Electric Power Optimization Centre

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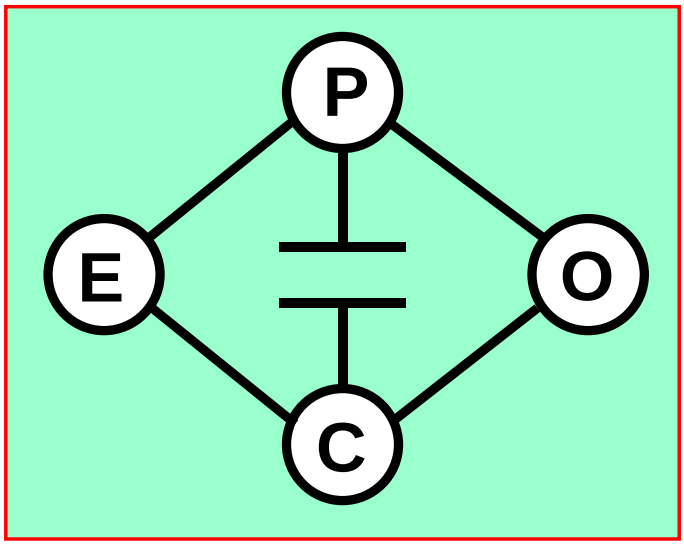

Winter Workshop 2007

Measuring and Improving Electricity Markets

Room 1.439
School of Engineering
The University of Auckland
20 Symonds Street

Friday, September 7, 2007

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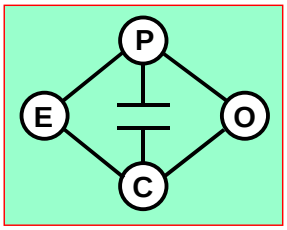

Winter Workshop 2007: Measuring and Improving Electricity Markets

Room 1.439, School of Engineering, The University of Auckland

Friday, September 7, 2007

The Electric Power Optimization Centre at the University of Auckland is a research group supported by the Public Good Science and Technology Fund. Our research focuses on the development of optimization and statistical models for decision support in wholesale electricity pool markets. The Sixth Annual Winter Workshop at the University of Auckland is a free one-day meeting for invited industry participants. The theme of the 2007 Workshop is on measuring and improving electricity pool markets. There will be time allocated after each talk for questions and discussion.

Timetable and presenters:

9:00: **Convene in 4th floor atrium of School of Engineering, 20 Symonds Street**

9:00 – 9:30: **On the convergence of SDDP and related algorithms**
Ziming Guan (EPOC)

9:30 – 10:00: **Measuring productive efficiency losses in the NZEM**
Owen Auger (EPOC)

10:00 – 10:30: **Discussion: Market performance modelling**

10:30 – 11:00: **Coffee**

11:00 – 11:30: **Mixed integer programming models for wind farm design**
Hamish Waterer (EPOC)

11:30–12:00: **A new dispatch model for intermittent generation**
Geoff Pritchard (EPOC)

12:00 – 12:30: **Discussion: New dispatch and pricing models for intermittent generation**

12:30 – 1:30: **Lunch**

1:30 – 2:00: **Competitive capacity sets - existence of equilibria over transmission networks**
Tony Downward (EPOC)

2:00 – 2:30: **The GEM model**
Phil Bishop (Electricity Commission)

2:30 – 3:00: **Coffee**

3:00-3:30: **Competition policy and regulation in hydro-dominated electricity markets**
Luiz Rangel (UoA Energy Centre)

3:30 – 4:00: **Uniform-price auctions versus pay-as-bid auctions**
Andy Philpott (EPOC)

4:00 – 4:30: **Long-term network development demand forecast for Vector Networks**
David Spackman (UoA Power Systems Group)

Abstracts

On the convergence of SDDP and related algorithms

Ziming Guan and Andy Philpott

Abstract
We discuss the almost-sure convergence of a broad class of sampling algorithms for multi-stage stochastic linear programs. Although the convergence of methods of this type is part of the stochastic programming folklore, we provide an explicit convergence proof based on the finiteness of the set of distinct cut coefficients. This differs from existing published proofs in that it does not require a restrictive assumption. Some inferences will be drawn about assumptions made in various implementations of SDDP and their effect on convergence.

Measuring productive efficiency losses on the NZEM

Owen Auger, Andy Philpott, and Golbon Zakeri

Abstract
We present preliminary results of an experiment designed to study the loss of productive efficiency in the New Zealand wholesale electricity market. The historical dispatch over the year 2005-2006 is compared with a counterfactual centrally-planned dispatch computed using a sampling-based stochastic program, and implemented in a rolling horizon over this period. We assume that demand is unchanged in each model, and focus on productive efficiency differences as defined by the difference in fuel costs (rather than allocative efficiency including the demand, or dynamic efficiency which includes investment effects.) The emphasis of the talk will be an exploration of methodology rather than numerical results, as we work towards a repetition of this experiment over a longer time period.

Mixed integer programming models for wind farm design

Stuart Donovan, Hamish Waterer, Rosalind Archer

Abstract
There is significant potential for optimizing the design of a wind farm in New Zealand. The complex nature of the wind resource and the larger size of the wind farms being built increase the complexity of the decisions that need to be made, while tight economic margins create a drive for greater efficiency. Current industry practice utilises commercial packages that are heuristic in nature and limited in the types of constraints that can be modelled. A mixed integer programming model for optimizing the layout of a wind farm has been developed that is capable of determining the optimal locations of turbines subject to constraints on the number of turbines, turbine proximity, and turbine wake. Results have shown that this model produces layouts that are comparable to those from a commercial package. Moreover, this model can be extended to include capital budget constraints, noise and line of sight restrictions, constraints relating to wind quality such as maximum gusts, inflow angles and turbulence, as well as modelling reticulation and different mixes of turbines.

A new dispatch model for intermittent generation

Geoff Pritchard, Andy Philpott and Golbon Zakeri

Abstract
Allthough much attention has been paid in the NZEM to forecasting intermittent generation, forecast errors are and will remain substantially larger than current load forecast errors. These errors mean the pre-dispatch of generation under the current market arrangements is likely to be less efficient than anticipated because it must later make expensive (or at worst physically impossible) adjustments to meet variations from the forecast. We describe a stochastic programming model for the optimal dispatch of intermittent generation in the NZEM. The model invovles a predispatch and real-time market, which are dispatched simultaneously using a stochastic program, but allow for real-time variations from forecast load using offered deviation curves. This results in two energy spot prices for each node in each trading period. Our proposed market mechanism will effectively discount the payments made to uncertain generation, and impose a price premium on uncertain demand. The hope is that such prices will provide incentives to encourage investment in intermittent generation at the most efficient scale at the most effective locations.

Competitive capacity sets - existence of equilibria over transmission networks

Tony Downward, Andy Philpott and Golbon Zakeri

Abstract
This talk is concerned with characterizing a set of conditions which ensure the existence of an uncongested Cournot equilibrium over an electricity network. Our Cournot model consists of strategic generators and linear fringes over a pool market. When the transmission network is radial, we derive necessary and sufficient conditions on the line capacities, ensuring that the unconstrained Cournot equilibrium remains an equilibrium. These conditions form a convex polyhedral set, which allows for optimization of resources while ensuring competitive play. We extend this work to examine the impact of other network effects (loops and losses) on the convexity of this set.

Generation expansion model (GEM)

Phillip Bishop

Abstract
The Electricity Commission has developed GEM over the past year and has made it freely available to industry participants since May 2007. In its current state, GEM is best described as a long range generation capacity planning model. It is formulated as a mixed integer programming problem (MIP) and is solved using the GAMS/CPLEX software. The main purpose of GEM is to assist with the development of the market development scenarios that are to used as assumptions when analyzing transmission investments, a regulatory requirement under part F of the Rules. A stylized description of GEM will be presented followed by a discussion of some key aspects of the model - solution strategies, the treatment of losses, and the use of system security constraints and their implication for the resulting build schedule. The presentation will conclude with some comments on expected unserved energy and security margins.

Competition policy and regulation in hydro-dominated eectricity markets

Luiz Rangel

Abstract
This paper reviews the main competition issues that arise in electricity systems dominated by hydro generation, arguing that technological differences between hydro and thermal plants may allow hydropower producers to exert market power. The paper shows that the traditional Herfindahl-Hirschman index (HHI) is not an appropriate measure of concentration in hydrothermal electricity systems, and describes some proposed adjustments to the index. Some market simulation approaches to measuring market power in hydrothermal systems are reviewed. Finally, possible interventions to mitigate market power are analysed.

Uniform-price auctions versus pay-as-bid auctions

Andy Philpott and Eddie Anderson

Abstract
We consider the problem of optimizing a supply function bid into a discriminatory auction in which each agent is paid their bid price on each increment of offered capacity. The efficiency of pay-as-bid auctions in comparison with uniform-priced auctions has been debated, as it is conjectured that in the former auction, agents will simply bid their offer prices up to an anticipated clearing price. Using market distribution functions, we derive optimality conditions for each agent in a pay-as-bid auction, and compute Nash equilibria in supply functions. In most realistic cases, there are no pure-strategy equilibria in this game. In the absence of capacities and price-caps, there are infinitely many mixed strategy equilibria, which become uniquely determined when generators have limited capacities and are subject to a price cap.

Long-term network development demand forecast for Vector Networks

David Spackman and Nirmal Nair

Abstract
Long-term load forecasts determine patterns of load distribution and are useful for planning network asset investment. This paper outlines the development of a new long-term spatial demand forecast model for distribution networks in the Auckland region of New Zealand. This model uses a policy guided approach to simplify the data and simulation requirements of previous methods. The forecast model derives the electric demand saturation limit for small geographical areas from land use zoning policy. The model incorporates scenario analysis to modify expected peak demand values. Results from a case study on the Auckland area are to be presented.