



# AUPEC'04

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Using a market game as a tool for teaching  
strategic behaviour in an electricity  
industry restructuring course

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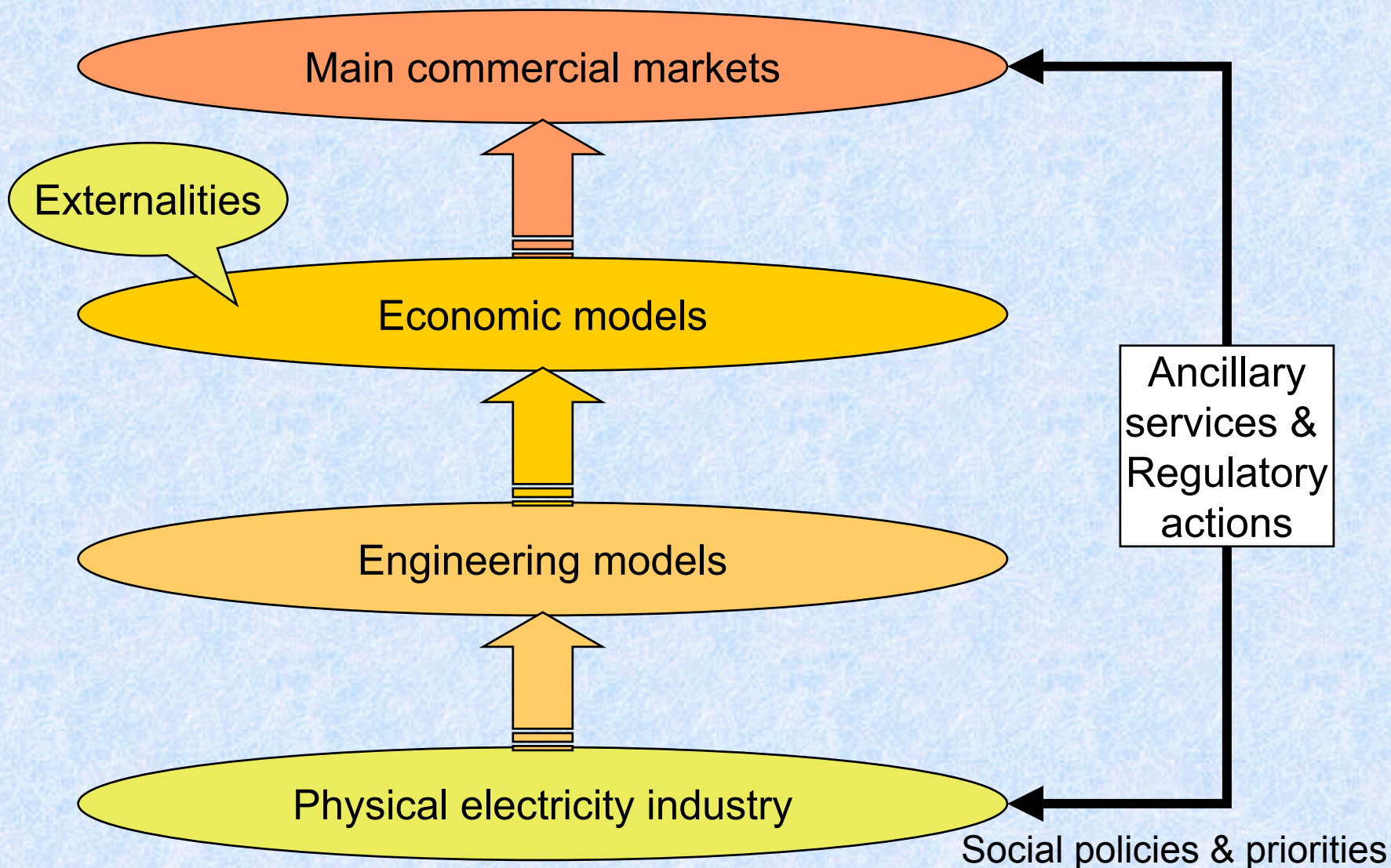
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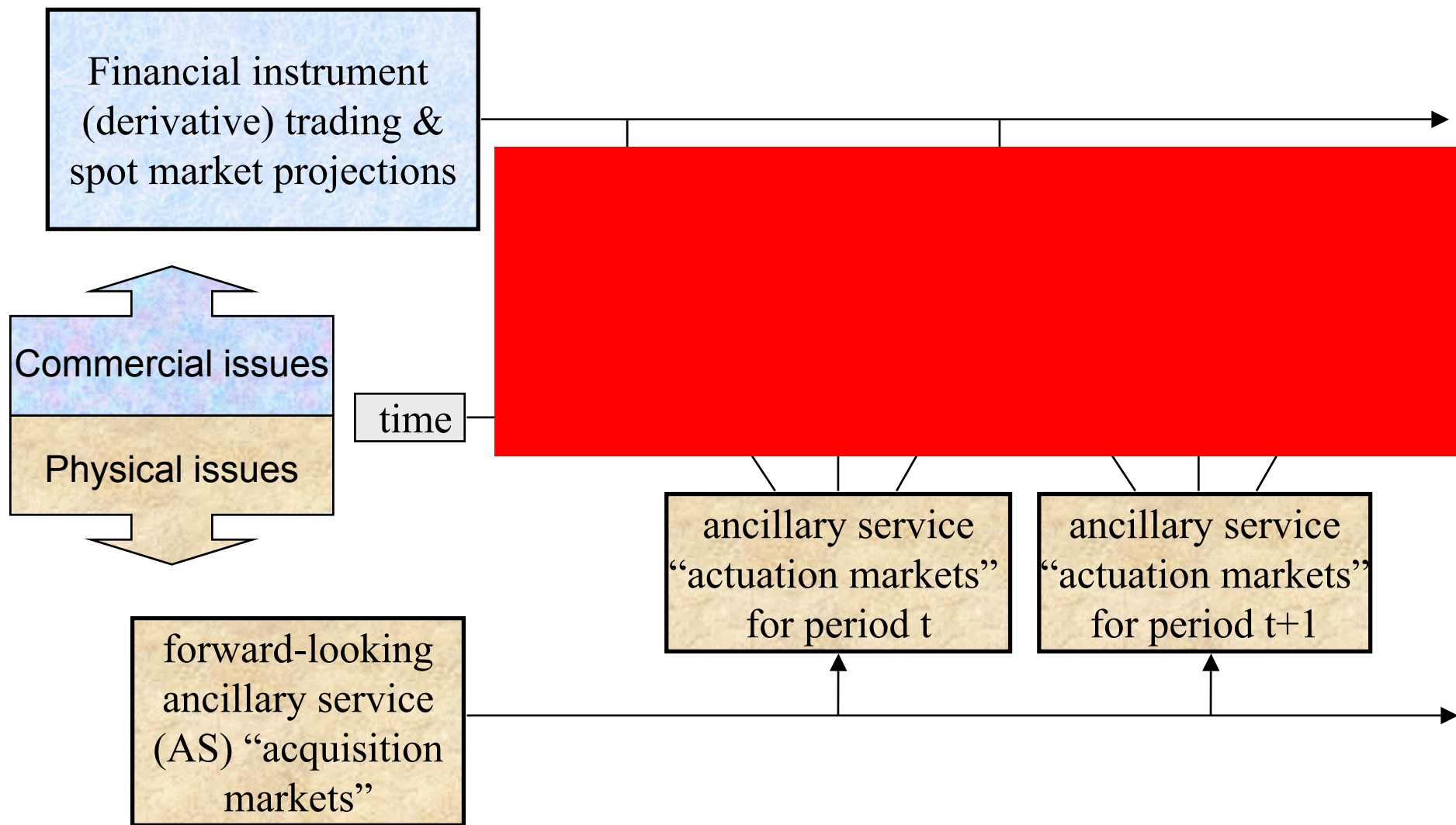


# Electricity industry restructuring – useful models





# Markets in the restructured electricity industry

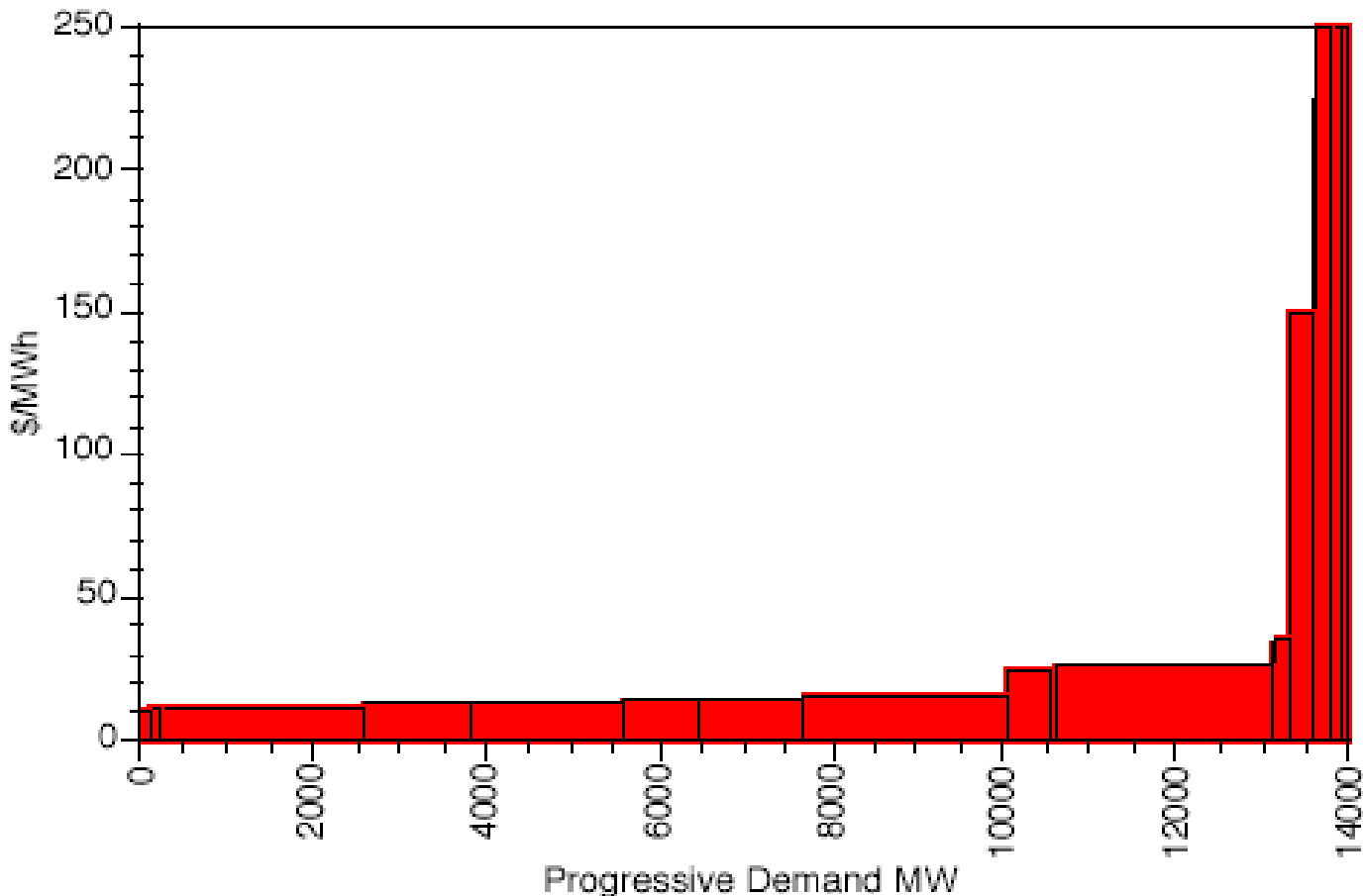




# Economic (+ perhaps commercial) models for spot mkts

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

### NSW SRMC 2002





## Strategic behaviour in spot mkts

- Strategic behaviour is
  - Trading actions of generators that can profitably influence spot prices
    - *Individual market power* of a single firm
    - *Tacit collusion* of a group of firms
- Typically exercised by
  - Withholding generation
  - Setting their mkt offers above marginal cost
- The realities of strategic behaviour in actual mkts driven by
  - Mkt design (rules) + structure (players)
  - opportunities: eg. summer peak days, contingencies
  - Particular players





# Teaching tools for strategic behaviour in spot mkts

- A range of teaching tools available
  - eg. Finland, Mexico, US...
- UNSW post-grad courses in EI restructuring
  - Power systems operation and control
    - Operation of existing system (*20 ms => year*)
  - Electricity industry planning and economics
    - Planning for investment (*year =>*)
- Spot mkts play a key role in both operation + investment  
=> Simple spot mkt tool developed for UNSW course



## Tool design

- Design criteria were simplicity + clarity
- Model assumes
  - Competition only on supply side amongst generators – deterministic demand + no DSR
  - Transmission network not specifically modelled – loss factors ok
  - No unit commitment or de-commitment
  - No forward contracts in place – revenue only from spot mkt
  - No ancillary services mkts
  - Each generating firm has a portfolio of units – each unit with constant incremental variable cost + max output
  - Firms offers to mkt up to 10 (*price, quantity*) \$/MW pairs
  - Mkt coordinator solves dispatch to clear mkt at minimum cost
- Both single and day-ahead spot mkts supported



# Implementation

- Implemented via two Excel Workbooks
  - Coordinator
    - Mkt clearing mechanism
    - Economic dispatch to benchmark mkt outcome against perfectly competitive response
    - Game reports – concentration (HHI) + monopoly (Lerner) indexes
  - Firms scenario analysis tool
    - From an estimate of competitors' behaviour
    - ⇒ Tool generates residual demand curve so that firm can explore strategic offer options  
(*Excel solver can be used although not necessarily global optimum*)





## How the game is played

- Game process
  - Mkt coordinator establishes structure (firms + their portfolios)
  - Firms submit offers to coordinator
  - Coordinator clears mkt + informs all Firms of
    - Dispatch price + quantities for all firms
    - Offers of all firms
    - Profits of all firms
  - Game continues



*Communications undertaken via email*



## Some games

- Six firms 'staffed' by UNSW post-grad students
- Motivation – bonus class marks according to firms ranking
- Four games over 14 weeks of class

	Hourly spot mkt	Day-ahead mkt with 24 one-hour trading intervals over daily demand profile
All firms with identical portfolios	1	2
3 large firms with mkt power, 3 without	3	4



## Some results

- Identical portfolios + no individual mkt power (*not all participants reqd to be dispatched in order to meet demand*)  
=> almost no tacit collusion emerges
- Identical portfolios + some limited individual mkt power  
=> collusion for 3 firms only but not if all six firms competing in mkt
- A mix of portfolios, with some having mkt power  
=> fairly cautious use of mkt power with only limited price impacts
- Why such little enthusiasm for exercising mkt power?
  - Engineering students rather than Commerce + Economics students?
  - **OR?**



## A rational response to the bonus structure

- Student firms earn bonus marks for ranking amongst firms
- A firm exercising mkt power has to withdraw generation or increase offer price above marginal costs
  - => generally leads to higher mkt price but reduced dispatch
  - => other firms do better than the strategic firm
- In actual mkts, firms are motivated by profits rather than just strict rankings



## Conclusions + future work

- Existing tool a useful introduction to strategic behaviour in spot mkts, also familiarises students with spreadsheet model
- Possible future work
  - Games with stochastic demand
  - Day-ahead mkts with multiple offers + rebidding
  - Web-based implementation





# Centre for Energy + Environmental Markets (CEEM)

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

- *to formalise* growing interest + interactions between UNSW researchers in Engineering, Commerce + Economics, AGSM...
- *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



For more information.....

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