benefits	Reduction in voluntary Demand Side Participation Reduction in involuntary load shedding

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Transmission pricing
(existing arrangements; under review)

- Allowed annual revenue (AAR) for network
  - Set by regulator (AER), based on:
    - 'Optimal deprival' value of the network assets:
      - How would each asset be replaced today if it disappeared?
        - » Considering network & distributed resource options
      - Existing assets and audited five-year expansion plan
    - Allowed rate of return:
      - Depends on the assessed risk of the business
  - Five year reset, (CPI-X) annual adjustment:
    - Pressure to control costs between assessments
    - Incentive to further reduce costs, because profits are retained at least until the next assessment

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Transmission pricing within regions
(existing arrangements; under review)

- Recovering AAR from network users
  - Based on assessed use of the network
  - Network elements considered individually:
    - Overall network AAR is assigned to individual elements in proportion to their optimised replacement cost
  - Each network element allocated to a category:
    1. Serve particular network users at a single connection point (*entry or exit*)
    2. Provide a *common service* to all network users
    3. Shared by market customers in an identifiable way:
       - these costs to be allocated in an 'equitable' fashion
       - At present using "Cost Reflective Network Pricing"

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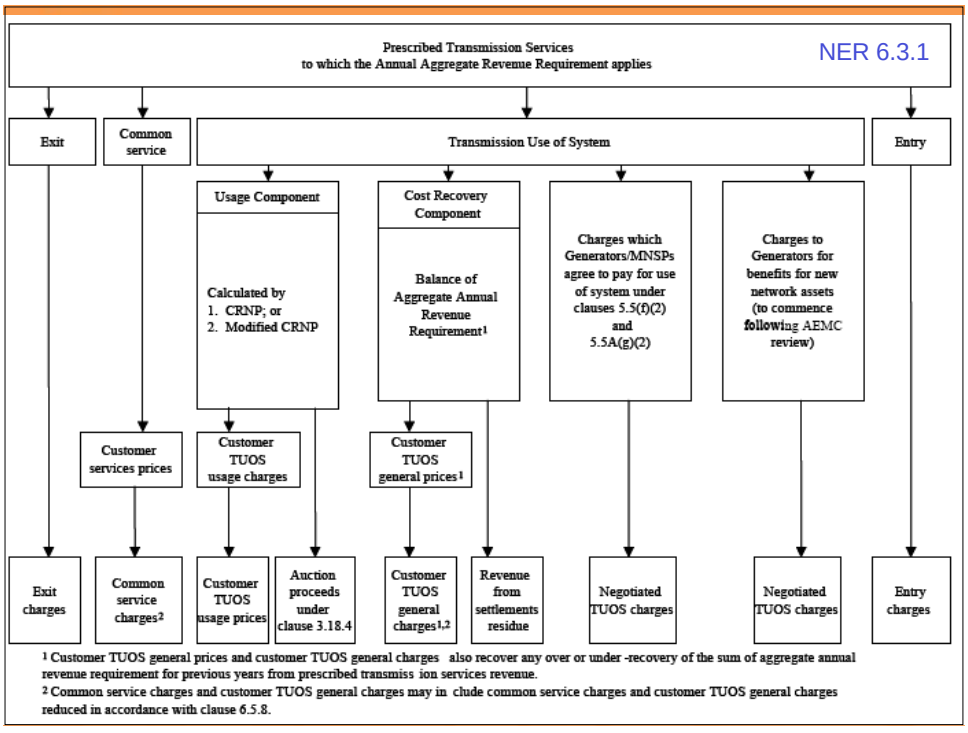

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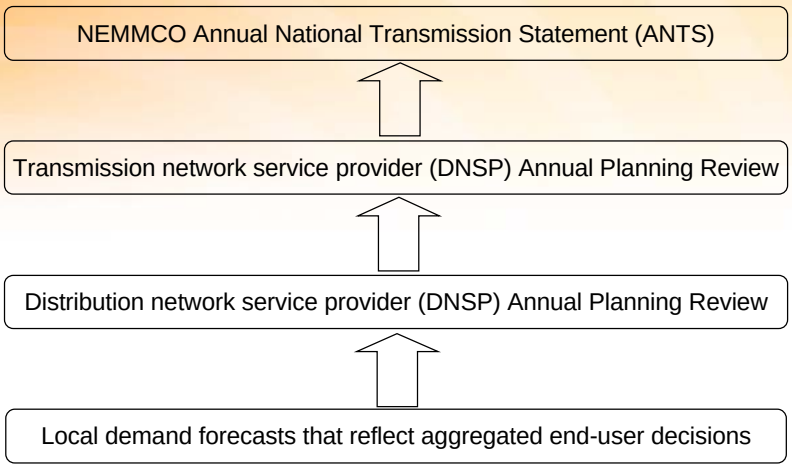
Network planning process in NEM
(all processes to 10 year horizon)



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Network investment decision-making

- Each network service provider (NSP) takes own network augmentation (investment) decisions:
  - Subject to review by Independent Regulator:
    - AER (transmission) or State-based (distribution)
  - Accepted by Regulator if pass the Regulatory Test:
    - Reliability criterion OR positive net benefit
- Required to consider distributed resource options:
  - However supply-side bias remains - “obligation to serve”
- Regulator-approved augmentation enters rate-base:
  - Cost recovered from end-users (not avoidable)
  - Also supply reliability incentives for network operation

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TNSP reliability performance (MMA, 2006)

	2001/02	2002/03	2003/04	2004/05
Powerlink –Loss of supply events, number greater than 0.2 system minutes	4	12	4	3
TransGrid – Network reliability, system minutes lost	0.44	4.4	2.2	0.15
VENCorp – Energy constraints, electricity not delivered due to constraints	Not available	Not available	0	0
ElectraNet – Number of events greater than 0.2 system minutes	3	4	2	7
Transend – Number of events greater than 0.1 system minutes	Not available	13	16	18

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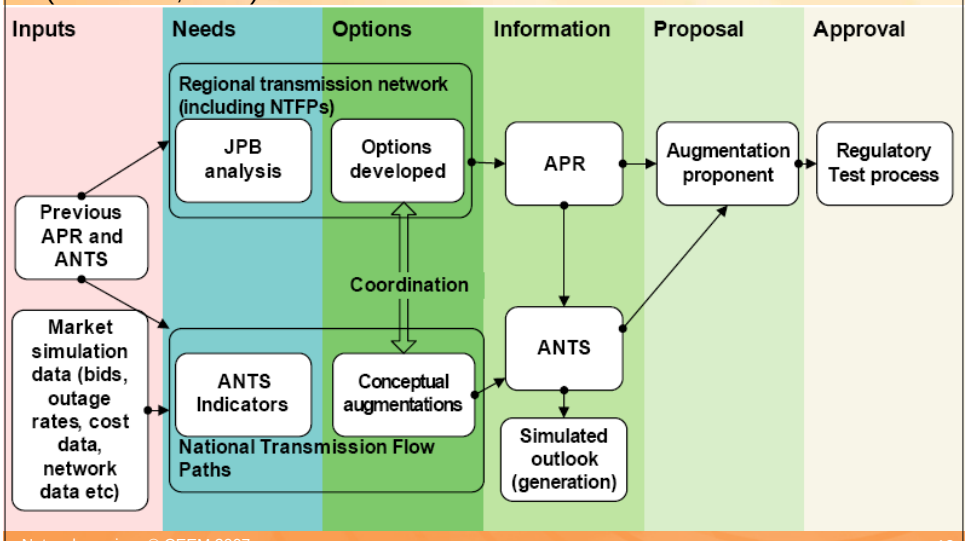
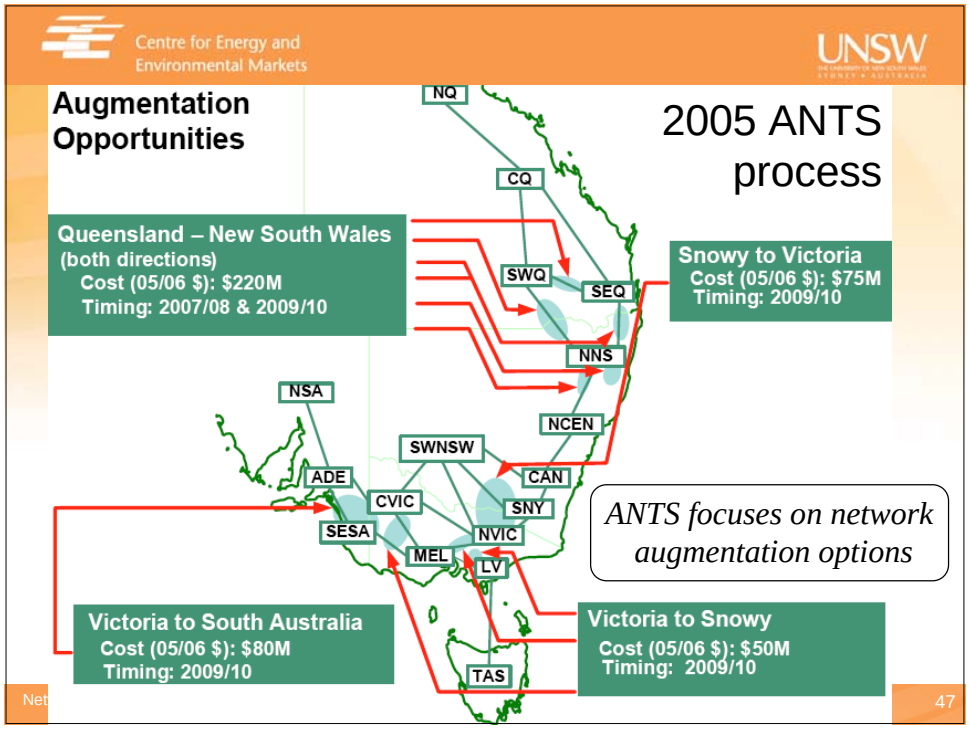
ANTS process based on demand forecast

(NEMMCO, 2005)

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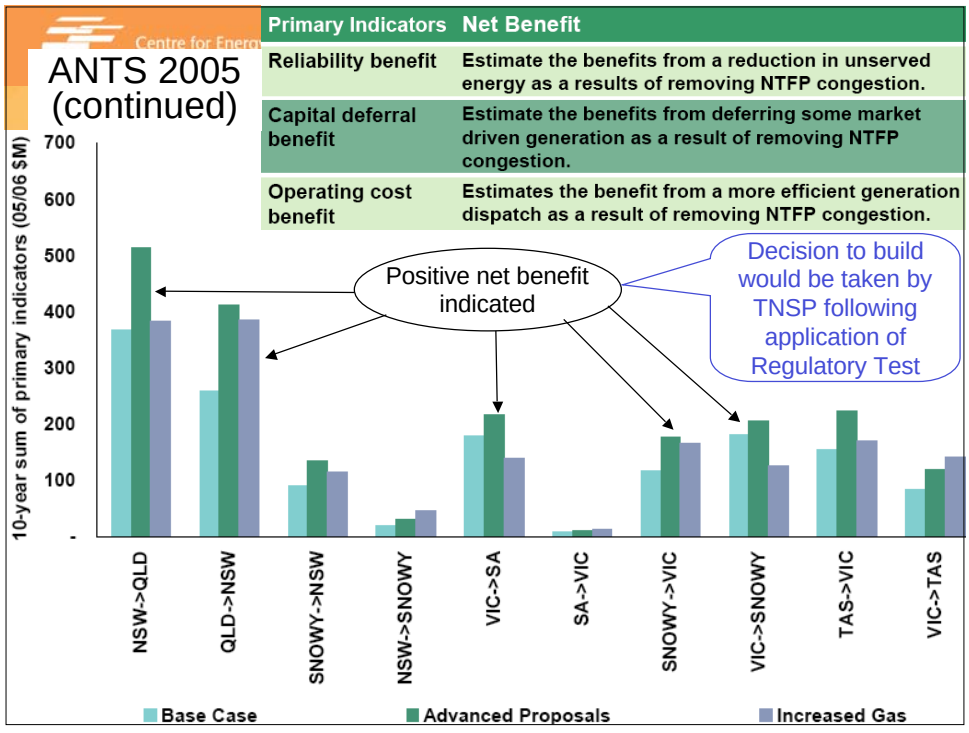
Augmentation Opportunities
2005 ANTS process
Queensland – New South Wales
(both directions)
Cost (05/06 $): $220M
Timing: 2007/08 & 2009/10
Snowy to Victoria
Cost (05/06 $): $75M
Timing: 2009/10
ANTS focuses on network augmentation options
Victoria to South Australia
Cost (05/06 $): $80M
Timing: 2009/10
Victoria to Snowy
Cost (05/06 $): $50M
Timing: 2009/10
NQ
CQ
SWQ
SEQ
NNS
NCEN
NSA
SWNSW
ADE
CAN
CVIC
SNY
SESA
NVIC
MEL
LV
TAS
47


ANTS 2005 (continued)
Primary Indicators
Net Benefit
Reliability benefit
Estimate the benefits from a reduction in unserved energy as a results of removing NTFP congestion.
Capital deferral benefit
Estimate the benefits from deferring some market driven generation as a result of removing NTFP congestion.
Operating cost benefit
Estimates the benefit from a more efficient generation dispatch as a result of removing NTFP congestion.
Positive net benefit indicated
Decision to build would be taken by TNSP following application of Regulatory Test
10-year sum of primary indicators (05/06 $M)
700
600
500
400
300
200
100
-
NSW->QLD
QLD->NSW
SNOWY->NSW
NSW->SNOWY
VIC->SA
SA->VIC
SNOWY->VIC
VIC->SNOWY
TAS->VIC
VIC->TAS
Base Case
Advanced Proposals
Increased Gas

NEM DNSP reliability targets

SAIDI = system ave. outage duration in min/yr

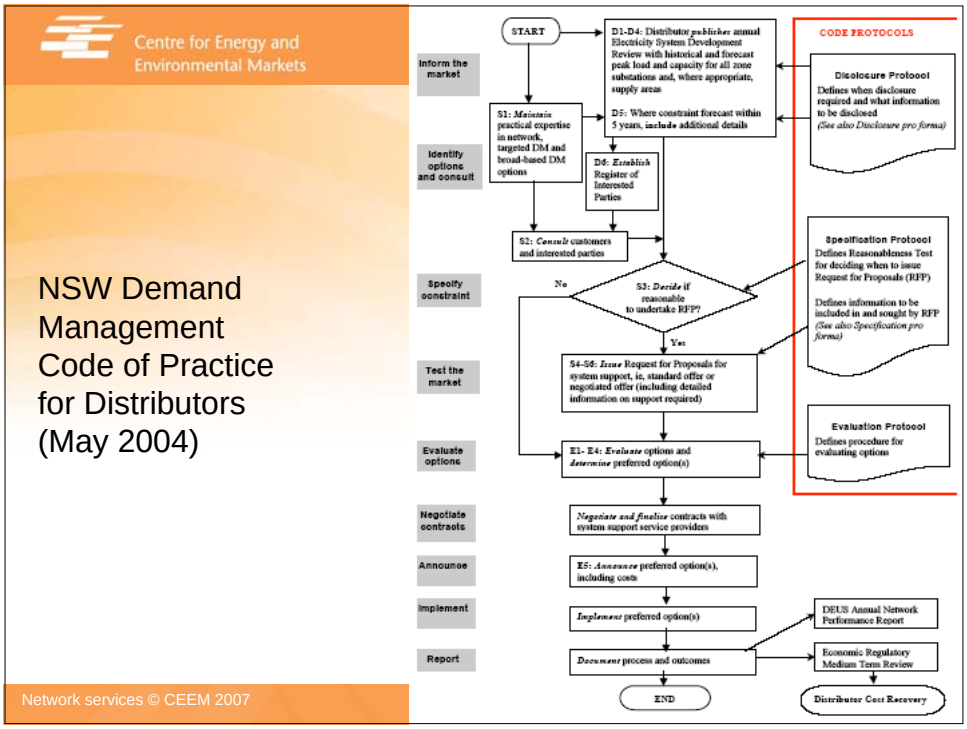
SAIFI = system ave. no. of outages per year

CAIDI = SAIDI/SAIFI = customer ave. outage duration in min/yr

(AEMC, 2006)

Region	DNSP	Feeder	SAIDI	SAIFI	CAIDI
Queensland	Energex	CBD	20	0.33	
		Urban	162	1.78	
		Short Rural	272	2.84	
	Ergon Energy	Urban	220	2.75	
		Short Rural	610	5.70	
		Long Rural	1,180	9.00	
New South Wales	Integral Energy	Total	374	2.91	128
	Energy Australia	Total	102	1.20	
	Country Energy	Total	403	3.56	113
	Australian Inland	Total	303	1.70	182
South Australia	ETSA	Urban	90	1.10	
		Rural	290	2.65	
		Remote	200	1.20	
Victoria	Citipower	CBD	21.4	0.25	63
		Urban	44.9	0.80	44
	TXU	Urban	116.0	1.78	60
		Short Rural	216.0	2.75	68
	Powercor	Total	212.0	2.28	76
	AGL	Urban	79.0	1.27	58
		Short Rural	127.0	2.25	50
	United Energy	Urban	79.0	1.17	57
		Short Rural	128.0	2.24	48
ACT	ActewAGL	All	91	1.2	74.6[1]

NSW Demand Management Code of Practice for Distributors (May 2004)



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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

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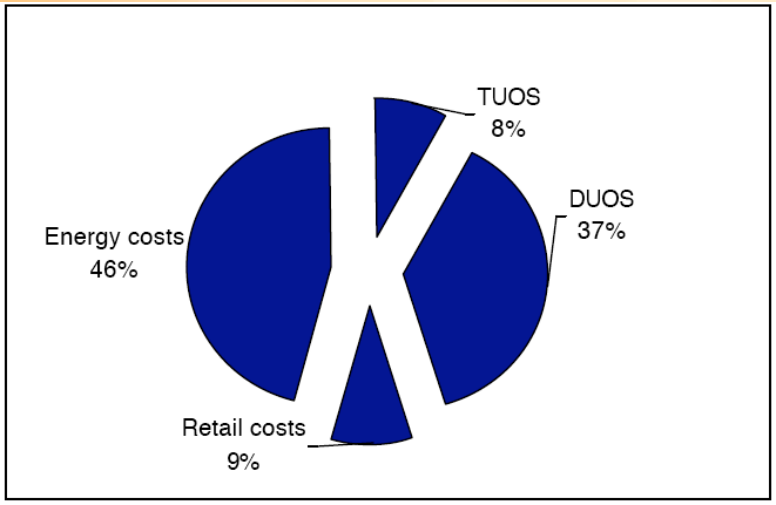
Typical NSW residential electricity bill

(IPART, DNSP Review Issues Paper, 2003)



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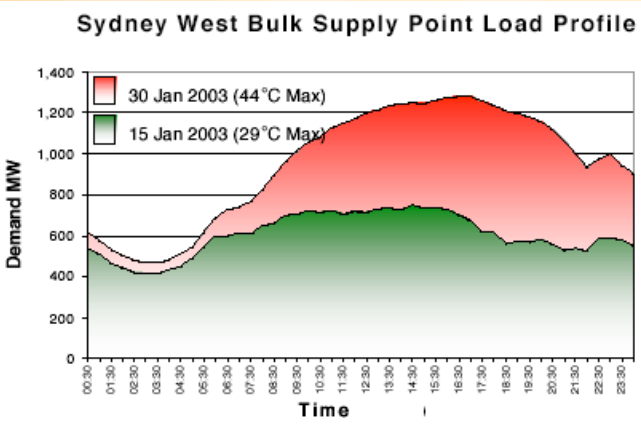
Residential & commercial air conditioning is the key driver for peak demand growth

(IE Submission, IPART DNSP Review, 2003)

Residential ADMD

Pre 2000 houses: 3.5-4.0 kVA

Post 2000 houses: 5.0-7.5 kVA



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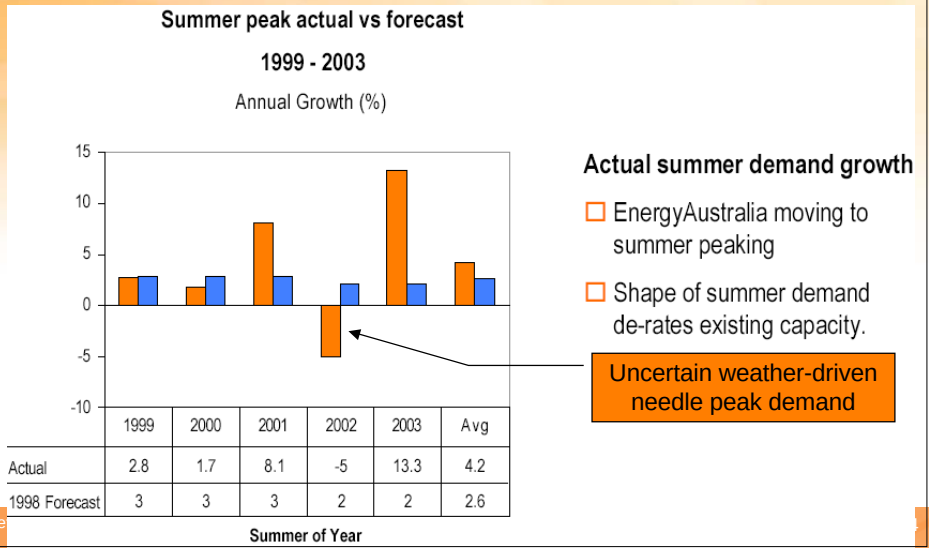
EnergyAustralia summer peak demand

(EA submission, IPART DNSP review, 2003)



	1999	2000	2001	2002	2003	Avg
Actual	2.8	1.7	8.1	-5	13.3	4.2
1998 Forecast	3	3	3	2	2	2.6

Actual summer demand growth

- EnergyAustralia moving to summer peaking
- Shape of summer demand de-rates existing capacity.

Uncertain weather-driven needle peak demand

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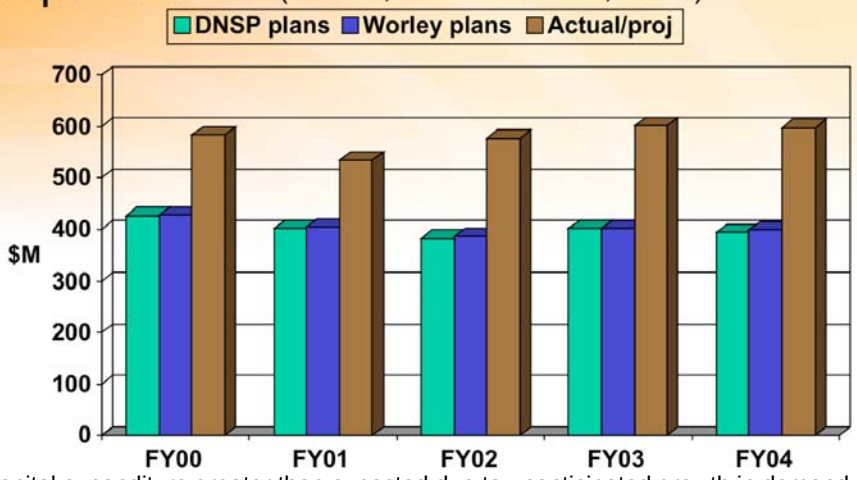
Actual & projected DNSP capital expenditures (IPART, DNSP Review, 2003)



Capital expenditure greater than expected due to unanticipated growth in demand

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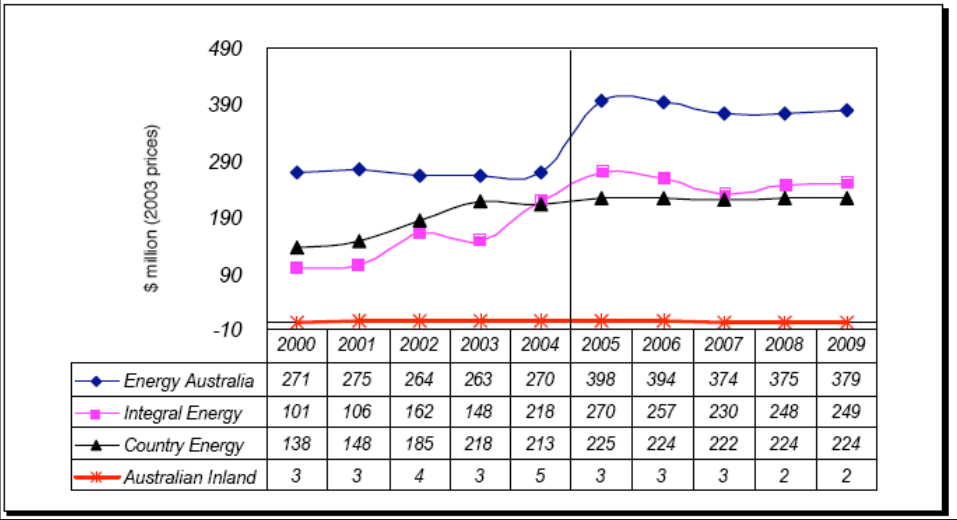
NSW distributor actual & forecast capital expenditure (IPART, Dist Pricing Draft Rpt, 2004)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Energy Australia	271	275	264	263	270	398	394	374	375	379
Integral Energy	101	106	162	148	218	270	257	230	248	249
Country Energy	138	148	185	218	213	225	224	222	224	224
Australian Inland	3	3	4	3	5	3	3	3	2	2

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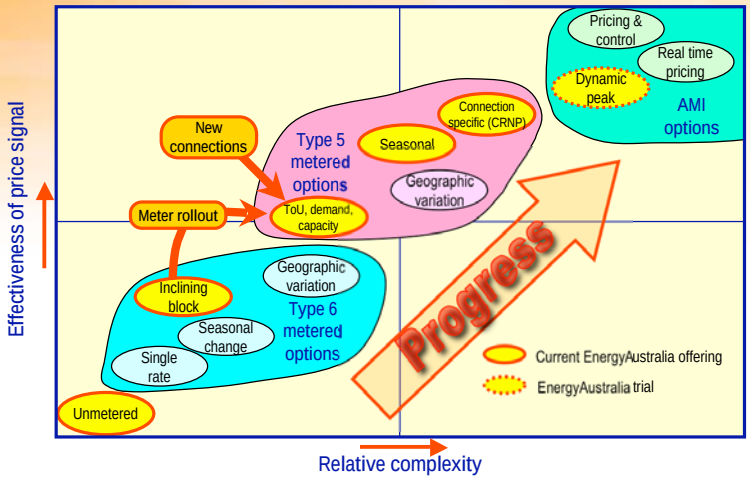
EnergyAustralia vision for network pricing
(Colebourn, 2006)



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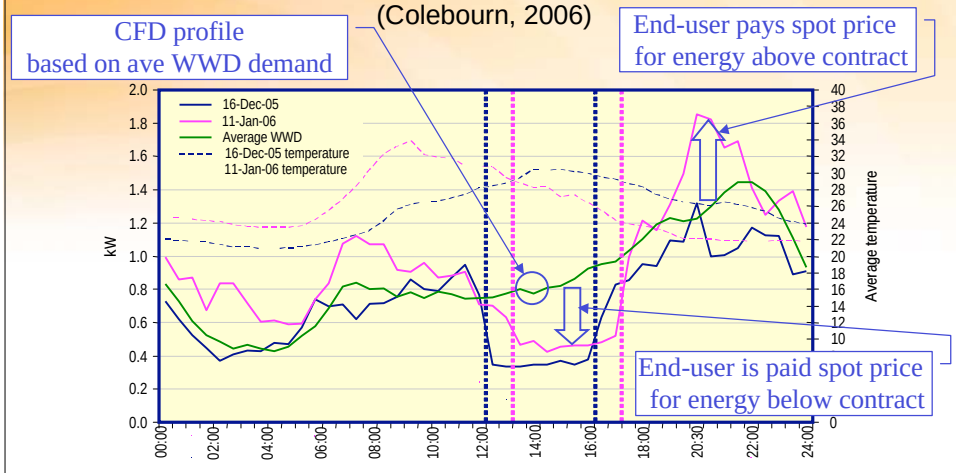
Spot & derivative access contract based on EA trial of residential dynamic peak pricing
(Colebourn, 2006)



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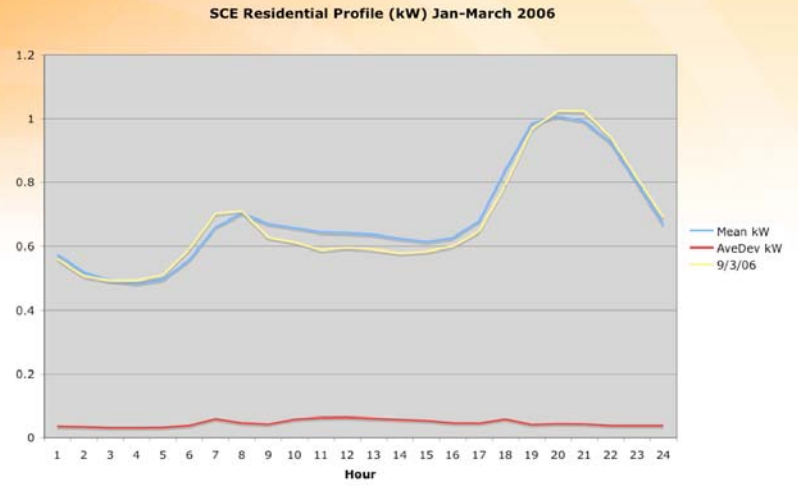
Profile example: SCE Residential load

(http://www.sce.com/AboutSCE/Regulatory/loadprofiles/2006loadprofiles.htm)



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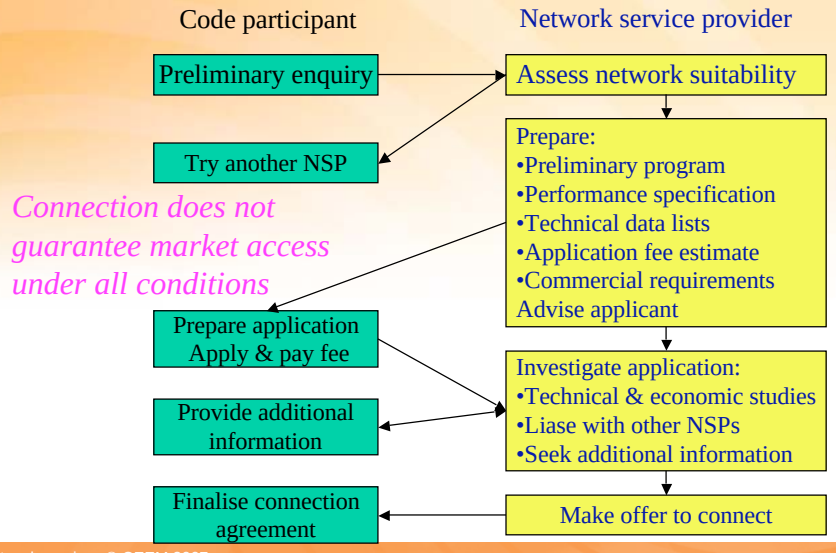
Default residential NSP forward contracts

- Forward demand profile to meet basic household needs for normal weather conditions:
  - May include a location-influenced allowance for air-conditioning
  - May be a function of household size
  - May include energy as well as network pricing
- Forward price profile determined by area-specific network LRMC estimate for cost of supply:
  - Considering economically efficient investment
- Forward term to be 3-5 years with annual update
- To be determined by regulator & offered by DNSP:
  - As default derivative aggregator if energy pricing included

Network connection: NSP as gatekeeper (NER, Ch. 5)



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NER connection requirements for generators

- Reactive power & voltage control capability
- Quality of electricity injected into network
- Protection requirements
- Remote control arrangements
- Excitation system requirements
- Loading rates
- Ride-through to avoid cascading outages:
  - Loss of largest generator; 175ms network fault:
    - Robustness against off-nominal voltage & frequency

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Conclusions

- Network services:
  - Vital to an electricity industry but hard to separate from generation & demand-side services
- Network services in a restructured industry:
  - HV transmission services can be:
    - At least partly represented in an electricity market
    - Provides some competitive pressures (MNSPs, DR)
  - Sub-transmission & distribution:
    - Likely to remain regulated for the time being
    - Distributed resources could compete if legal obligations clarified
    - Consider spot & derivative network access contracts for end-users & distributed resources

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