Electricity Industry Restructuring - A review of progress

Hugh Outhred

Presiding Director, Centre for Energy and Environmental Markets

The University of New South Wales

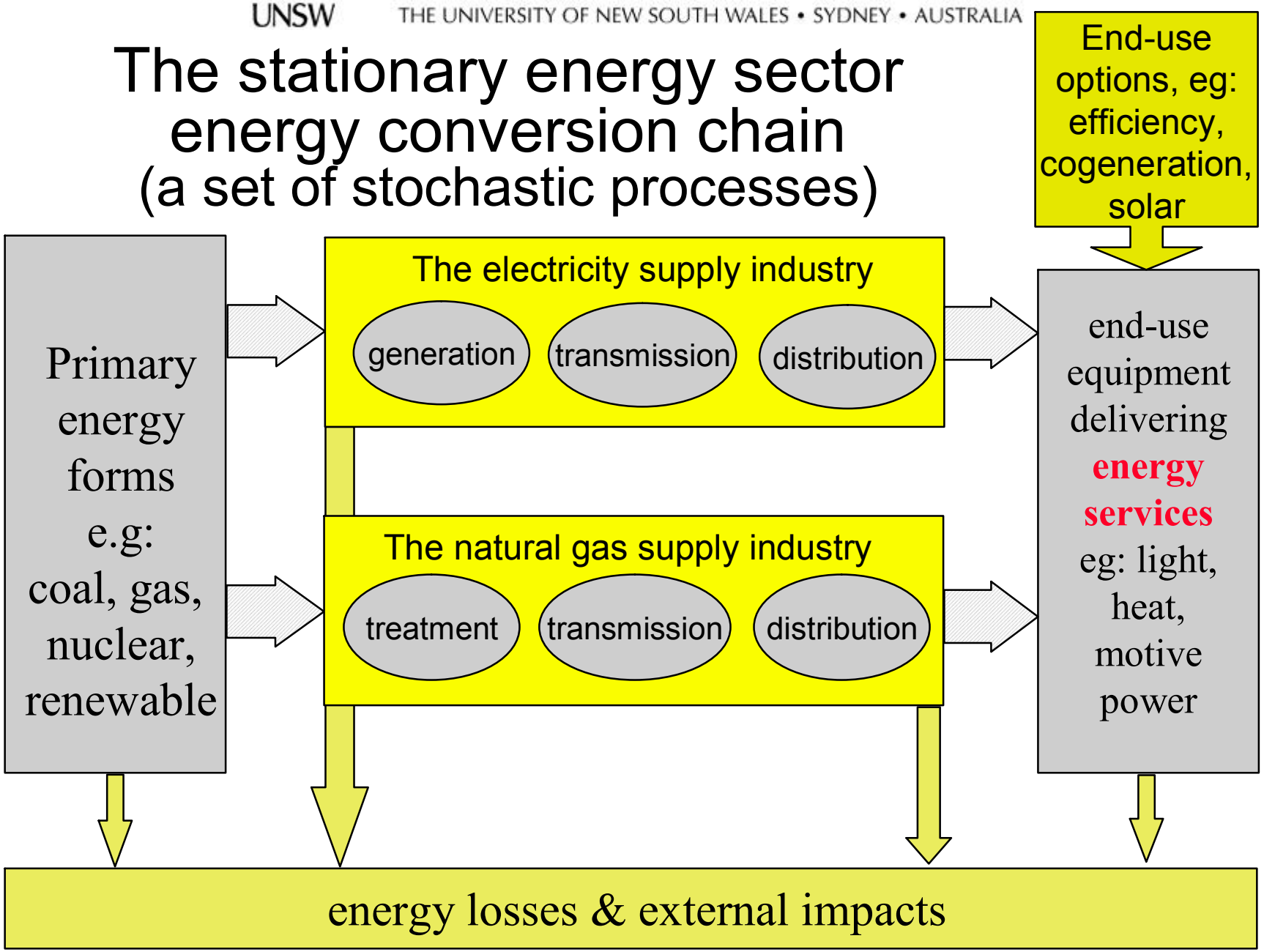
Sydney, Australia

Tel: +61 2 9385 4035; Fax: +61 2 9385 5993;

Email: h.outhred@unsw.edu.au

www.ceem.unsw.edu.au

The stationary energy sector energy conversion chain
(a set of stochastic processes)



Key issues for the electricity industry

- Part of the stationary energy sector:
  - Capital intensive, long-lived *infrastructure*
  - In competition with other energy vectors to deliver end-use energy services
- "Essential good" for households & industry:
  - A high quality, secondary energy form:
    - Expensive to make but flexible to transport & use
- Externalities of primary energy forms, e.g:
  - Fossil fuel depletion & climate impact
  - Nuclear waste

- Specific properties of electrical energy:
  - No cost-effective electrical energy storage
  - Instantaneous transmission & distribution
  - Availability & quality of supply always at risk
- A "just in time" *flow industry:*
  - Energy flows according to network laws:
    - From all generators to all end-use equipment
    - 'pool' rather than 'bilateral' trade
  - Production determined by end-use equipment
    - Supply & demand side options are equally valid
    - Retailers don't have a clear role in an electricity industry

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 - continuous flow
- A consumer receives continuous flow of energy from all power stations:
  - Consumer can't buy from a specific power station
  - Power station can't guarantee quality of energy at point of end-use
- Availability & quality varies with location due to network imperfections

Bilateral trade does NOT work well:

- *Must design & implement a trading regime that works for electricity*

Traditional electricity industry model: Vertically integrated *electricity supply utility*

- Britain, New Zealand, Australia, etc:
  - Statutory authority supervised by a Minister
  - Decision making political, "behind closed doors":
    - Politicians negotiate tradeoffs
- USA:
  - Regulated private monopoly (in most cases)
  - Regulatory commission & formal public hearings
- Criticisms of traditional model:
  - Inefficient; stakeholder capture; risk averse

Electricity industry restructuring objectives

- 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

Other drivers for change in infrastructure industries

- Improving theoretical understanding:
  - Imperfect regulation versus imperfect markets
- Evolving political context in western world:
  - Emphasis on individual choice & accountability
- Challenging conditions for central planning:
  - Slow & uncertain growth in demand
  - Technology progress creating new options, eg:
    - Renewable energy; end-use efficiency
  - Growing environmental concerns

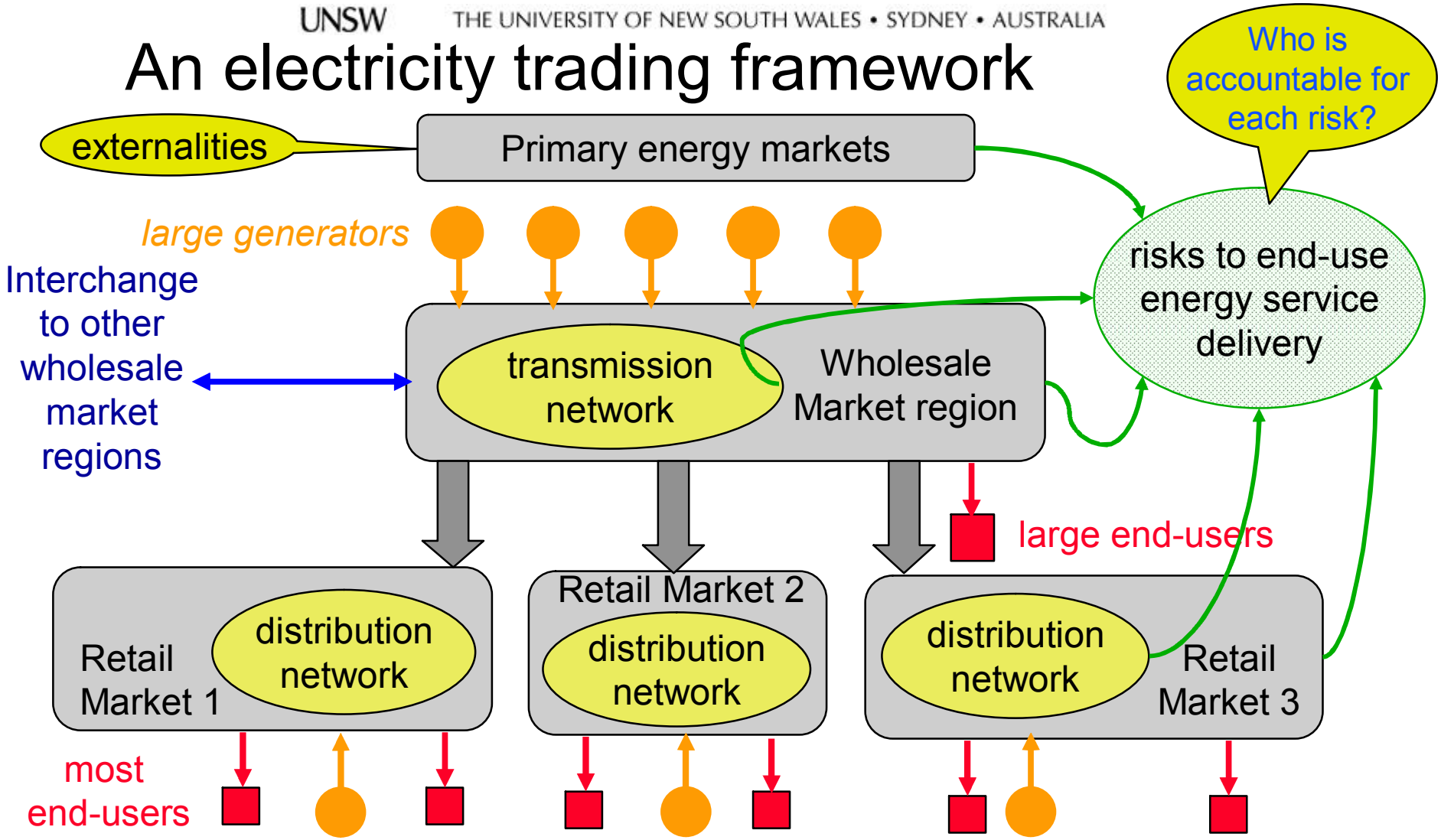
World Energy Council perspective on electricity & gas industry restructuring (2004)

- Examine competitive potential:
  - Of each stage in the energy conversion chain
- Ensure benefits commensurate with costs:
  - For each stage of the proposed reforms
- Respect the limits & costs of competition:
  - Focus on simple choices & market designs
- Governments should:
  - Restrict their role to setting sound rules to be administered by impartial regulators
  - Take account of links between gas & electricity

The electricity industry restructuring process

Issue	Transition	Key challenges
Industry structure	*From* monopoly *To* competing firms *Keeping* central operation *Obligation to supply?*	Cultural change; Adequate competition; End-user participation *Accountability*
Supply industry cash flow	*From* cost recovery *To* trading profitability	Market power; Market design fidelity; *Accountability*
Industry regulation	*From* rate of return *To* Incentive Regulation *Obligation to supply?*	Multiple objectives; Measuring outcomes; *Accountability*
External impacts	*From* direct cost *To* full costs	Variable RE energy flows End-user participation; *Accountability*

An electricity trading framework



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

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

Electricity (& gas) industry participants

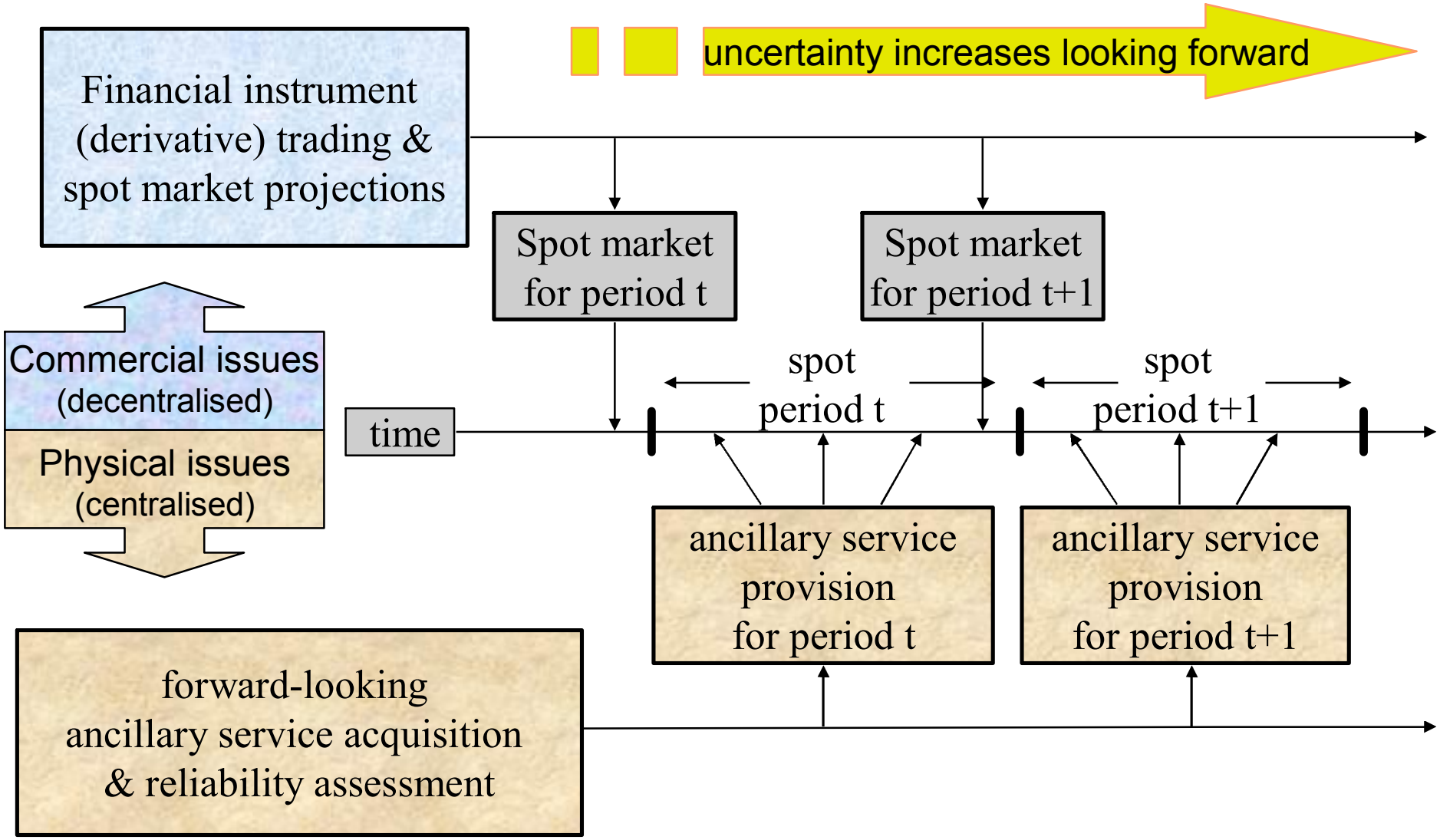
Commercial, location-specific	• primary energy suppliers • electricity generators • electricity end-users • reversible storage
Commercial, inter-location traders?	• network service providers (electricity & gas)
Non-commercial	• system operators • industry regulators • policy makers

Challenges for a restructured industry

- Consistency between centralised & decentralised processes:
  - *Centralised:* short-term industry operation; long-term industry design; industry regulation
  - *Decentralised:* spot & forward energy markets; some ancillary services
- Sound interface between centralised & decentralised processes:
  - Clear accountabilities & “hand-overs”
- Effective design of spot & forward markets
  - Cost of supply much less than end-use value:
    - Need active participation by informed end-users

Timeline for electricity trading

(requires locational detail & active demand-side participation)



Uncertainty & risk in electricity trading

Time scale	Issues	Mechanisms

< 30 minutes	• Supply-demand balance
	  • Demand uncertainty
	  • Contingencies
		• Ancillary services

30 minutes to several days	• Supply-demand balance
	  • Security of supply
	  • Unit commitment
		• Ex-ante spot market
		• Derivative markets
		• Forecast capability

Weeks to years - *operation*	• Inter-temporal links, eg
	  • Retail tariff setting
	  • Hydro scheduling
		• Derivative markets
		• Forecast capability

Weeks to years Š *investment*	• Investment decisions:
	  • Economic efficiency
	  • Future supply security
		• Derivative markets
		• Forecast capability
		• Policy framework

Ideal spot market trading of electricity

- Specify quality of supply (QOS) criteria:
  - Assume QOS maintained by Ancillary Services
- 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
    - Demand & supply side options fully equivalent

Practical implementation of electricity trading

- Wholesale spot & forward market:
  - Large generators, retailers, large consumers
  - Some representation of networks in markets
- Retail spot & forward market (transition?):
  - Retailers, consumers, embedded generators
- Ancillary services & future projections:
  - Hybrid engineering & commercial arrangements
- Residual network services:
  - Regulated access regime, administered network pricing, limited competition in some aspects

Metering and communication

- Metering:
  - Interval metering essential for all participants:
    - Record 30 minute energy, quality & availability
    - Provide data read-out for participant
  - 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

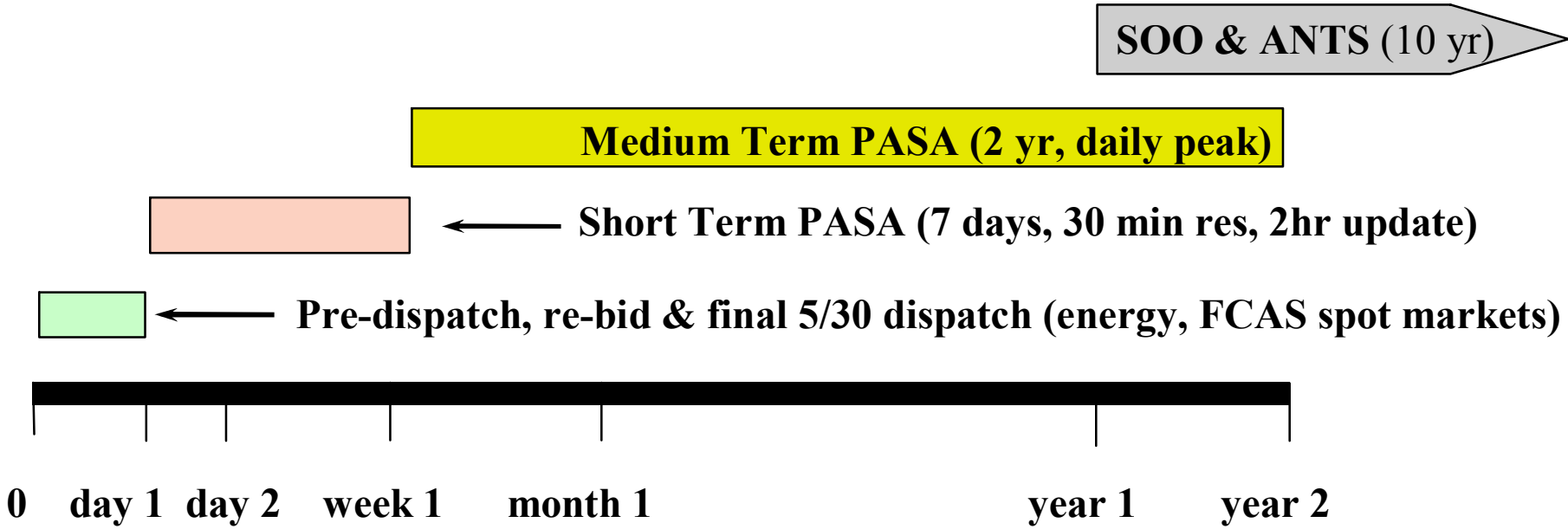
Summary of electricity industry restructuring

- 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
- Restructuring is still a learning situation:
  - No complete successes, some serious failures, difficult to return to monopoly industry
  - Must solve commercial, technical & institutional challenges (each aspect must function well)

Electricity market models

- Gross pool (eg Australia & New Zealand):
  - Temporal & location risk managed collectively:
    - Ancillary services, spot market, PASA, SOO
- Net pool (eg UK NETA, California):
  - Long term & location risk managed bilaterally
    - Network not modelled in trading arrangements
  - Short-term operational risk managed collectively:
    - System operator given only one day's notice of bilateral trades

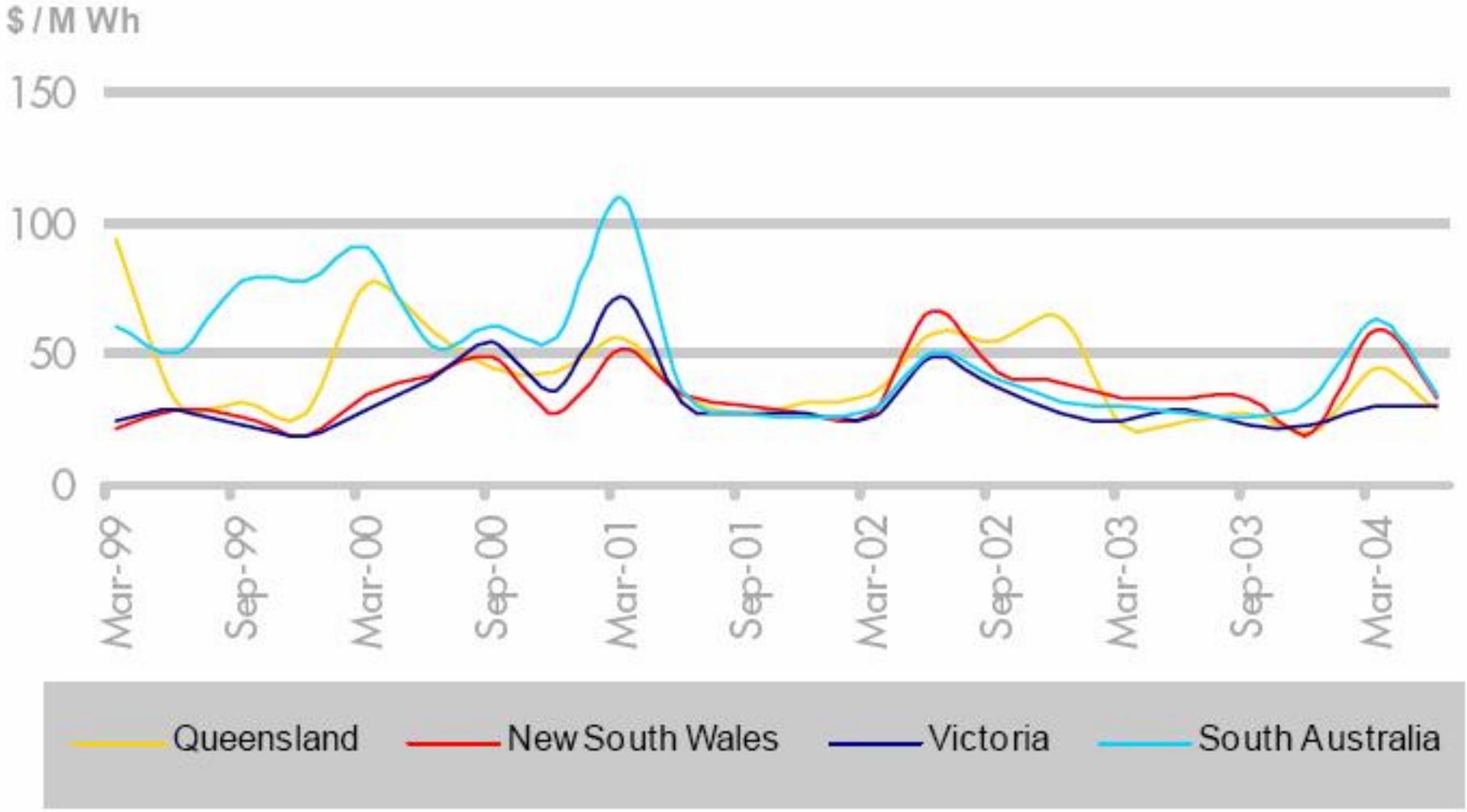
Implementation of Australian National Electricity Market (source: NEMMCO)



- 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)

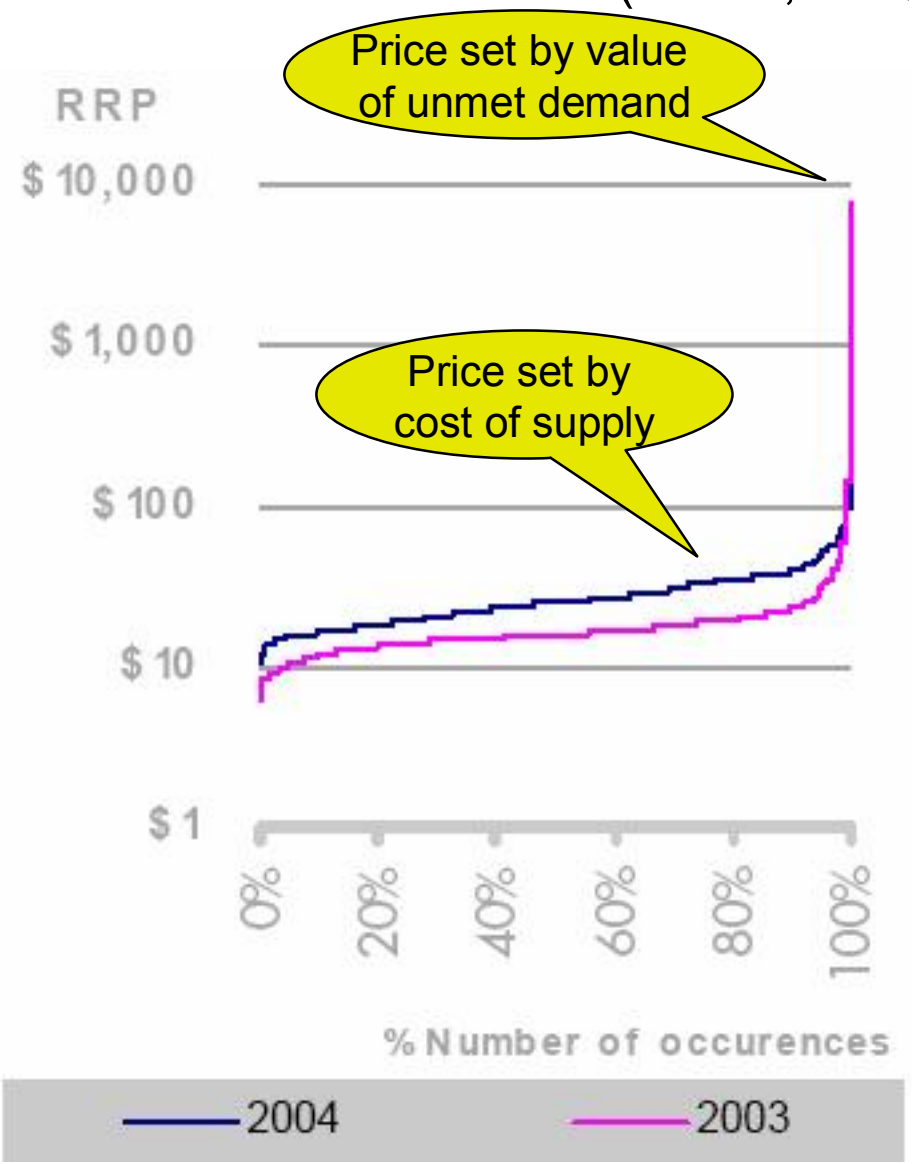
Smoothed Regional Ref Prices (RRPs) since start of Australian National Electricity Market

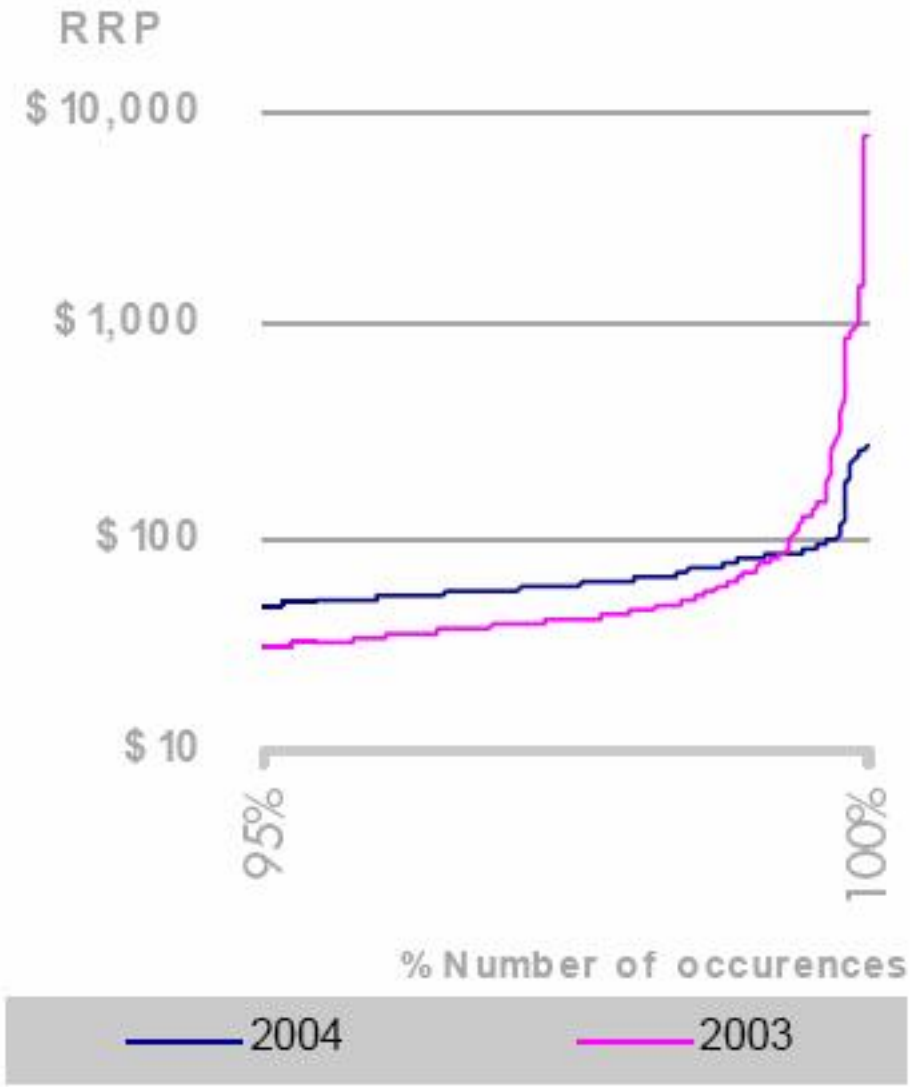
(NECA, 04Q2 Stats, 2004)



Qld RRP duration curve, March-June 04

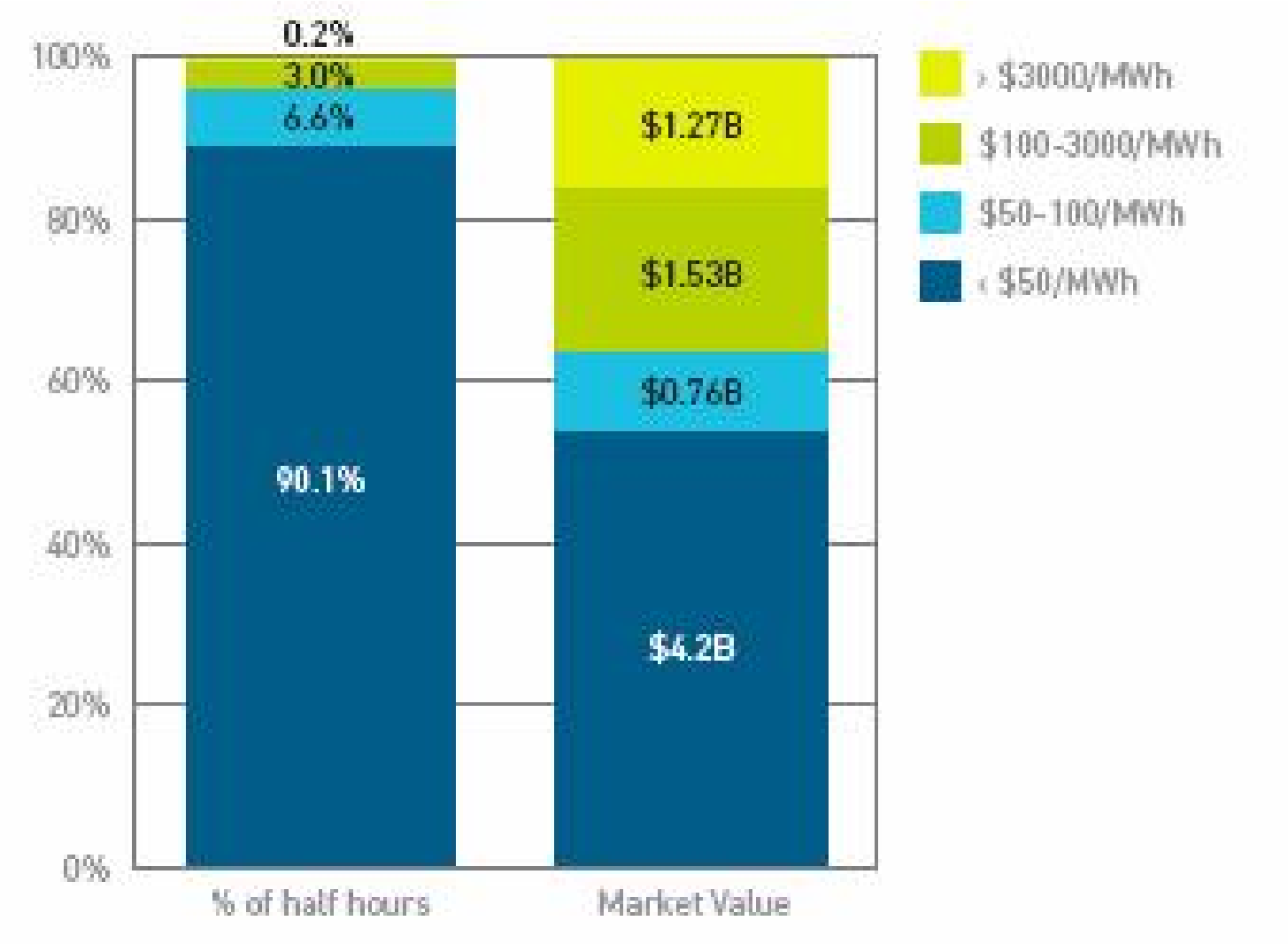
(NECA, 04Q2 Stats, 2004)





Distribution of NEM spot prices & revenues

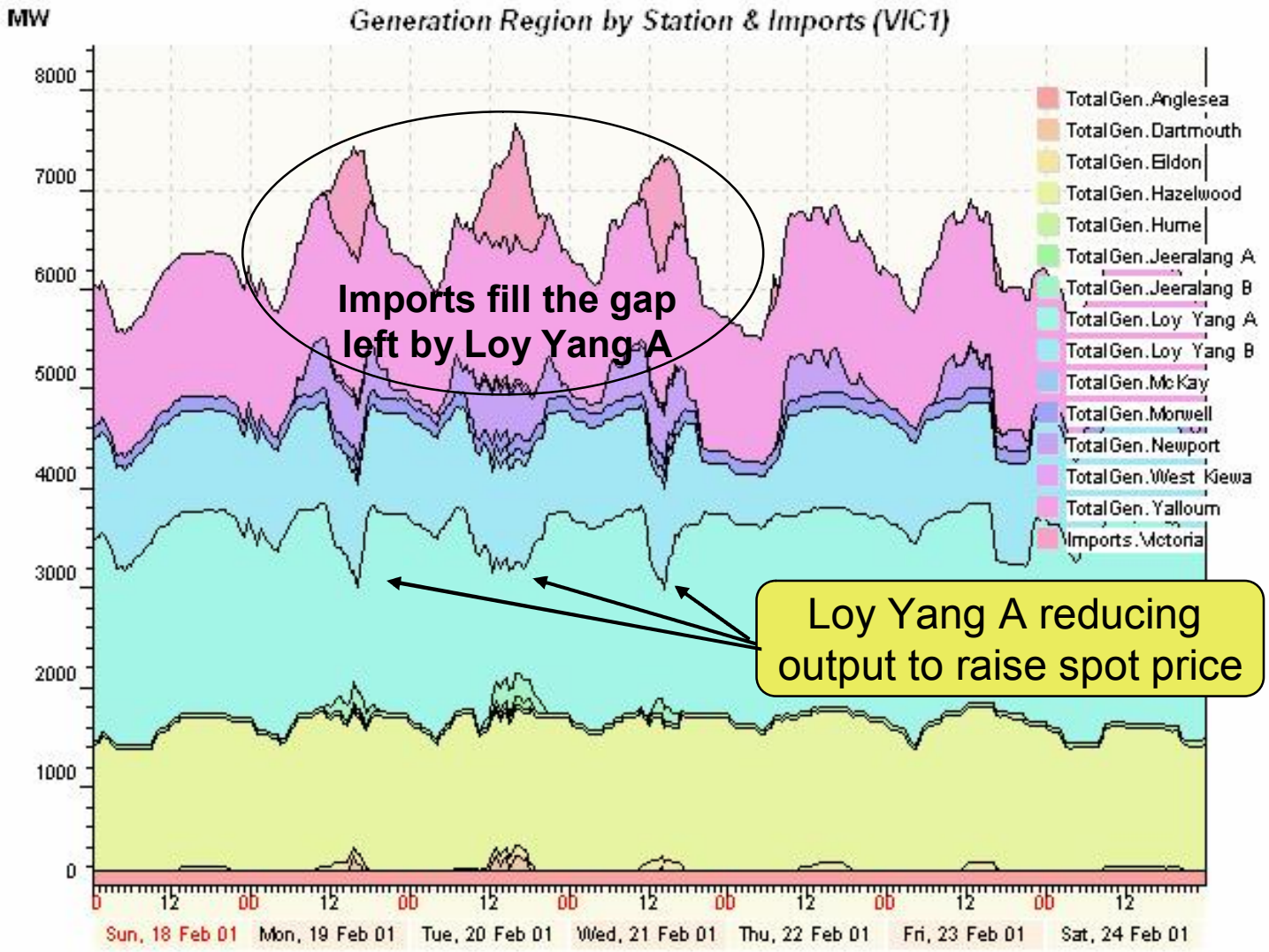
(Federal Govt: *Securing Australia's Energy Future,* 2004)



Reducing generation to raise spot market price

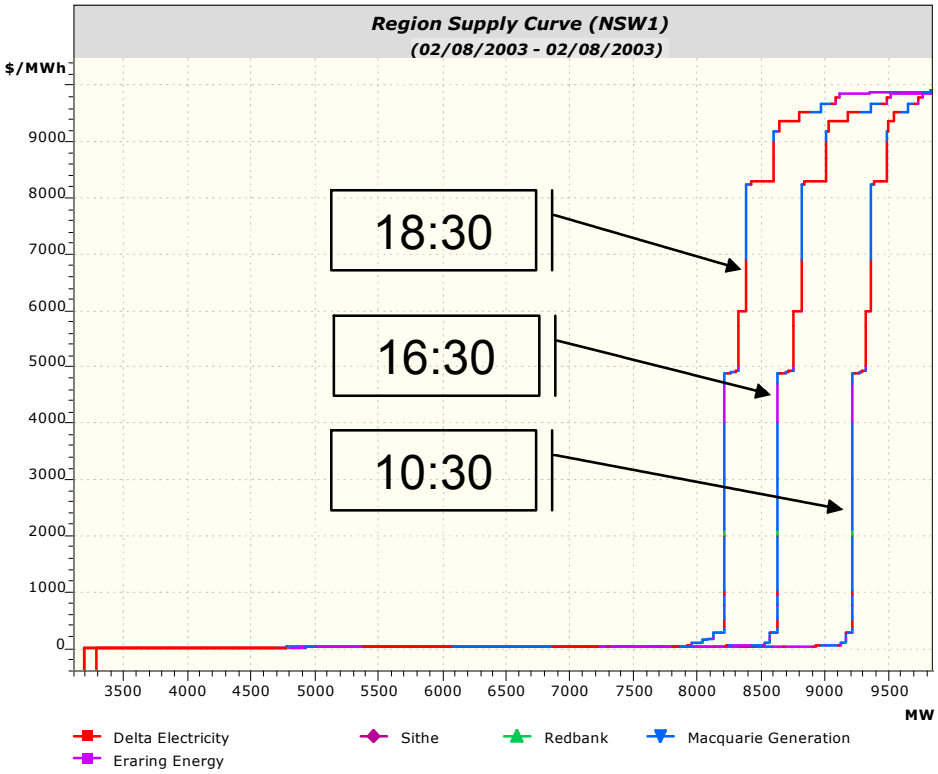
(graph courtesy of Intelligent Energy Systems EMIS facility)

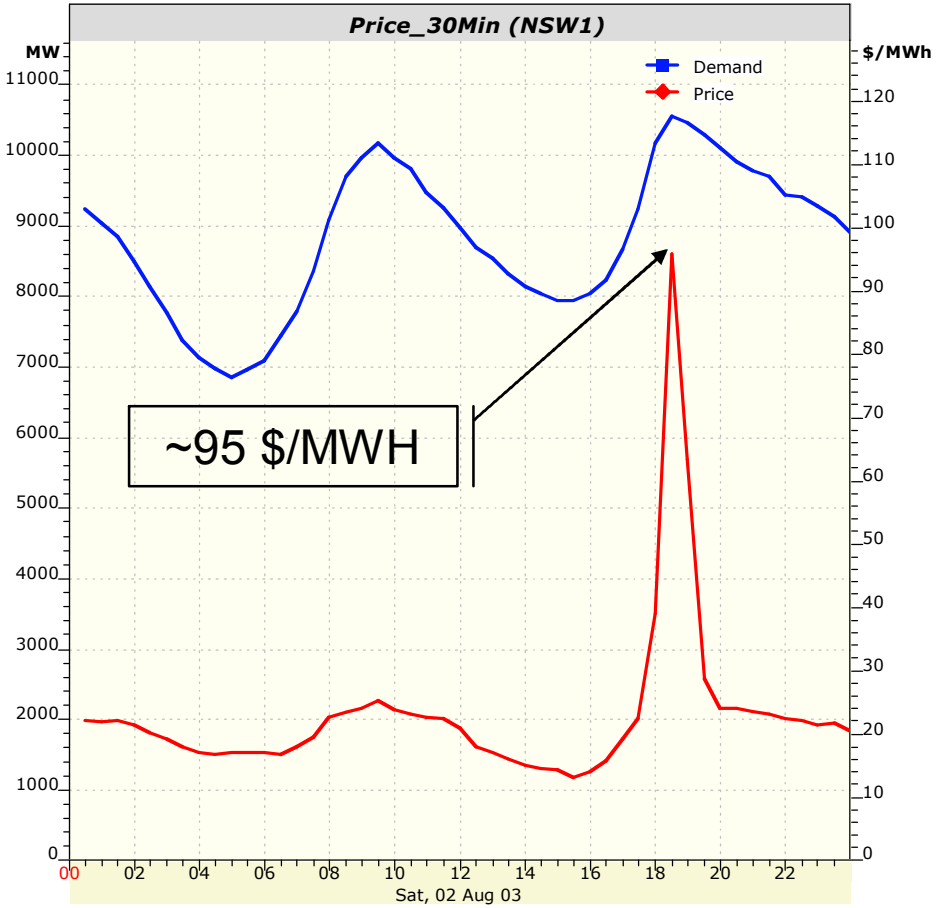
(demand-side response: derivative contract or reduce demand)



Changing generation offer to raise spot market price (2/8/03)

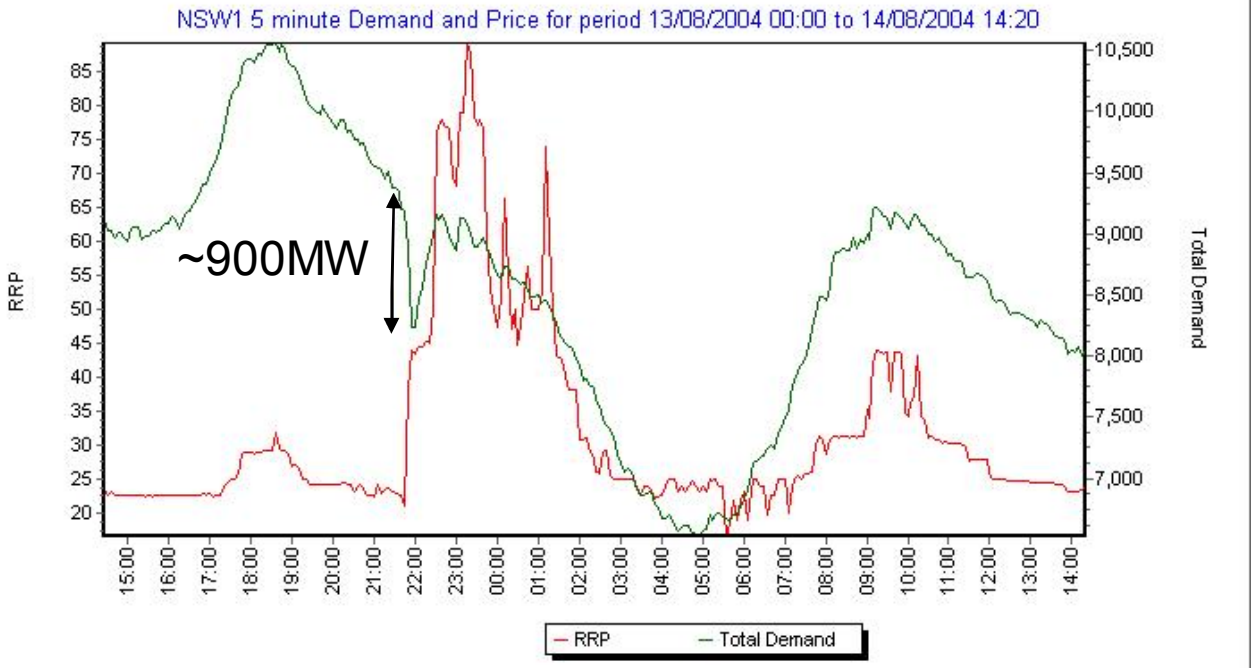
graph courtesy of Stuart Thorncraft &
Intelligent Energy Systems EMIS facility (www.iesys.com.au)
(possible demand-side responses: derivative contract or reduce demand)

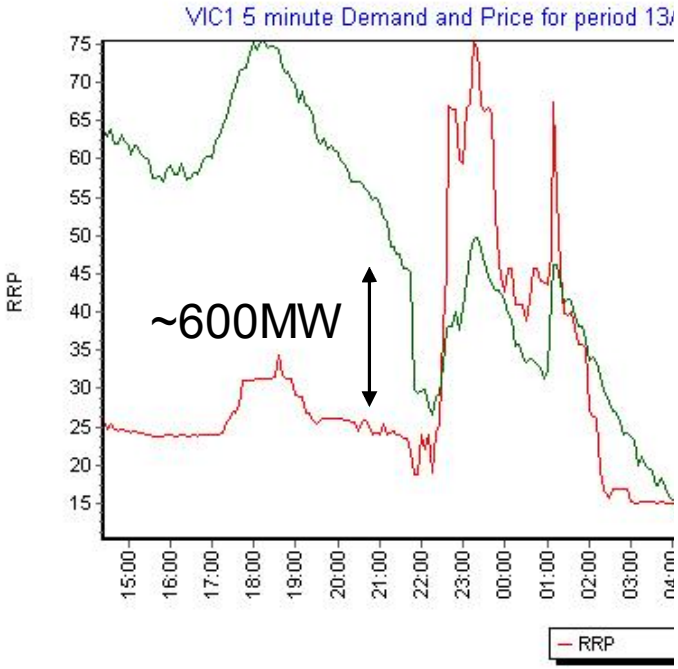


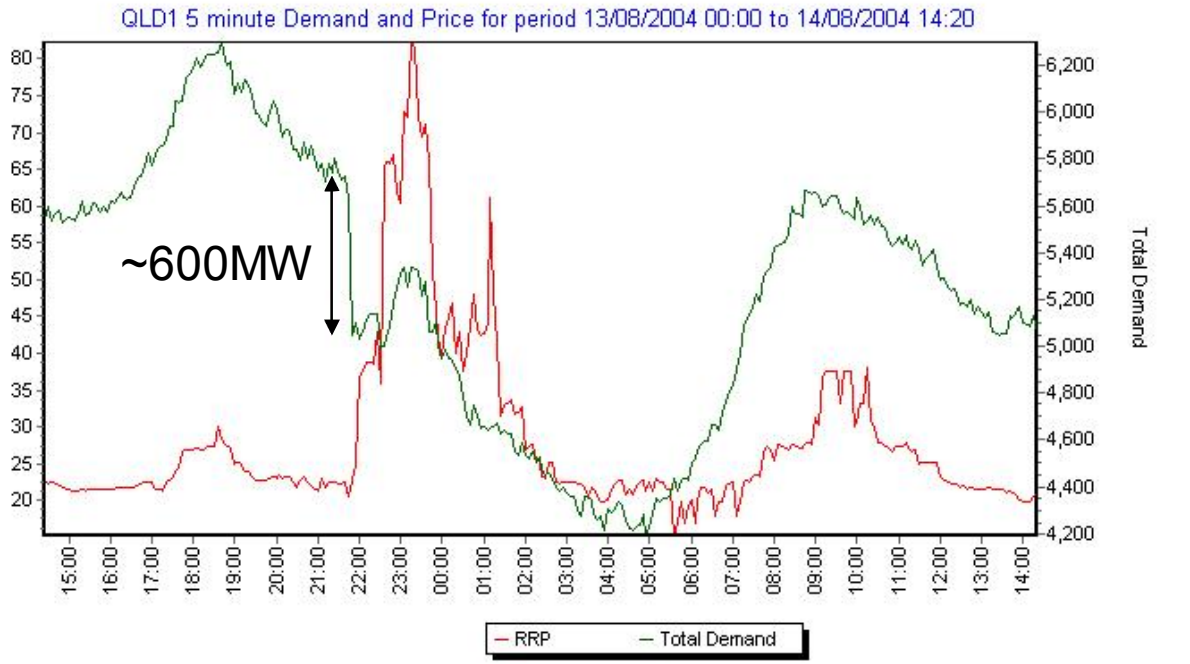


UNSW T

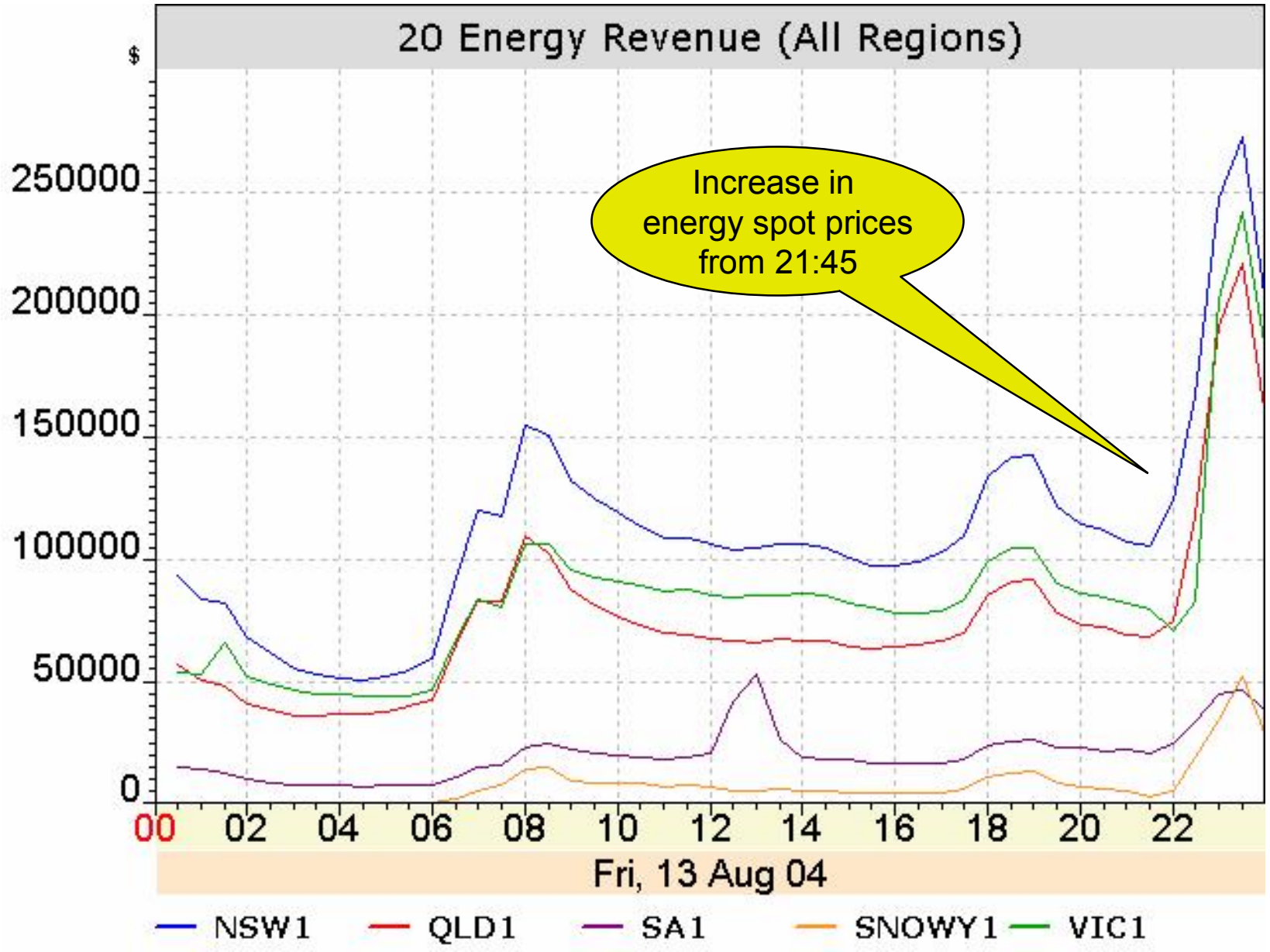
Transgrid CT failure at 21:42 13/8/04 caused 3,100MW of generation to trip: frequency fell to 48.9Hz; ~2,100 MW load shed in NSW, Queensland & Victoria (www.nemmco.com.au)



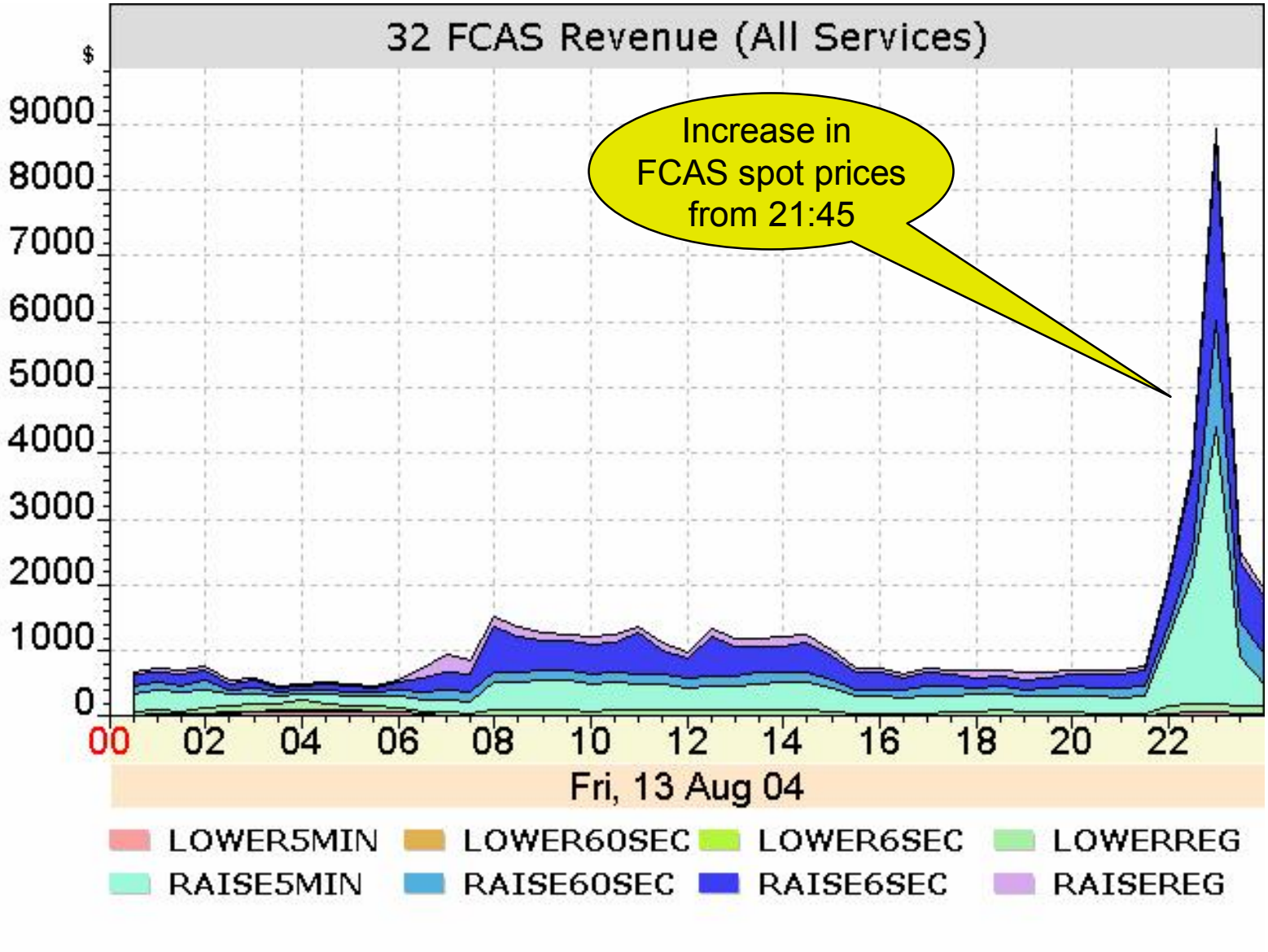




NEM energy revenue, 13/8/04



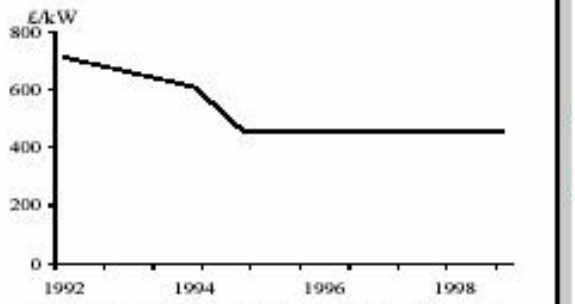
NEM frequency control ancillary service (FCAS) revenue 13/8/04 (NEMMCO, 2004)



Perceived problems with the UK pool

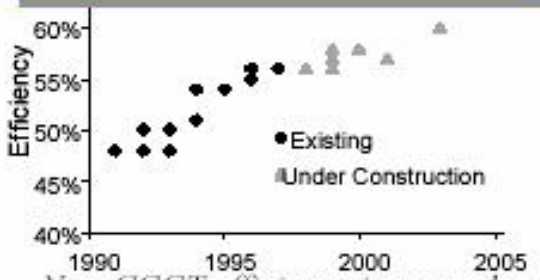
(E Marshall, England & Wales wholesale market 2 years on, Ofgem, 2003)

Capital costs fell



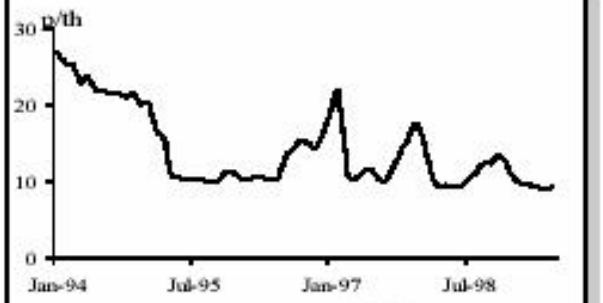
Capital costs of new plant fell by nearly 40% between 1992 and 1998

Efficiency Improved



New CCGT efficiency increased by over 10% from 1990

Fuel costs fell



Spot gas prices fell by 50% between 1994 and 1998

But Pool Prices didn't

Pool Purchase Price rose by over 10 % from 1990 levels.

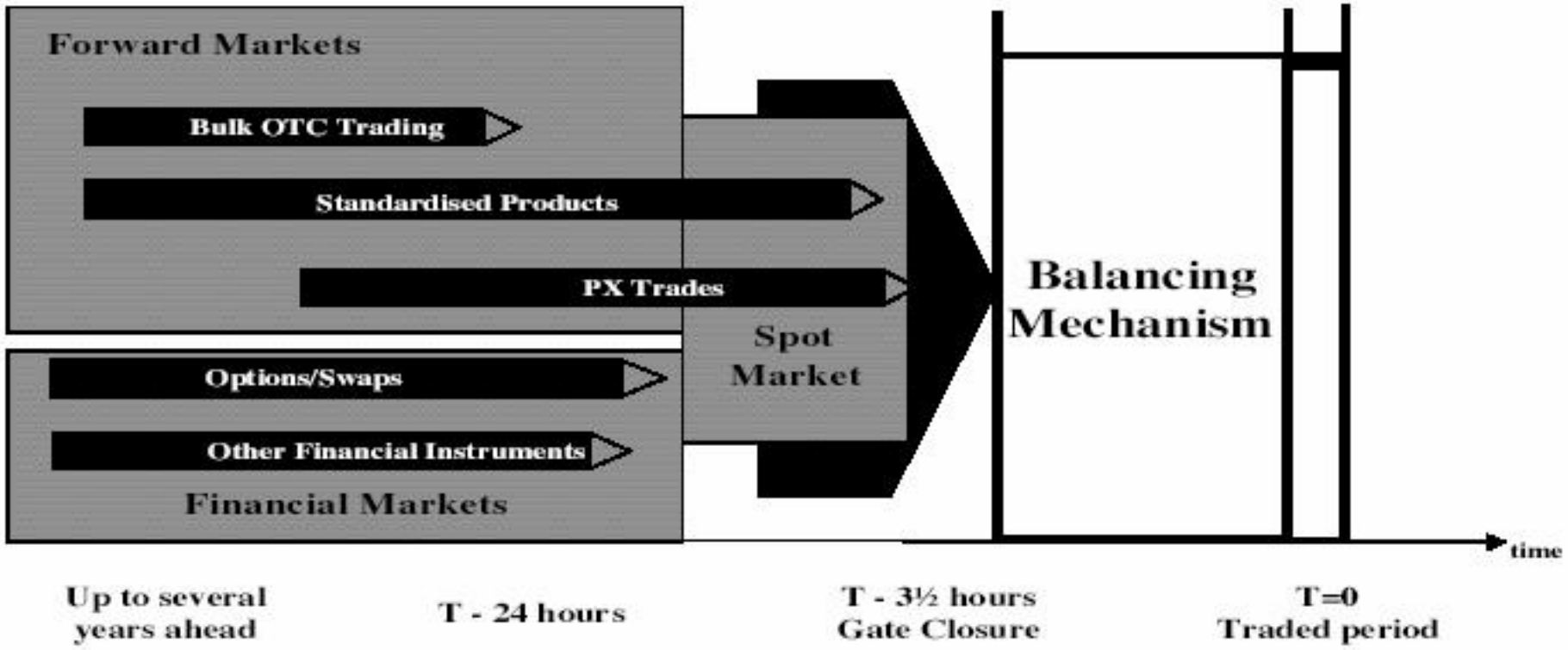
Key features of NETA

(www.ofgem.gov.uk)

- Bilateral forward trading:
  - Compulsory notification of contract position to System Operator (NGC) by "Gate Closure":
    - Initially 3.5 hour then 1 hour ahead from 2/7/02
- Voluntary offers to provide balancing services
- Settlement process for mismatches:
  - Under contracted generators & over contracted retailers receive "system sell" price (SSP)
  - Over contracted generators & under contracted retailers pay "system buy" price (SBP)
    - Normally expect that SBP > SSP

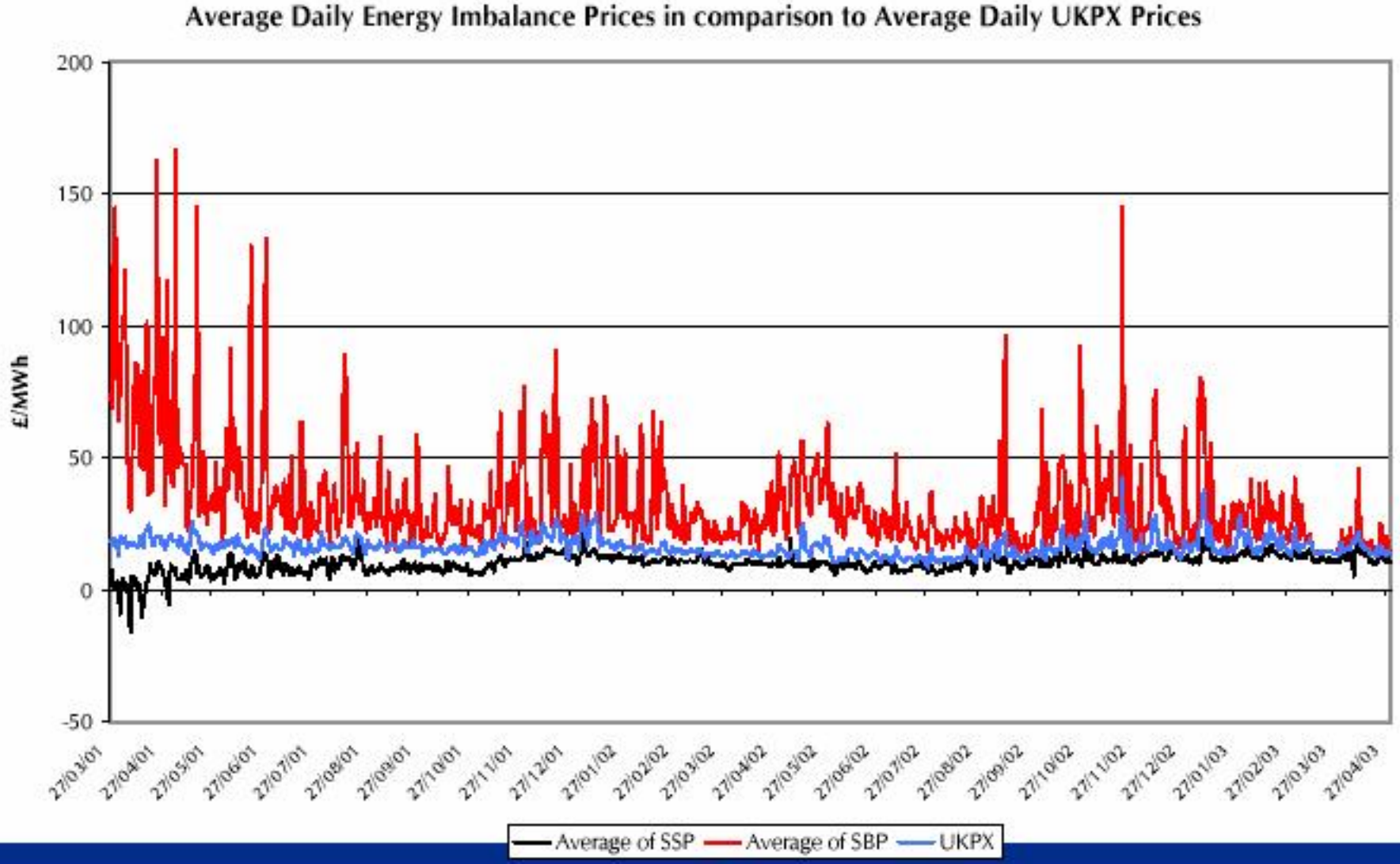
Key features of NETA

(Ofgem 1 year review of NETA, July 2002)



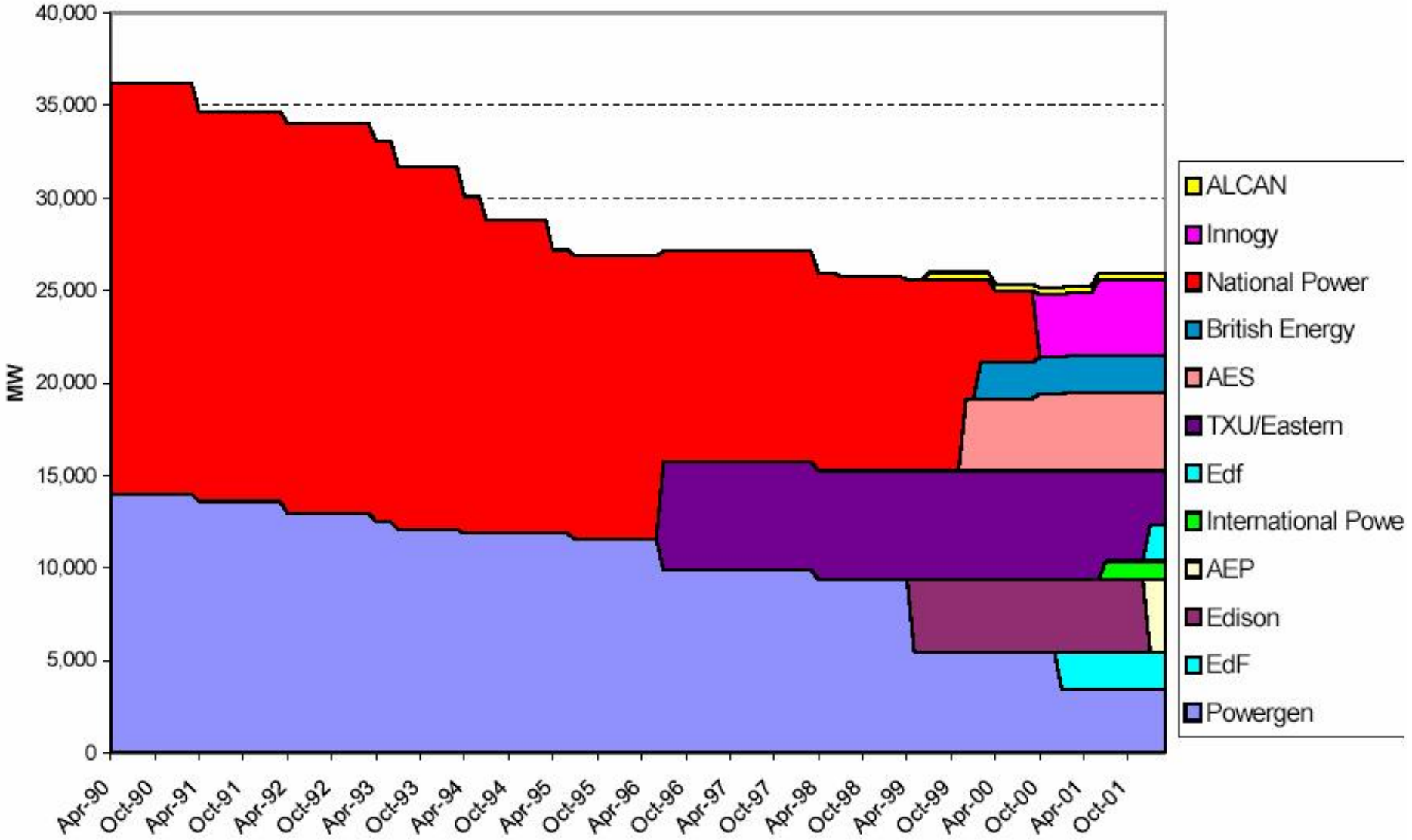
Daily average system buy & sell balancing prices and current day forward price (UKPX)

(S Brown, England & Wales wholesale market 2 years on, Ofgem, 2003)



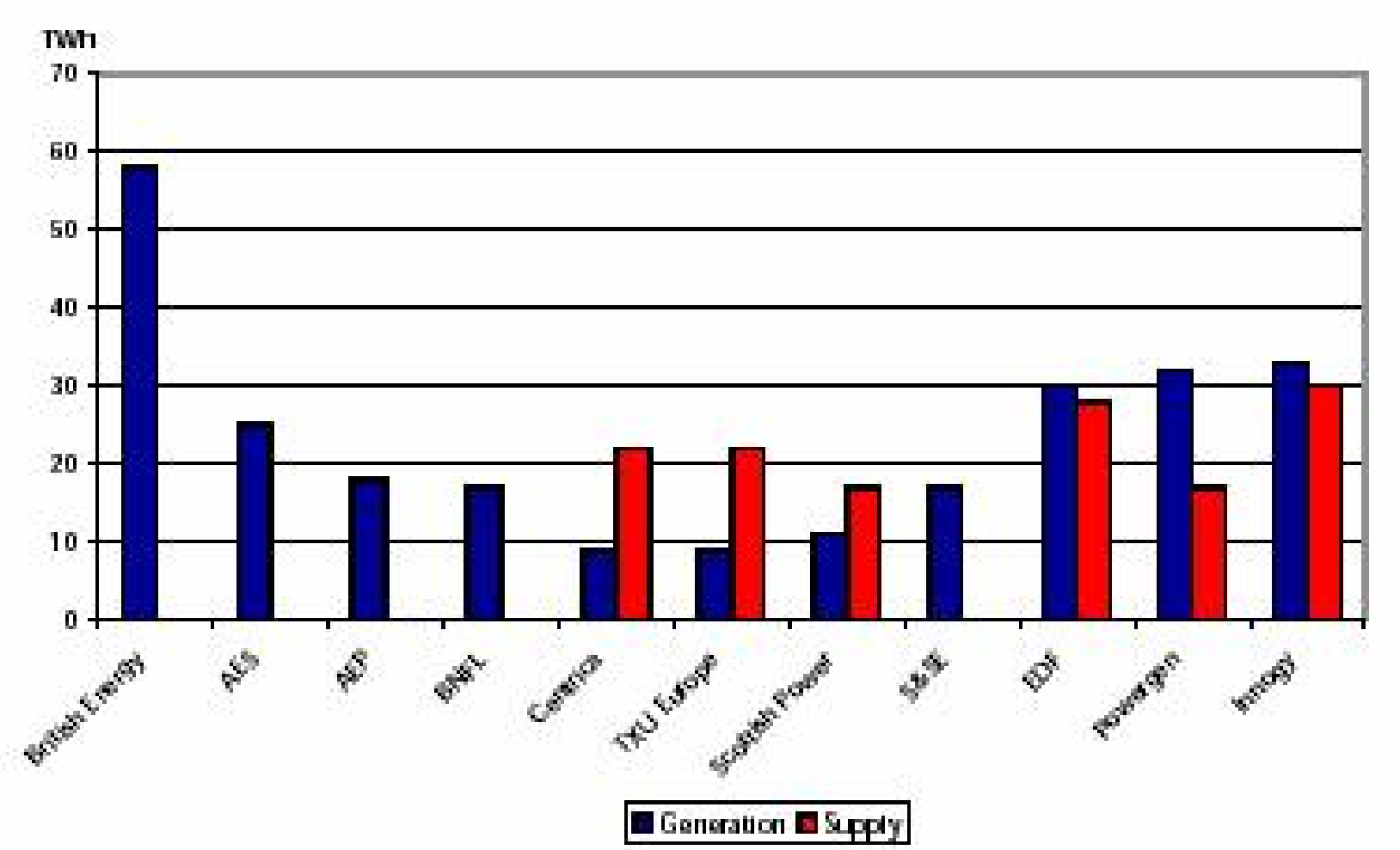
Ownership of UK coal-fired generation 1990-2001

(D Newbery, England & Wales wholesale market 2 years on, Ofgem, 2003)



Trend towards vertical integration reduces reliance on balancing mechanism

(Ofgem 1 year review of NETA, July 2002)



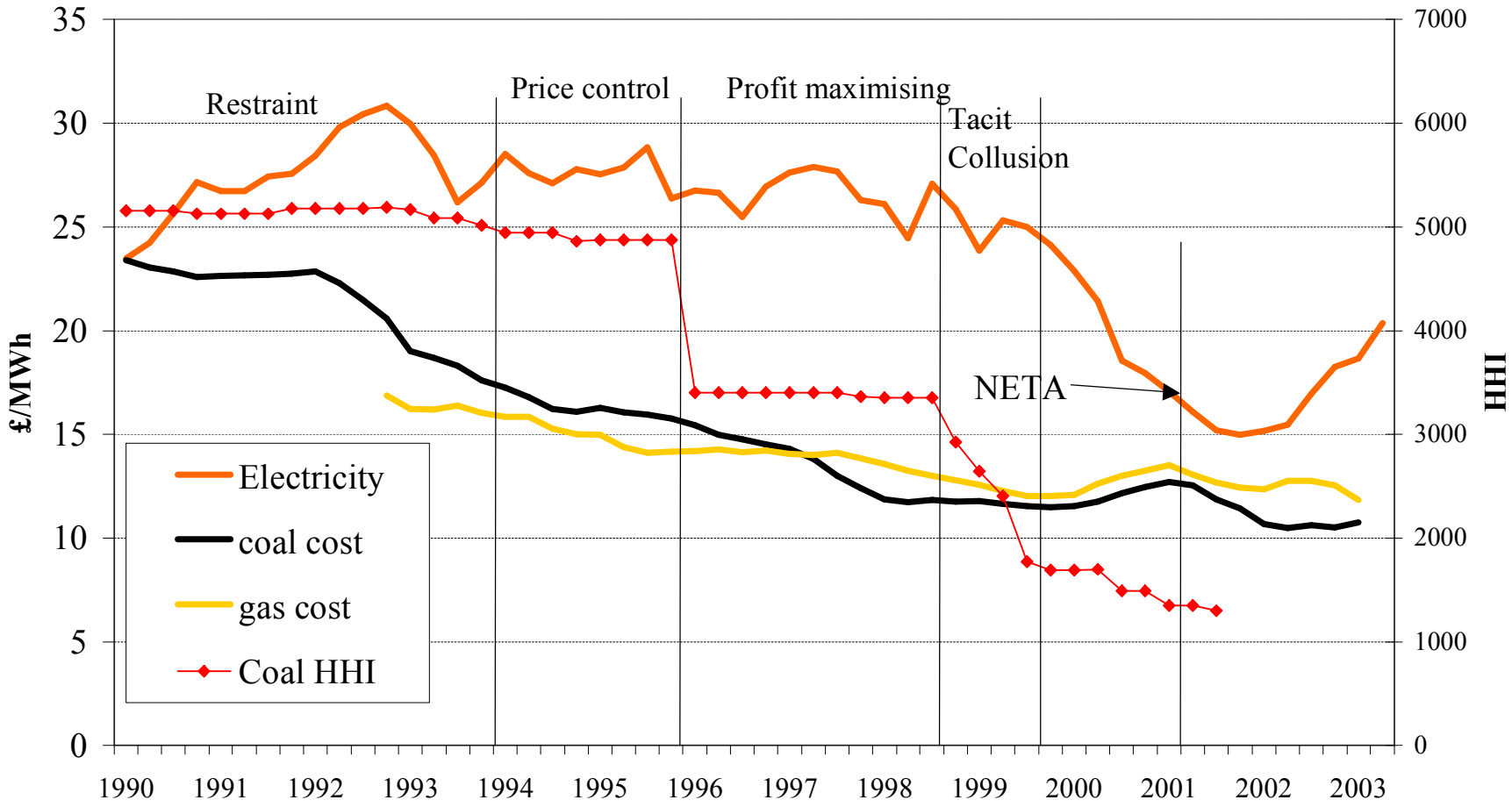
Some UK perspectives on NETA

(England & Wales wholesale market 2 years on, Ofgem, 2003)

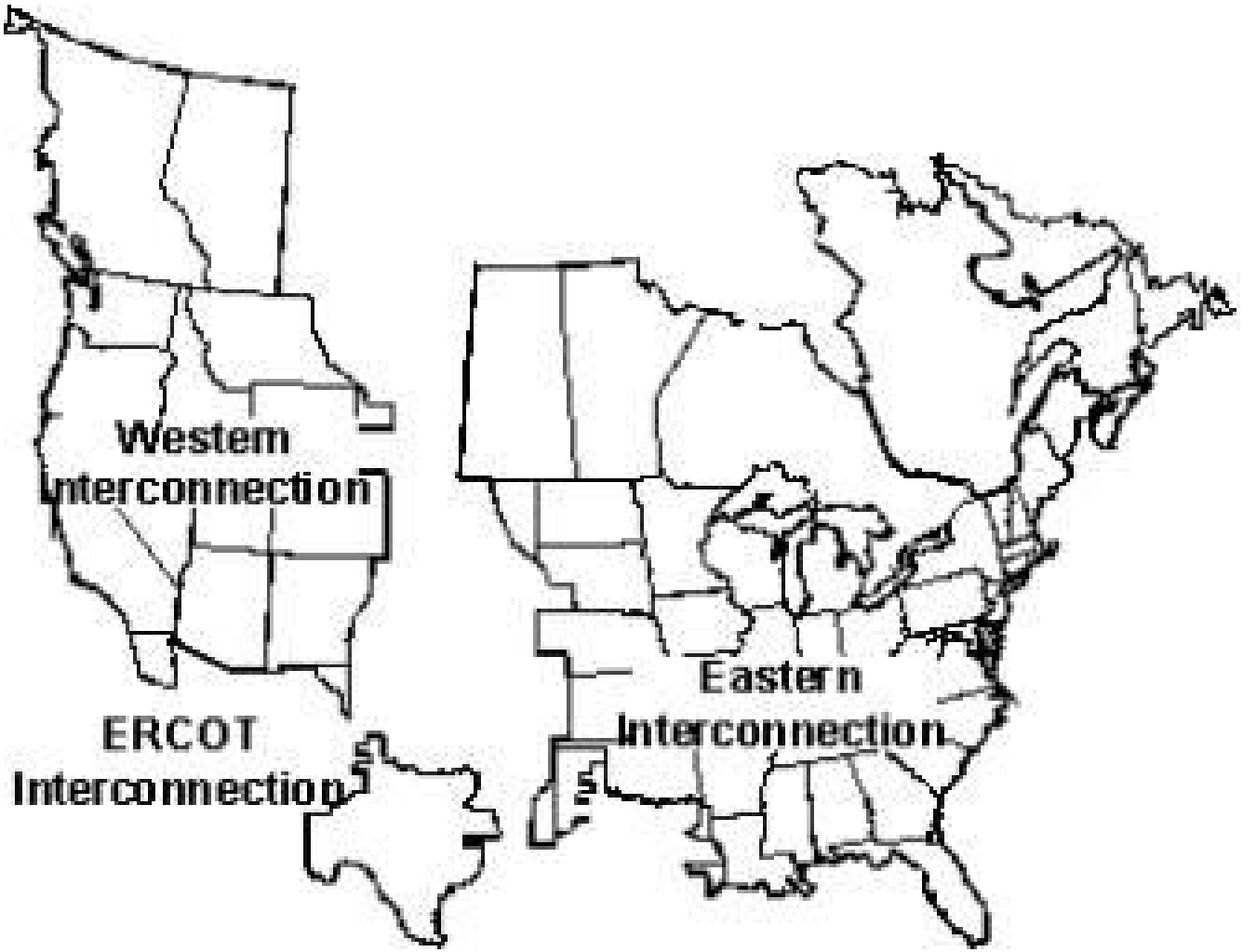
- Newbery (Cambridge University):
  - Increased competition in fuel & generation may be the key driver on wholesale price reductions
  - NETA very expensive to implement
- Yarrow (Oxford University):
  - How will long-term security of supply be maintained?
  - NETA can't represent transmission losses & constraints due to bilateral nature

Reduction in electricity prices "not due to NETA" (Mirrless-Black, IEE Ireland colloquium, 2004)

Real electricity and fuel costs 1990-2003



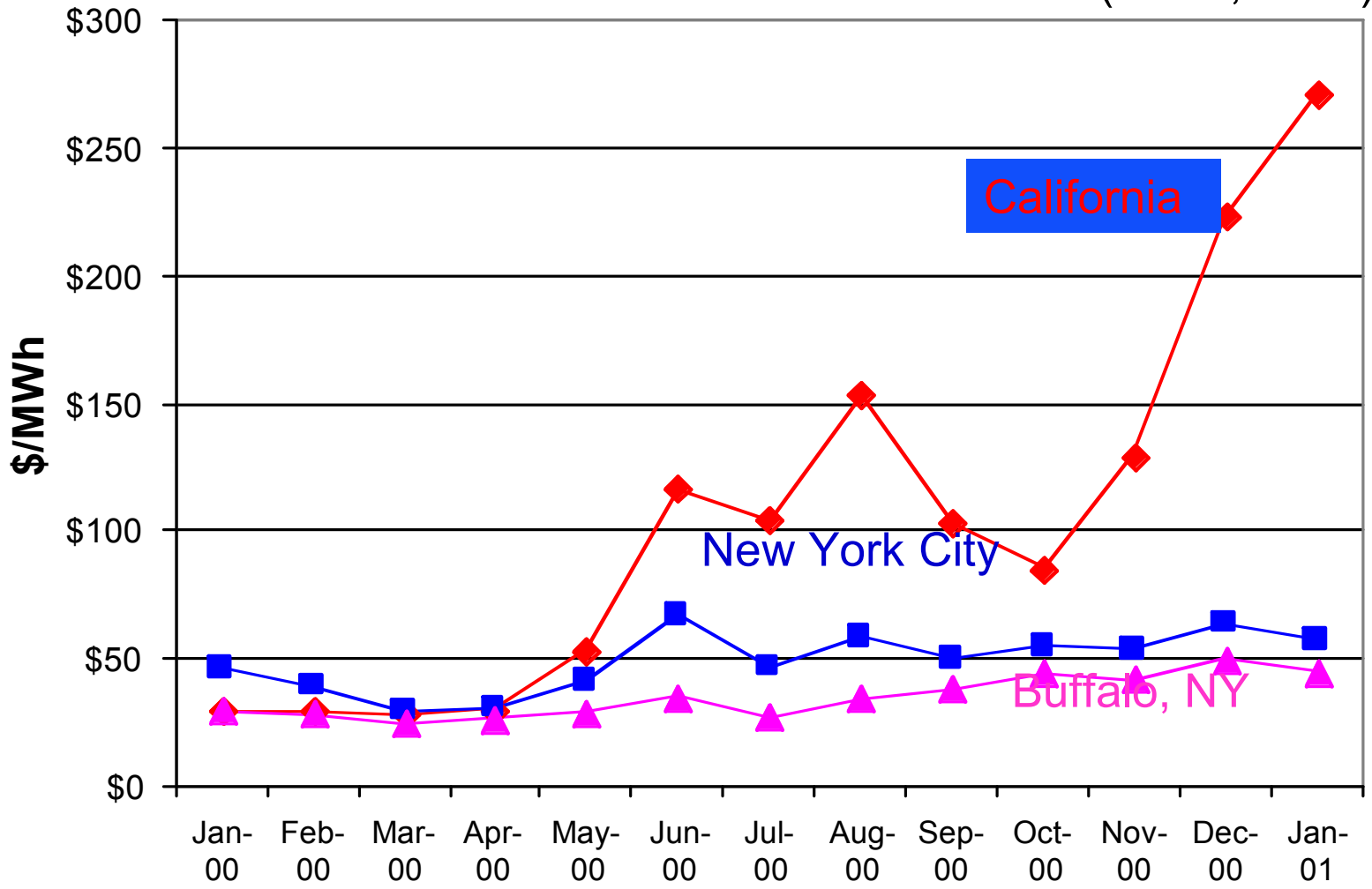
North America (USA, Canada, Mexico): Three interconnected power systems



Electricity industry restructuring in USA

- Federal level (inter-state trade):
  - PURPA (1978) required utilities to buy from "qualifying facilities" within their service territories
  - EPA (1992) mandated transmission access for wholesale transactions (buyers must be utilities):
    - Access & "wheeling" charges (a bilateral trade model) regulated by Federal Energy Regulatory Commission
- State level (intra-state trade):
  - Some states began EI restructuring:
    - Bilateral trade (eg California) or pool (eg PJM)
    - Single state (California) or groups of states (PJM)

Comparing day-ahead average electricity prices in California & New York in 2000 (Flaim, 2003)



Source: NYISO MIS 3/1/01; UCEI Berkeley web site

Comments on California restructuring

- A politically influenced bilateral trading model:
  - Compromises, inconsistencies & complexity
- Many non-ideal features:
  - Not consistent across Western System:
    - Or even within California
  - Economic & technical regulation separated
  - No coordinated support for investment decisions:
    - eg IOUs were forbidden to forward contract
  - Poor spot market design (CaI ISO default market)
  - Short horizon for managing system operation
  - Large residual task for ancillary services

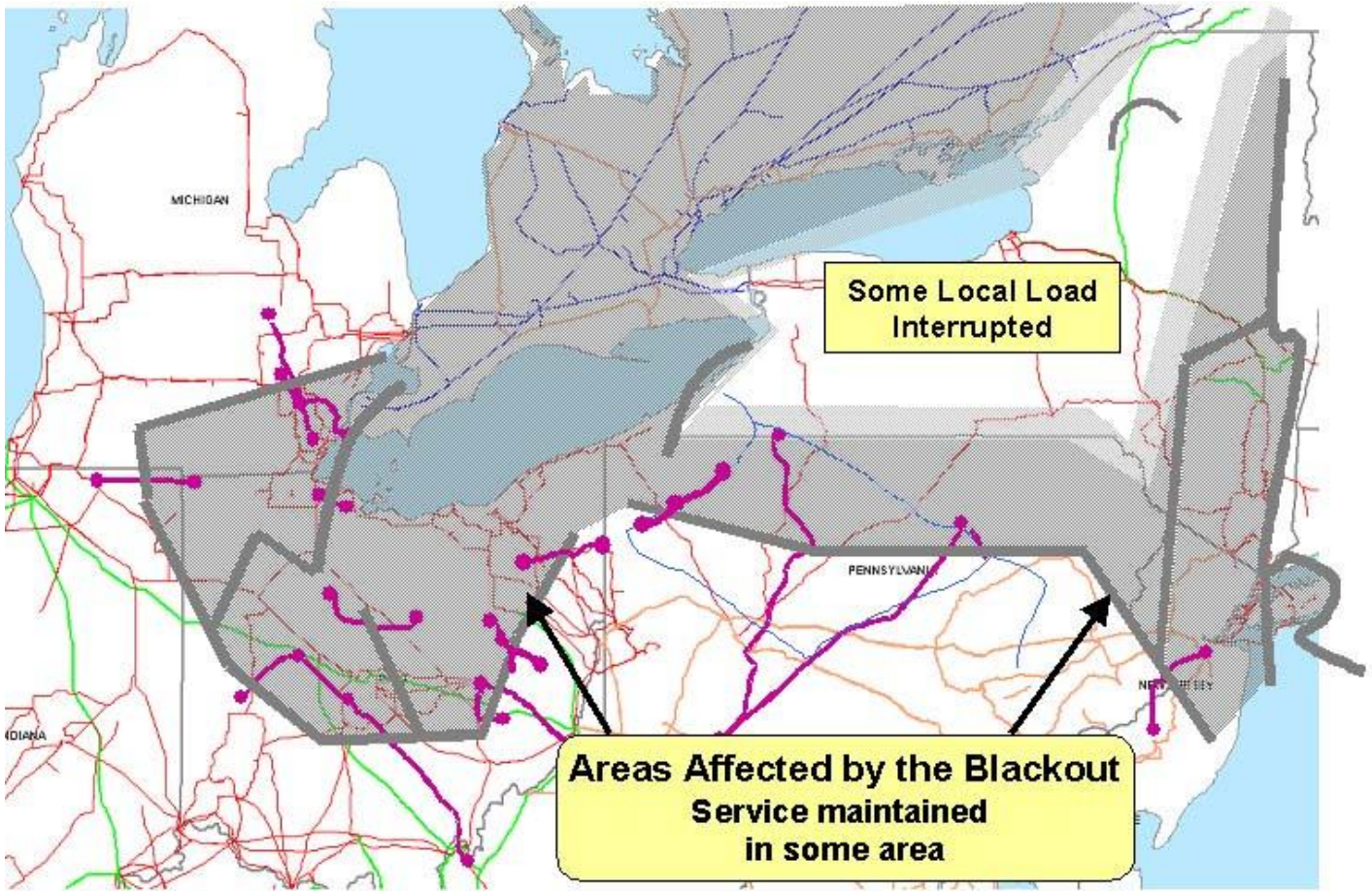
Other factors contributing to failure of California electricity restructuring

- Hydro reserves had been run down:
  - California still ~25% hydro energy
- Gas & NOx permit prices were rising:
  - Allegations of market power in gas market
- Approval difficult for new generation & network
- Continuing growth in demand, including:
  - Temperature sensitive residential air-conditioning
  - High-value commercial & high-tech industrial
- High wholesale prices & regulated retail tariffs:
  - PG&E and SCE eventually went bankrupt

Areas affected by blackout of 14/8/03

(T Mount, Cornell University, 2004)

By 4:13pm, cascading outages had blacked-out 50 million people in northeastern USA & Ontario Canada



The North America Blackout of 14/8/03

(www.spectrum.ieee.org/webonly/special/aug03/black.html)

- DOE studies had predicted trouble since '98:
  - Inadequate regional oversight & control
- Operators unable to stop problem escalating:
  - Midwest ISO had less authority than PJM & New England counterparts; SCADA failures
  - Human errors & loss of institutional capacity
- Proposed remedies:
  - Clarify operator accountability: regional ISOs
  - Build network capacity & institutional skills

Conclusions from North American experience (Massey, 2003)

- Electricity doesn't respect political boundaries
  - Consistent rules over entire market region
- Fundamental design principles:
  - Ex-ante, locational spot & derivative markets
    - Transmission losses & flow constraints
  - Independent grid and market operation
  - Market monitoring and mitigation of market power
- Enlarging market scope by interconnection:
  - Reduces supply-side market power
  - Requires consistent rules & regulation

Conclusions - future challenges

- Electricity:
  - Enhanced end-user participation & accountability
  - Uniform governance & regulation
  - Efficient network investment that gives equal consideration to distributed resource options
- Gas:
  - Efficient market design for existing gas network
  - Efficient investment in gas infrastructure
- Sustainability of the stationary energy sector:
  - Dramatic reduction in energy use