

Collaborations

Power engineers, control, statistics, ...

Information theory, control, and statistics to create models and tools for forecasting, state estimation, and control ... Markov models!?

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Control on long time-scales

Need for concepts from operations research, similar to inventory theory.

Approaches translated from queueing theory.

Dynamic programming must be approximate.

Potentially valuable tools:

Reinforcement Learning /

Approximate Dynamic Programming

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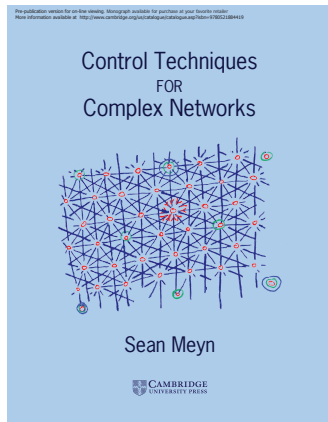
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Control on shorter time-scales

Must respect dynamics and costs

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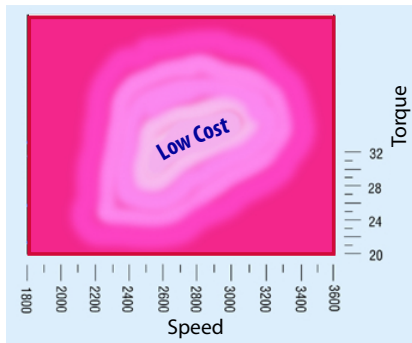
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Cost of generation:

Includes G and $\frac{d}{dt}G$.



Collaborations

Engineers and economists

Introduction of RTMs motivated by highly idealized models of generation.

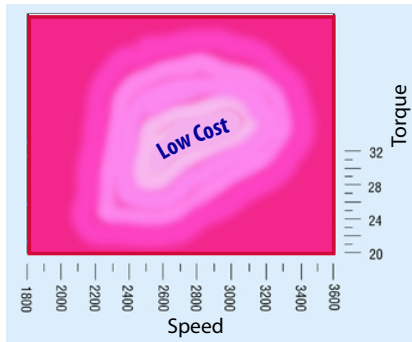
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start-up, shut-down,
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What is marginal cost?

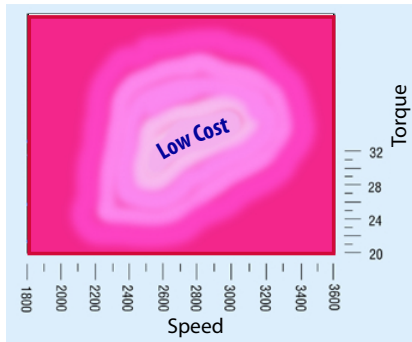
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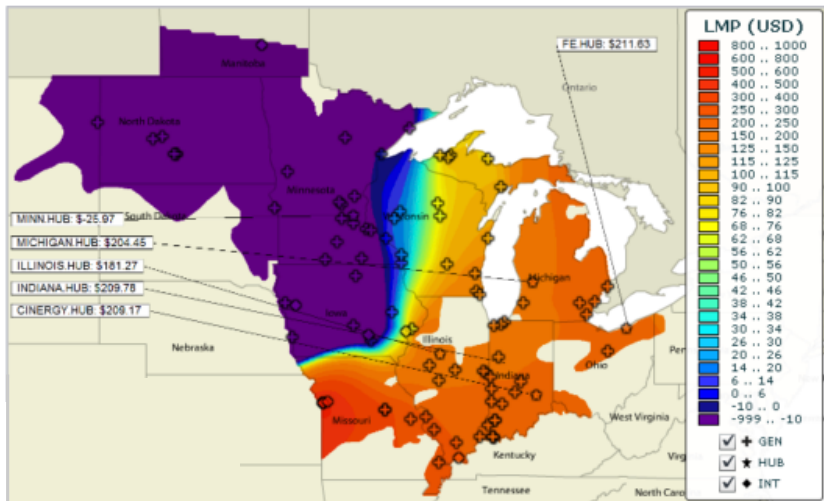
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Real time control \implies Real-time markets?

Real-Time Market Outcomes

Midwest ISO today: Friday afternoon, March 4, 2011

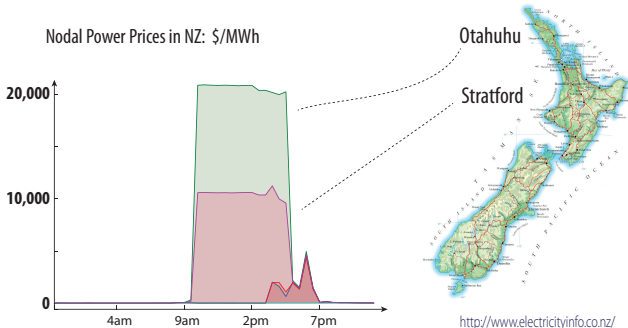
4:15 p.m.



Real-Time Market Outcomes

New Zealand today: March 26, 2011

\$25 million dollars extracted by the generators in just six hours

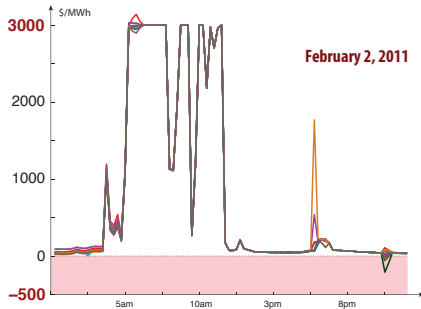
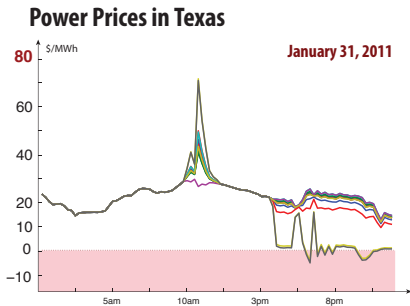


NZ Electrical Authority: *Genesis was not guilty of “manipulative” ... or “deceptive” conduct. However, high prices threatened to undermine confidence in, and ... damage the integrity and reputation of the wholesale electricity market*

3:59 PM Friday May 6, 2011 www.nzherald.co.nz

Real-Time Market Outcomes

Texas (ERCOT): Winter of 2011

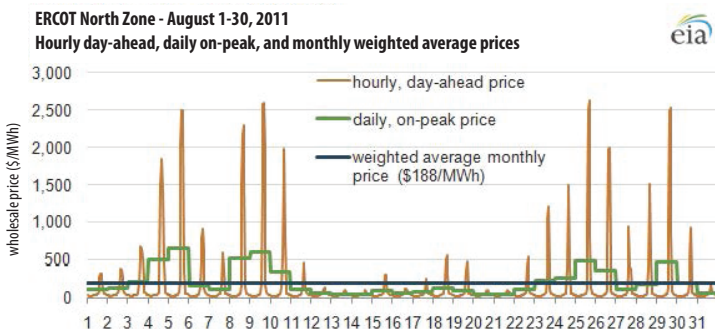


There will be multiple autopsies of the causes for the latest power breakdowns ... Who profited off this near-meltdown and what can be done to incentivize power producers to maintain adequate reserve capacity for emergencies rather than waiting for emergency windfalls?
 – HOUSTON CHRONICLE, Feb 12, 2011

New report hits ERCOT, electricity deregulation: A report released Monday concludes that electric deregulation has cost Texas residential consumers more than \$11 billion in higher rates...
 – DALLAS MORNING NEWS, Feb 14, 2011

Day-Ahead Market Outcomes

Texas (ERCOT): Summer of 2011



Source: U.S. Energy Information Administration, based on the Electric Reliability Council of Texas (ERCOT).

Note: ERCOT North Zone includes Dallas/Fort Worth metro region and surrounding areas of Northeast Texas. On-Peak refers to the 16-hour time block from hours ending 7:00 a.m. to 10:00 p.m. CDT on weekdays, excluding NERC holidays.

Market Issues Today

Do today's markets achieve societal goals? Goals of participants?

1. Incentives for services, not just energy
(e.g., responsive ancillary service)
2. Recognizing true cost of generation
(e.g., as measured in torque speed-curve)
3. Recognizing cost of uncertainty – Uncertainty from the environment, from generators, and from consumers.
Cost includes additional reserves, additional “jitter” demands from generators, and additional business risk.

Needs for the future

Incentives to provide better services to the grid. Both generators and consumers will participate to provide ancillary services, storage, and unforeseen innovation