Optimisation in deregulated electricity markets – Australian Experience

MONASH University

Faculty of Engineering

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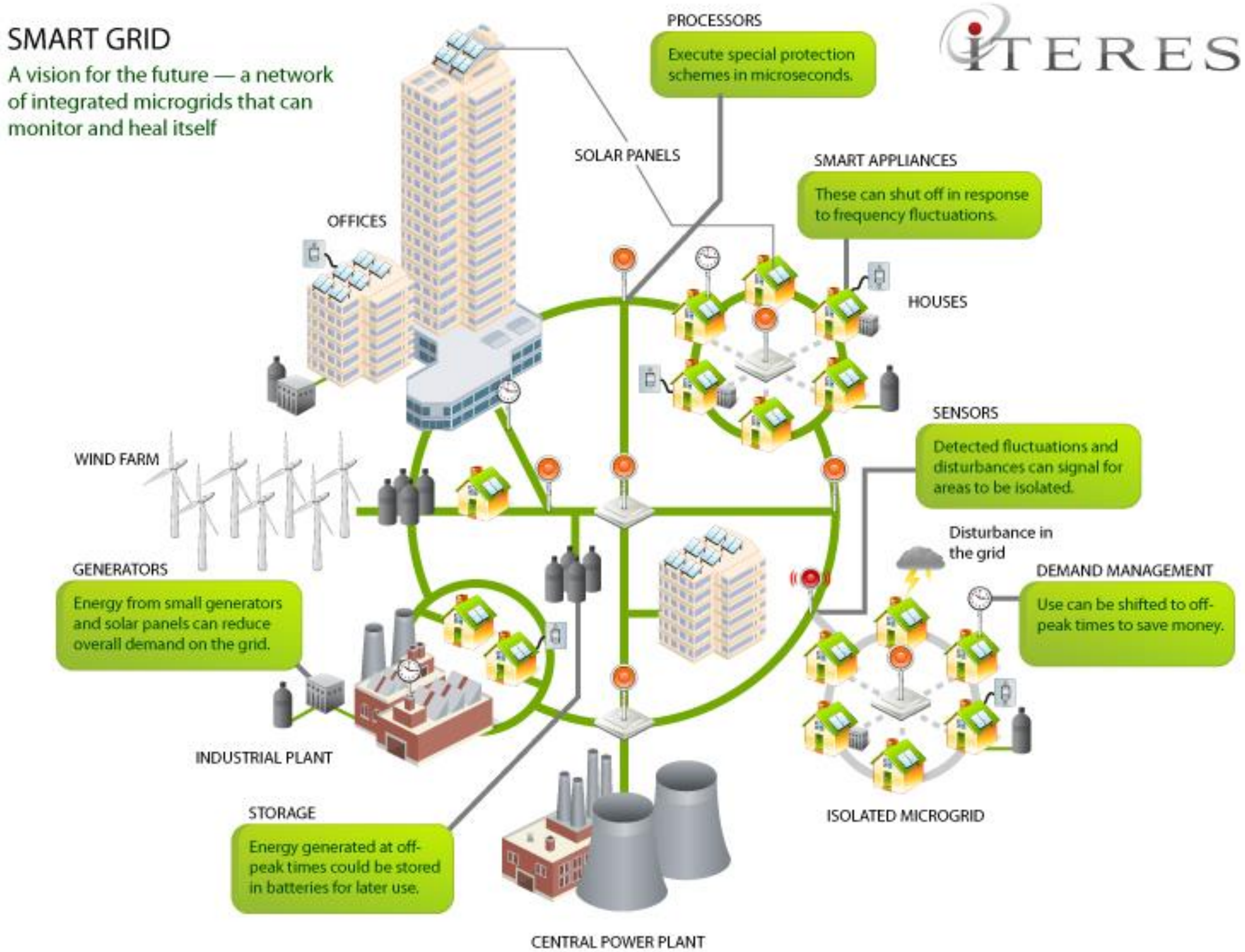
Global Innovation

Outline

- What's in an electricity market?
- What needs to be optimised in electricity markets?
- Who does it?
- How is optimisation coordinated in deregulated markets?
- What are the uncertainties?
- How are the uncertainties represented?
- How do uncertainties affect optimisation?

The Smart Grid



Levels of optimisation

INVESTMENT

- Transmission Network
- Large Scale Generation
- Distribution Network
- Control Systems
- Small scale generation
- Electro-technology (End-use)

OPERATIONS

- Generation outage scheduling
- Generation dispatch
- Storage Control
- Load scheduling and demand side response
- Network maintenance scheduling

Example of Decisions to be Optimised - Transmission

Regional Network	Transmission Line Optimisation	Transformer Optimisation
Highest voltage level	Identification of efficient route – tower placement	Rating (size)
Easement routes	Voltage rating and connections	Timing of Commissioning
Main Terminal Station (Bulk Supply) locations	Timing of commissioning	Design parameters for efficiency
Subsidiary lower voltage network layout	Standard Conductor size & number of conductors	
	Operation at lower voltage	
	Timing of maintenance	Timing of maintenance

Choices are limited by many factors (environmental, standard sizes and existing voltage levels)

Operational decisions - Generation

Seasonal	Weekly	Daily	Trading Interval
Management of hydro energy storage and production targets	Scheduling of hydro energy storage	Commitment to start and stop large scale peaking plant	Bidding of volume in price bands and dispatch of energy service
Maintenance scope and timing and commitment to start and stop base load plant	Commitment to start and stop intermediate thermal power plant	Bidding of price bands (NEM)	Bidding and dispatch of control ancillary services
Commissioning of new power plant			

Decisions depend on accurate forecasts of demand, variable renewable generation and thermal plant availability.

Who does the optimisation?

Entity/Sector	Transmission	Generation	Distribution	Customer
Competition Regulator	Investment Rules	Competition and Connection Rules	Investment Rules	Access Rules
Network Regulator	Regulated Network Services		Regulated Network Services	Access Standards
System Operator	System security	Energy and services Dispatch		
Network Owner/ Operator	Network and Equipment Design and unregulated Network Services	Coordinates network and generation maintenance	Network and Equipment Design	
Generation Operator	Plans for connection to the network	Service price/volume bids and plant maintenance	Plans for connection to the network	
Customer	Plans for connection to the network	Chooses self-generation equipment (e.g. solar, back-up diesel)	Plans for connection to the network	Chooses end-use equipment that controls use of electricity

The process of regulation also involves optimisation to ensure that rules do not create more costs than benefits

How is Optimisation Conducted?

For Transmission

- Regulator attempts economic optimisation of regulated network investment using forecasts of supply, demand, cost and price using
  - Scenarios of future market development
    - energy and emission abatement policies, economic growth
  - Forecasts of generation resource cost and availability
  - Network performance modelling
    - capacity, reliability and cost of unserved energy
  - Energy and ancillary service dispatch modelling
    - dynamic or linear programming methods
  - Commodity price forecasts
    - coal, gas, oil, emission costs
  - Sensitivity testing for robustness
- Seek network investment that minimises total cost of electricity service to the whole market
  - Often assumes optimal decision by market participants

How is Optimisation Conducted?

For Large Scale Generation Investment

- Generator attempts to maximise return on capital investment using forecasts of supply, demand, cost and price using
  - Scenarios of future market development
    - energy and emission abatement policies, economic growth
  - Forecasts of generation resource cost and availability
  - Network performance modelling
    - capacity, reliability and cost of unserved energy
  - Energy and ancillary service dispatch modelling
    - dynamic or linear programming methods
  - Commodity price forecasts
    - coal, gas, oil, emission costs
  - Sensitivity testing for robustness
- Seeks design and timing of generation investment to maximise investment return or to meet a rate of return hurdle

How is Optimisation Conducted?

For Small Customer Decisions

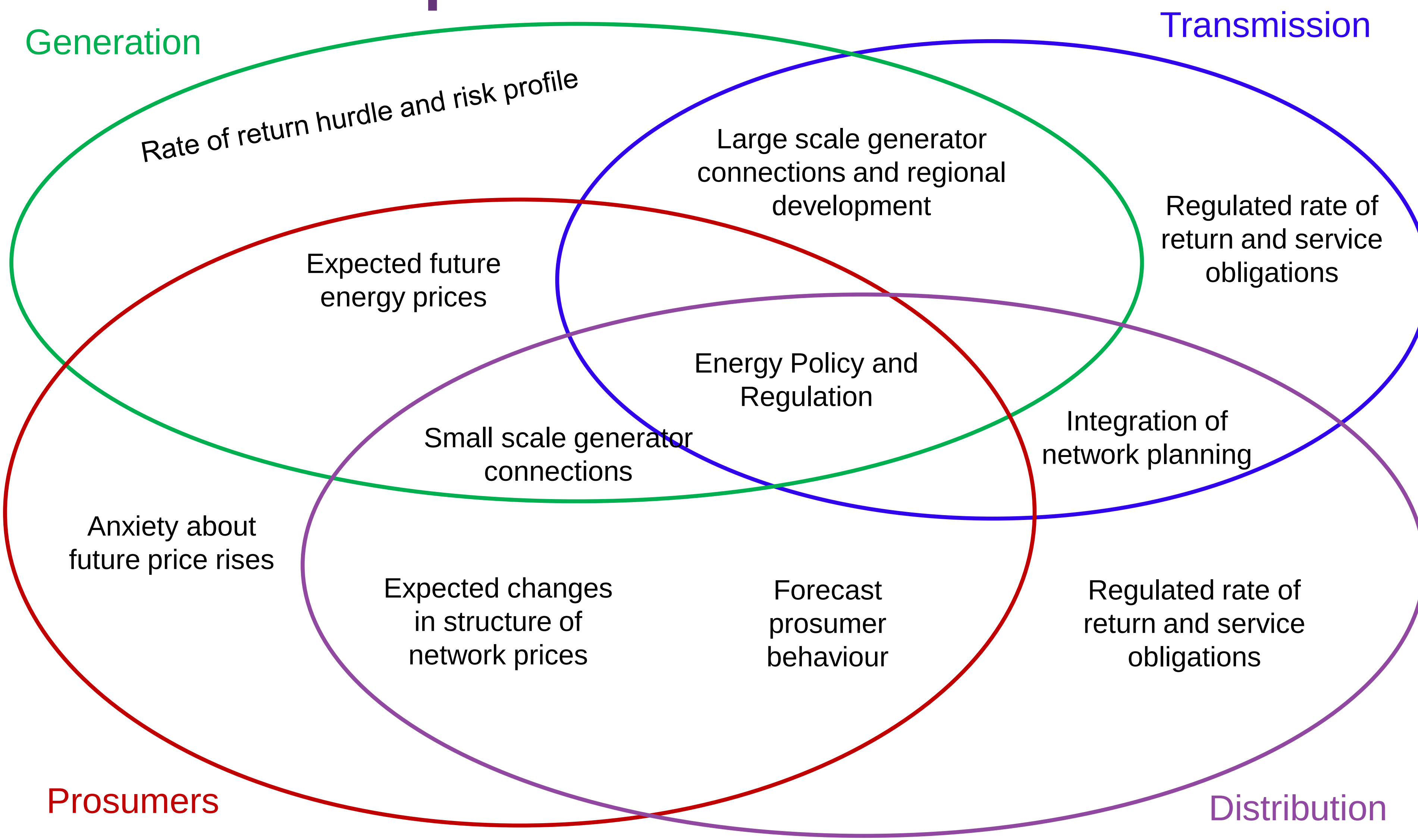
- Customer looks at current electricity retail tariff and works out savings
- Customer seeks substantial insurance from expected future energy price rises
- Customers buys because the neighbour has one (e.g. solar system)

- Rarely do small customers have a sophisticated view of long-term electricity market economics and prices.

What's used to coordinate optimisation?

- System Operator provides pre-dispatch demand and spot price forecast for the day ahead
- System Operator provides a forecast of system capacity adequacy
- Market consultants provide scenarios of long-term energy price forecast
- System Operator provides a network plan for the next decade based on a set of assumptions about supply and demand
- Market consultants or Network Operators provide economic analysis of network development options for regulatory approval
- Forecasts of Price - Reliability – Economic Value based on each party's optimisation

A View of Optimisation Issues



Treating Uncertainties

Uncertainty	How it is treated?
Thermal Plant Performance	Probabilistic modelling or Monte Carlo modelling of plant availability
Commodity Price Uncertainty	Scenarios of price variation
Investment Uncertainty	"What if" analysis built into supply scenarios
Policy Uncertainty (Emission Price)	Scenarios of price variation
Variable Generation and Load Correlation	Historical weather patterns used to drives models of variable generation and demand that are suitably correlated. Multiple years are simulated to assess variation of economic and performance impact.

How do uncertainties affect optimisation?

- Complicates the analysis
  - need to process multiple random samples and market scenarios
- Makes it difficult to communicate the results
  - there is often a set of possible decisions that have similar outcomes but vary in expected economic value and uncertainty.
  - For example, do we want the least expected cost or the least risk of an expensive decision with stranded investment?
- Visualisation and comprehension of results is becoming as important as the analysis because stakeholders need to be confident that a good decision results from the integration of everyone's optimisation.

The Methodological Challenge

- Current methods have weaknesses-
  - Assume that optimisation is conducted centrally and NOT by multiple parties
  - Assume rational economic investment behaviour with
    - Stable scenarios
    - Perfect foresight
    - Long-term perspective
  - Require simplification and approximation to yield practical results (e.g. load flow ignores reactive power)
  - Are complex to apply and understand
  - Require manual intervention to check modelling approximations for credibility
- New methods to apply commercially would benefit from automation of integration of standard modelling tools

Observations

- Optimisation in electricity markets
  - is multi-faceted
  - is conducted by multiple parties
  - is not well integrated between parties for lack of information
- Electricity optimisation would benefit from
  - standard and public data models
  - automation of modelling tools

Questions and Discussion

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