



# AUPEC'04

Brisbane, September 2004

## A new UNSW Research Centre for Energy and Environmental Markets

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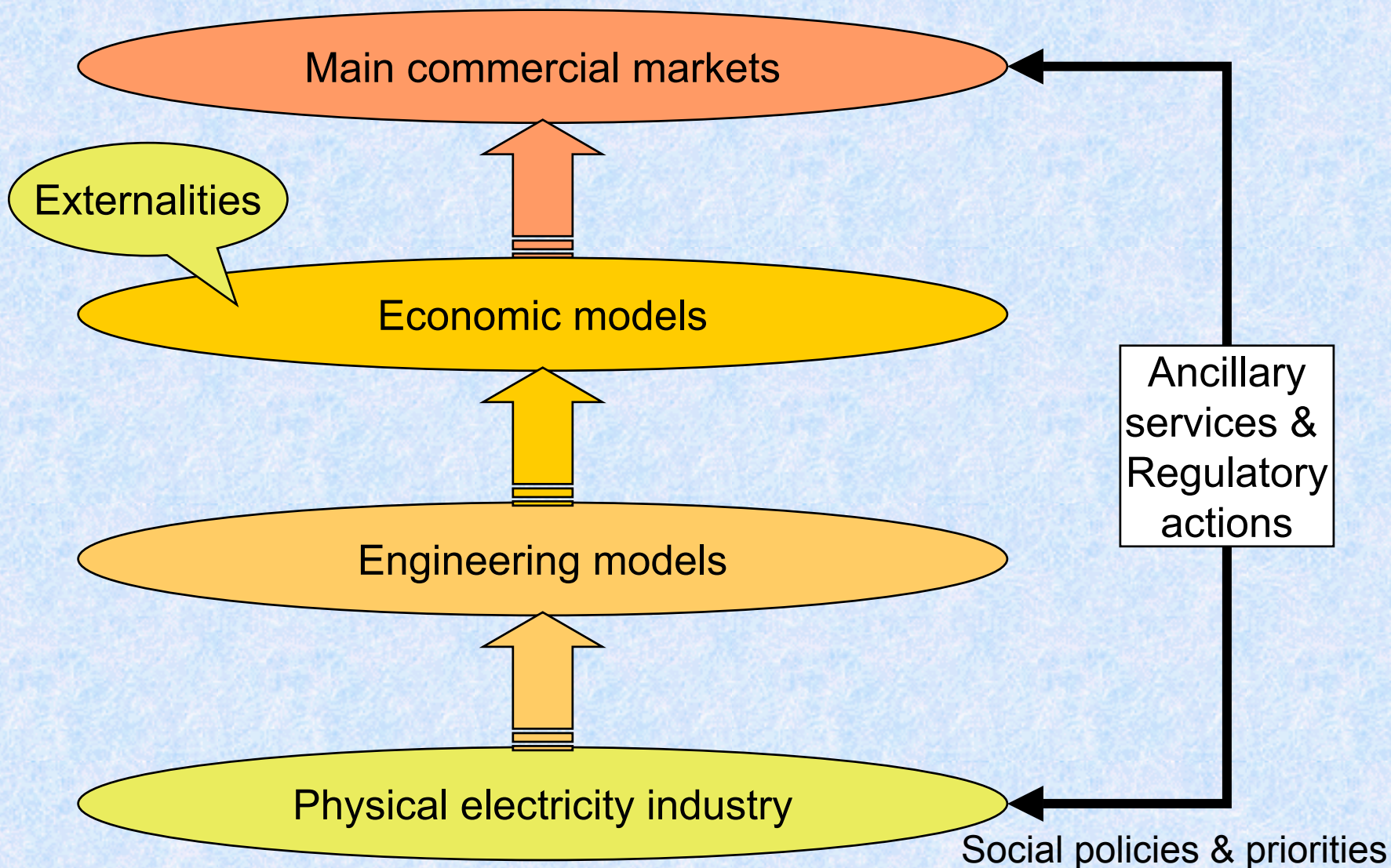
## The question... and answer up front

- **Q Why establish such a Centre?**
- **A Because** energy and environmental markets are important, yet challenging...
  - *When might market-based approaches be appropriate?*
  - *How might such markets be designed?*
  - *How might we try and fix markets that aren't working?*

and answering these questions seems likely to require a focussed inter-disciplinary approach



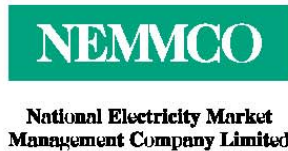
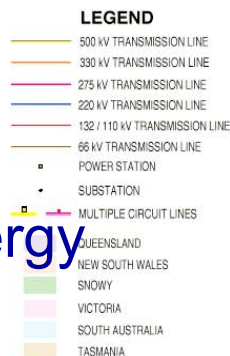
# The electricity industry – models to aid understanding





# The Australian NEM

- Physical properties of electrical energy
    - No cost-effective storage
    - Instantaneous transmission & distribution
    - Energy flows according to network laws from all generators to all consumers
- => Implications
- Supply & demand balance at all times
  - Electrical continuum - power station to end-use means can't assign energy from particular power station to particular consumer

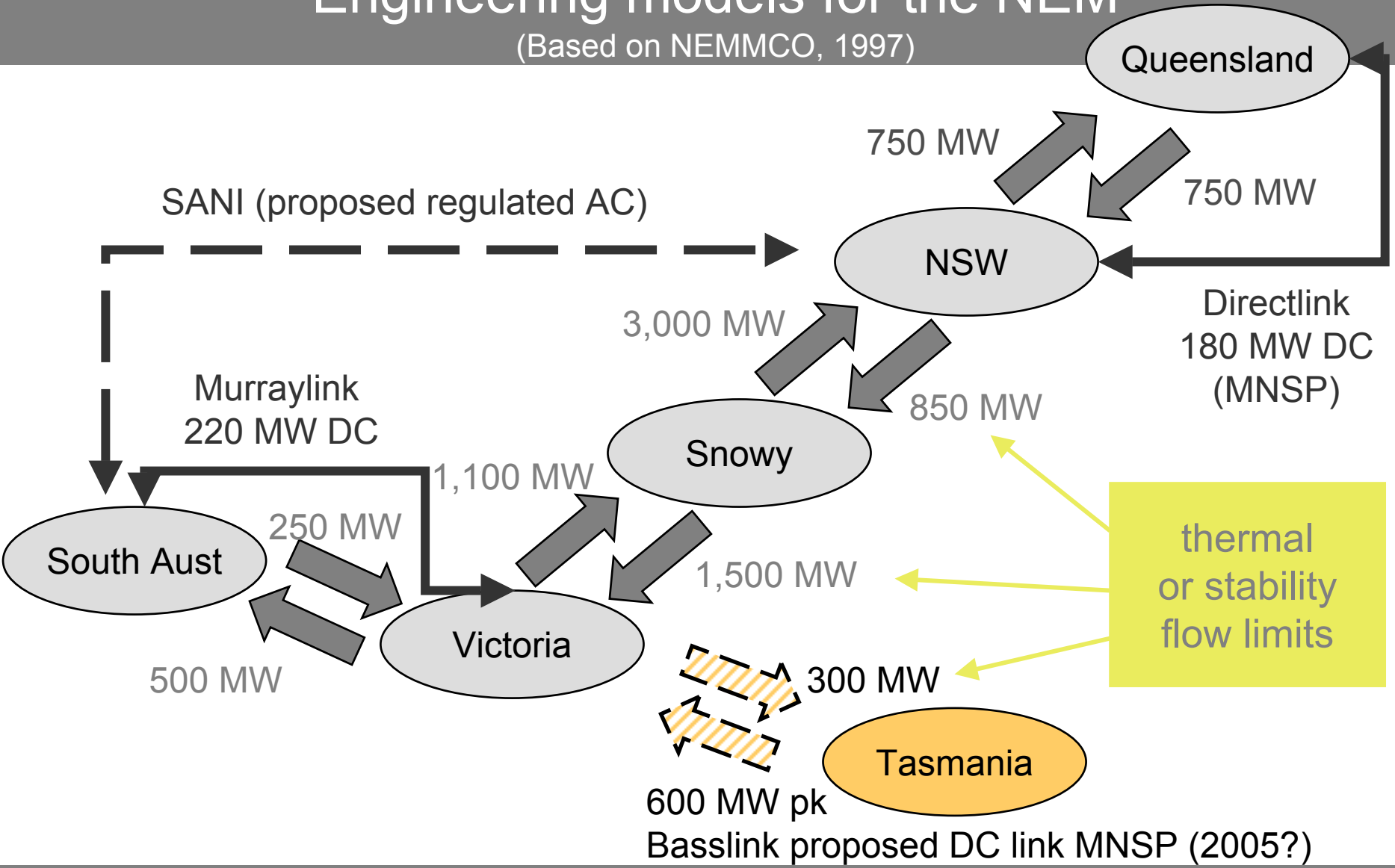






# Engineering models for the NEM

(Based on NEMMCO, 1997)

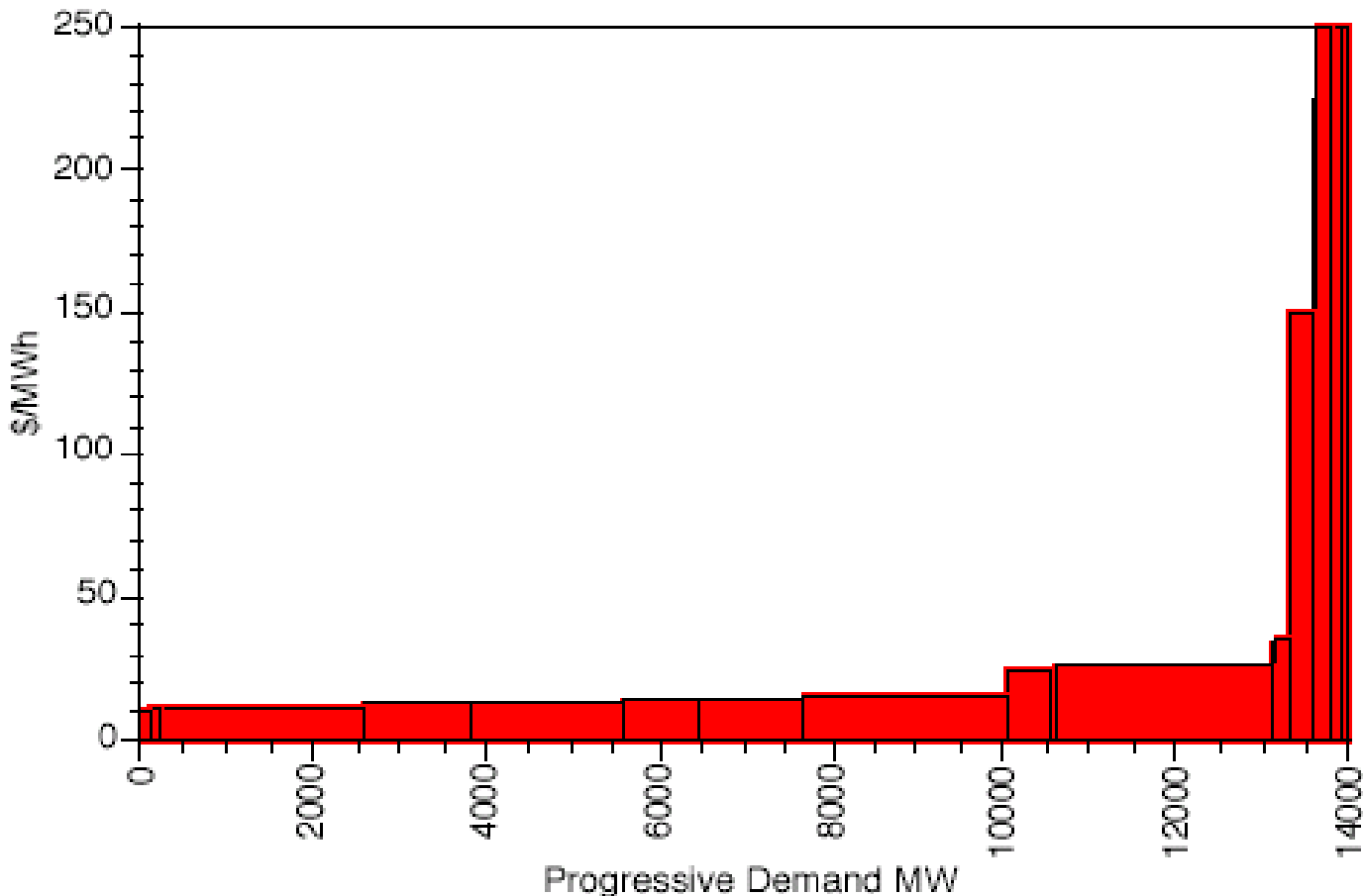




# Economic models for the NEM

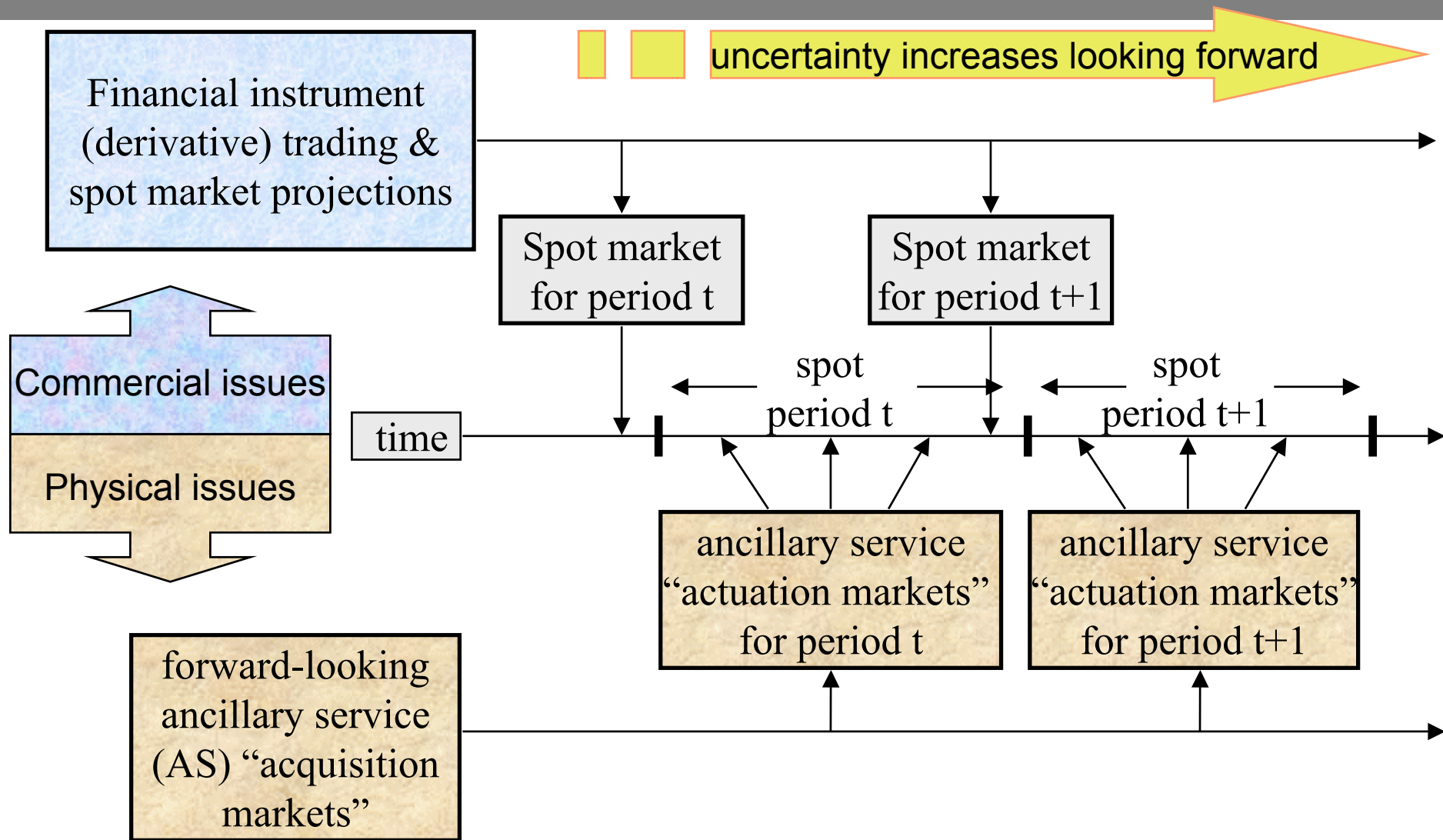
(from Bardak, "Pool prices in the NEM", 2003)

### NSW SRMC 2002



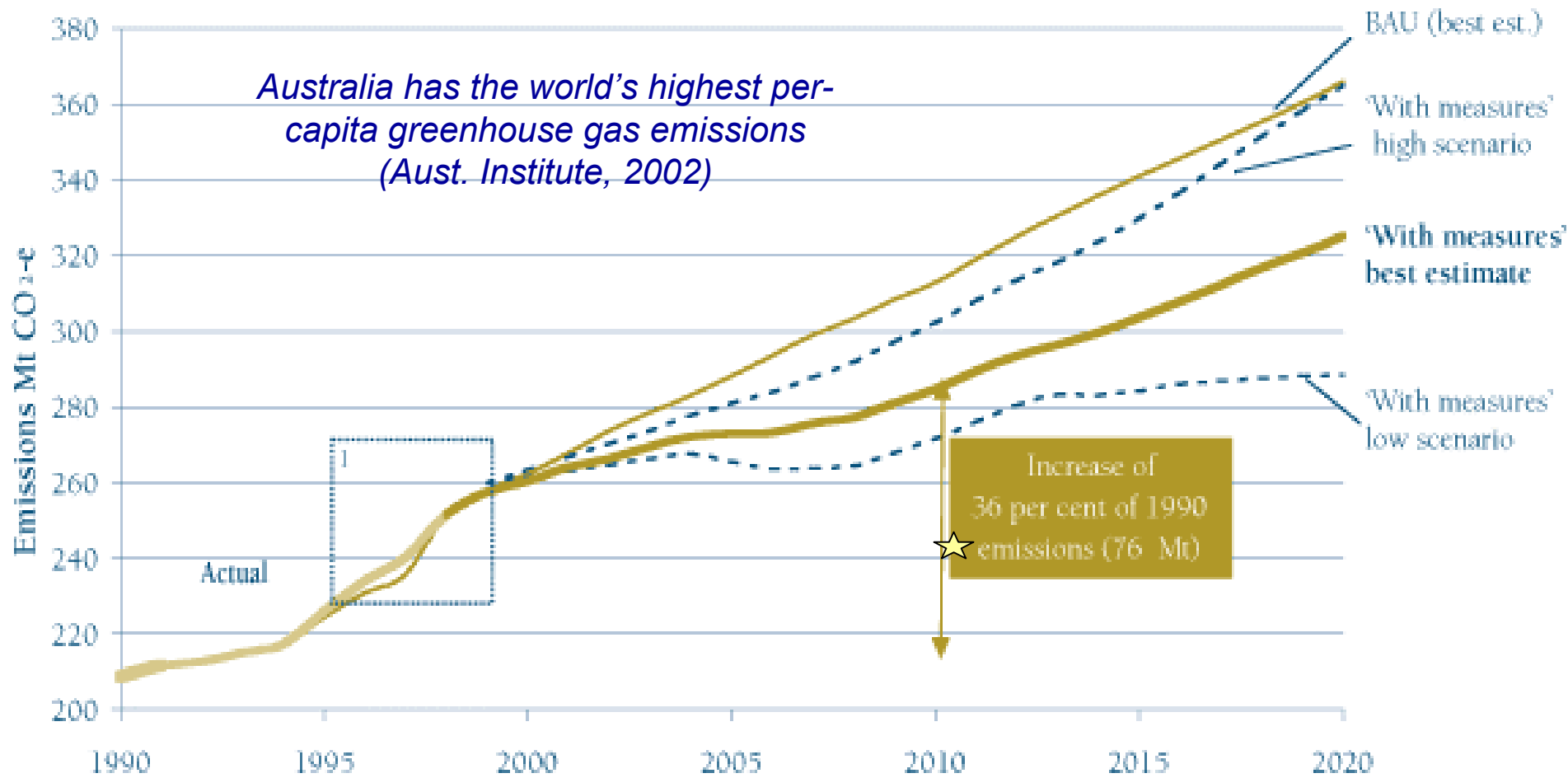


# Commercial models for the NEM





# The NEM and environmental externalities



Source: Australian Greenhouse Office (2002)





# Enviro markets – Mandatory Renewable Energy Target



## Renewable Energy (Electricity) Act 2000

The objects of this Act are:

- (a) to encourage the additional generation of electricity from renewable sources; and
- (b) to reduce emissions of greenhouse gases; and
- (c) to ensure that renewable energy sources are ecologically sustainable.



# Centre for Energy + Environmental Markets (CEEM)

## ***Established...***

- *to formalise* growing interest + interactions between UNSW researchers in Engineering, Commerce + Economics... + more
- *through UNSW Centre* providing Australian research leadership in interdisciplinary design, analysis + performance monitoring of energy + environmental markets, associated policy frameworks
- *in the areas of*
  - Physical energy markets (with an initial focus on ancillary services, spot market + network services for electricity + gas)
  - Energy-related derivative markets (financial + environmental including interactions between derivative and physical markets)
  - Policy frameworks and instruments in energy and environment
  - Experimental market platforms and AI 'intelligent agent' techniques to aid in market design
  - Economic valuation methodologies



## Tools for assessing market design + structure

- Economics – eg. general competitive market theory
- Experience with existing, similar markets
- ‘Common-sense’ assessment
- Mathematical analysis – Cournot + Bertrand paradigms, game theory...
- **Experiments**
  - ‘Trial + error’ simulations to explore possible market outcomes
  - Simulations guided by ‘intelligent’ market participants

***Experimental subjects***

***Software agents***



# Exploring a RECs market with experimental economics

Generator - Microsoft Internet Explorer

File Edit View Favorites Tools Help

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### Generator : 1

**Date and Days to Go**

Today is: 22 September 2000

98 Days to Acquittal date

**Current Bank Balance:**

\$544,976.50

**My Electricity Generator**

Month	Generated	RECs Created	Cost per REC
January 2000	1011 MWh	0	\$20.00
February 2000	762 MWh	0	\$40.00
March 2000	805 MWh	0	\$40.00
April 2000	861 MWh	0	\$40.00
May 2000	814 MWh	0	\$40.00
June 2000	769 MWh	4000	\$40.00
July 2000	672 MWh	0	\$40.00
August 2000	1036 MWh	0	\$20.00
September 2000	526 MWh	6000	\$0.00

**My RECS**

RECS generated but NOT YET CREATED

2782

Create RECS

**The REC Registry**

Number of RECs created

Month	Created
February 2000	0
March 2000	0
April 2000	0
May 2000	0
June 2000	4000
July 2000	0
August 2000	0
September 2000	6000

**TOTAL RECS IN THE REGISTRY**

10000

RECS currently in my Registry Account

5000

**Messages: INBOX**

FROM:	Message:
R1 @ 10 August 2000, 0:00	R1 bids to Buy G1 1000 RECs @ \$14 each

**Messages: SENT**

TO:	Message:
R1 @ 25 June 2000, 0:00	G1 offers to Sell R1 4000 RECs @ \$20 ea...

START STOP Send Offer Send Bid Accept Bid/Offer

**My Trade History**

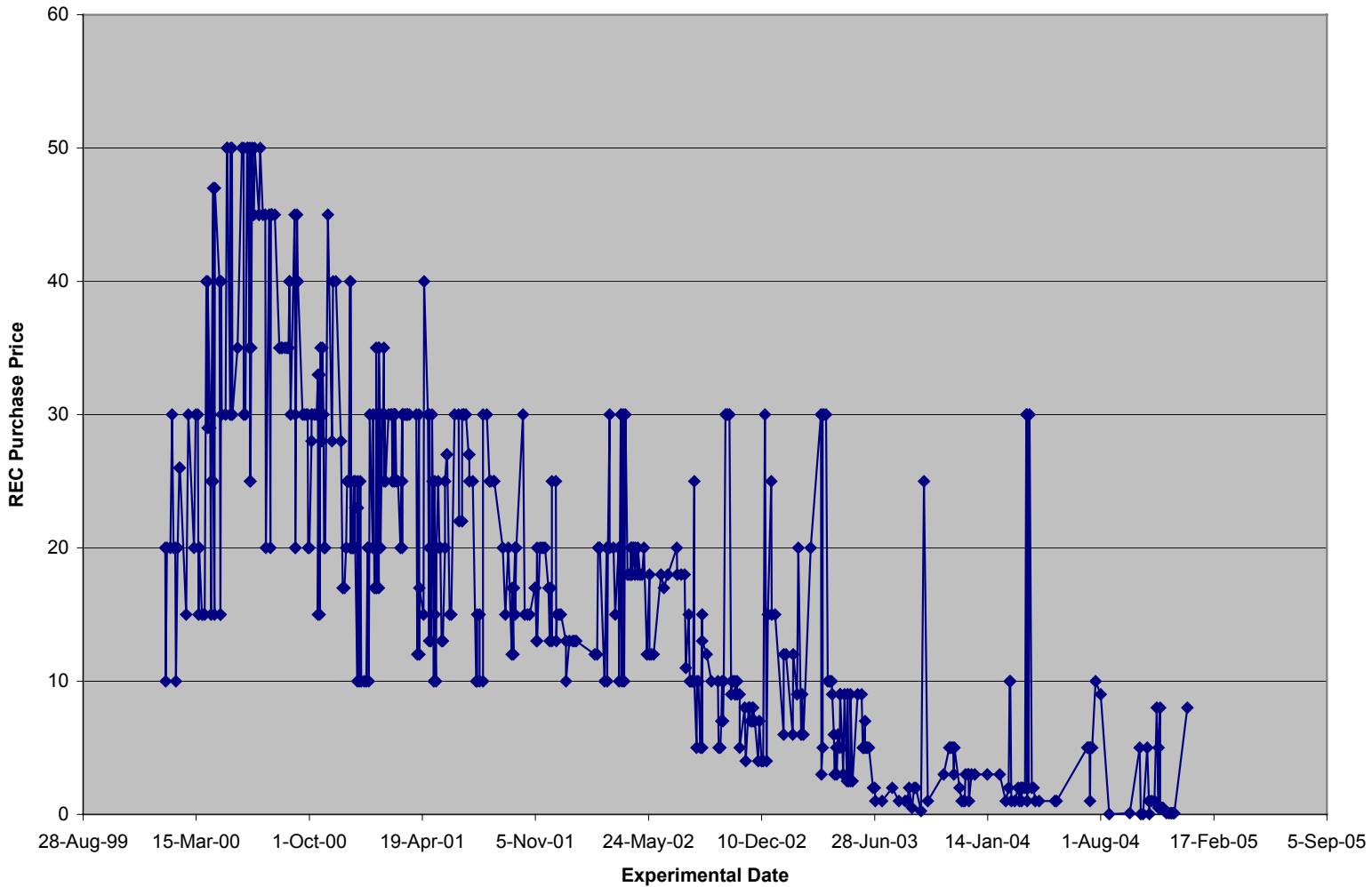
Time	Counterparty	Quantity	Price	Profit/(Loss)
4 July 2000, 0:00	R1	SELL 4000 RE...	\$20.0	\$80000.0
9 September 2...	R1	SELL 1000 RE...	\$14.0	\$14000.0

Applet rec.Generator started

Local intranet



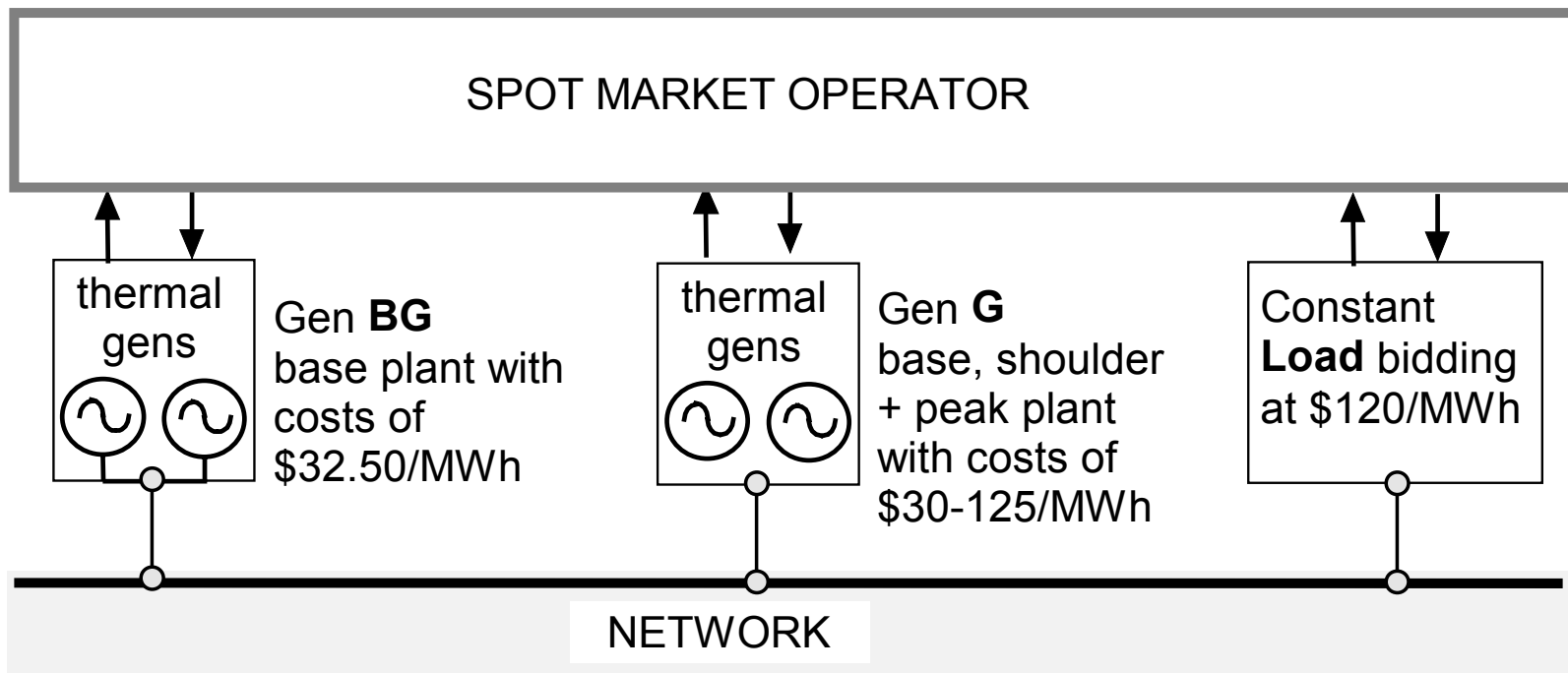
# Trial run for MRET experimental trading game







# Using AI agents and evolutionary programming (eg. simple power system with 2 generators)

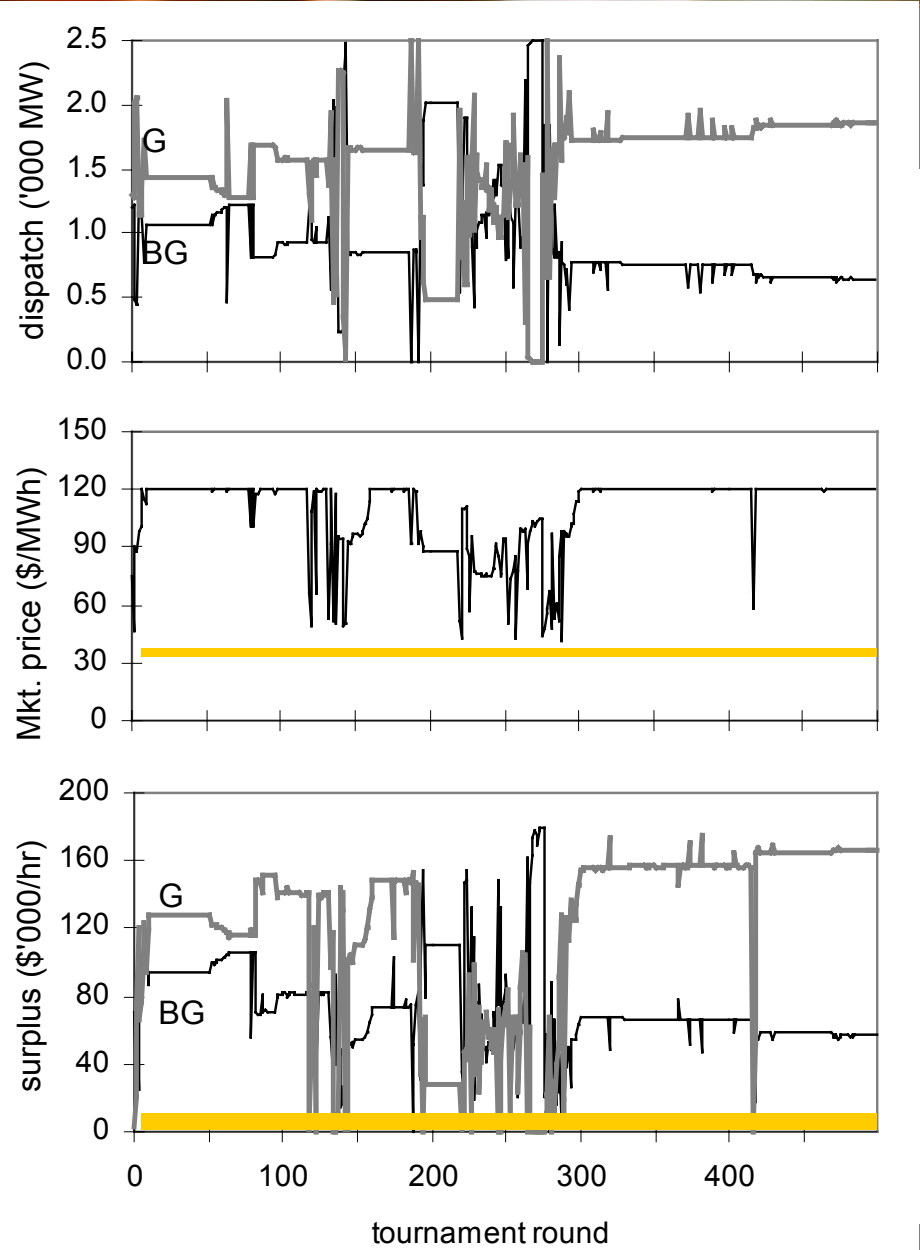




# EP Results

- Simple problems:  
=> EP + game theory agree
- Complex problems:  
=> EP shows useful insights beyond standard game theory  
Eg: BG and G 'fighting' over dispatch for Load that either can fully meet: *Go for dispatch volume or work together to increase price (no Nash equilibrium)*

Range of market price \$/MWh and G and BG surplus (profit) outcomes if none, or only one is attempting strategic behaviour





For more information.....

[www.ceem.unsw.edu.au](http://www.ceem.unsw.edu.au)