Using PRISM As A Planning Tool

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EPOC Winter Workshop
Sept 2005

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Outline

1. The Energy Centre & PRISM
2. Building Scenarios for PRISM input
3. Analysing & interpreting the output
4. Example: Simulating a "Grid Investment Test"

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The Energy Centre and PRISM

About the Energy Centre at University of Auckland

- Goal is to provide national research leadership on energy systems and issues.
- An interdisciplinary and inter-sectoral approach to NZ energy priorities
- Housed in economics department, the team comprises faculty, PhDs, post docs and visiting professors and fellows.
- Executive Director is Robert Kirkpatrick

Launching Research Topic: The Electricity Sector

- Understand the risks of alternative future electricity scenarios
- Grid critical to understanding => needed spatial model

Collaboration with EPOC

- Spatial and stochastic attributes of PRISM well suited
- Joint development of an excel-based interface for PRISM
- Energy Centre responsible for the analysis and interpretation of output

The Energy Centre & Prism (cont)

A tool to understand system.

- Dynamics of the system – variability and constraints
- How future investment affects which constraints become binding
- How these changes might impact price pressure and profitability
- Inform thinking on implications, or possible reactions

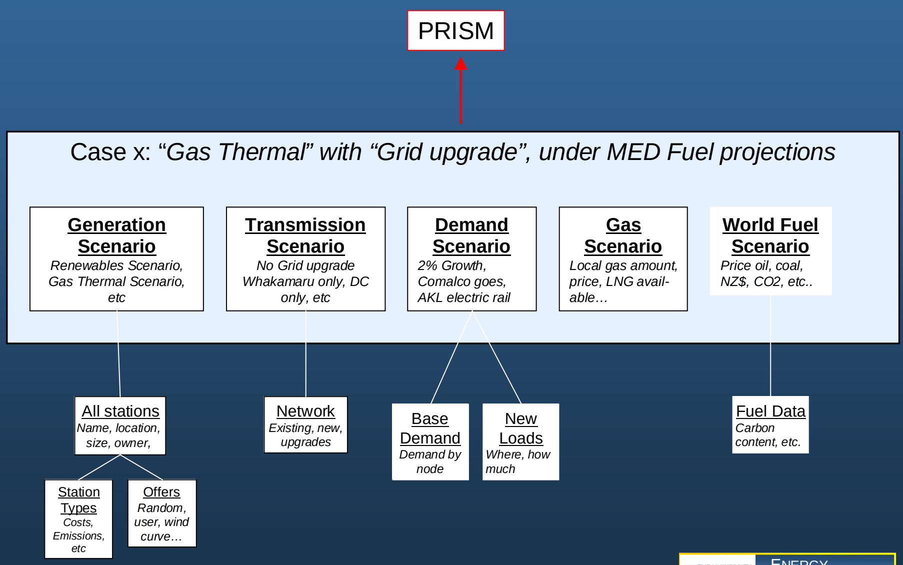
A tool to analyse future developments

- Grid upgrades, using the 18 nodes of the model
- Wind Penetration -> relation to transmission and hydro storage.
- Energy price escalation -> stochastic treatment of fuel price, CO2 charge, NZ$

Important to recognise limitations

- Spot market analysis in general.
  - Spot offers and prices are driven heavily by the contract position and operational factors, rather than simple costs.
- PRISM-specific limitations
  - Historically based offers. Hydro offers & thermal offers we use reflect market conditions of the period during which they were sampled. Offer strategies will change with evolving market structure and power.
  - Simple for period analysis
  - No feedback loops. Neither investment decisions nor offer strategies are related to evolving market structure or the electricity price.

PRISM Interface: Inputs and Scenarios



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PRISM Inputs and Scenarios (cont)

Hydro Stacks

- Historic samples

Thermal Stacks

- Small stations generally dispatched at SRMC
- For large stations, have experimented with variety of stacks.
- Observing real price and dispatch patterns, have settled on
  - Large thermals offer for a minimum run rate, then approx SRMC for the remainder (ie not seeking to gouge)
  - Huntly balances the thermals with a multi-level stack.

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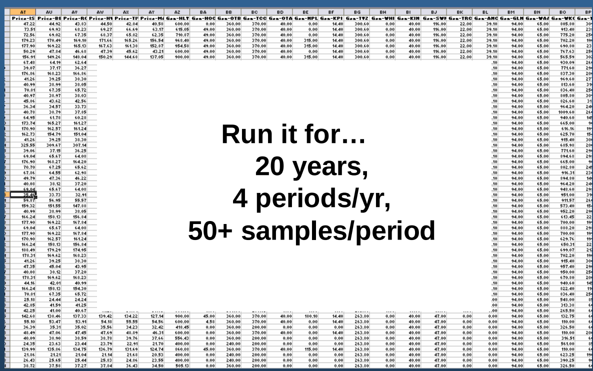
Run PRISM



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Outputs from each snapshots

Output from each run

- Demand, by node
- Price, by node
- Dispatch, by station

Calculations done on this for a given period

- Average prices, standard deviations of prices and probability distributions of prices and dispatch
- Emissions
- Costs to consumers (price at offtake node x nodal demand),
- Revenue to generator (price at dispatch node x dispatch quantity)

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Annual figures derived from the snapshots

Extrapolating annual figures from 4 periods…

- Take energy use over a year, and in weeks of a season, and compared to peak and off-peak demand during those times, using July '04 and Jan '05 data.
- Annual factors come out as:
  - Winter Peak represents 37.5% of annual energy use
  - Winter Off-peak: 29.5%
  - Summer Peak: 19.1
  - Summer Off Peak: 13.9%
- combined with probability of dry yr, normal yr, wet yr

Allows calculation of:

- Average prices & dispatch *over the year*
- Standard deviation *for the year*
- Annual consumer cost & generator net revenue (ie include fixed & variable costs)
- Annual emissions

Warning:

- Treat with caution in absolute terms, but interesting for comparisons
- Further calibration still required to test across years

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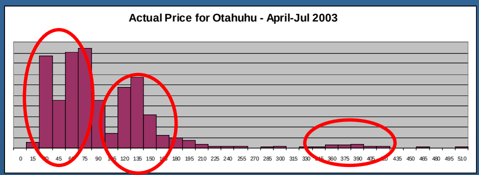
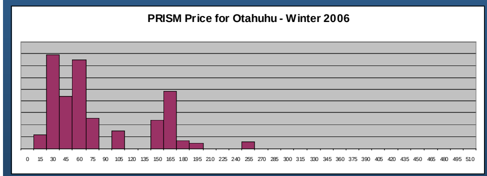
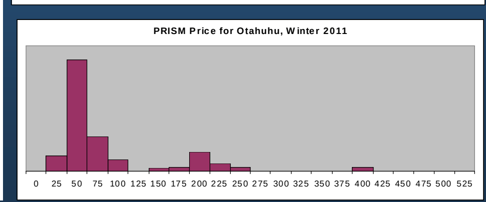
PRISM output compares with real prices

Real NZ spot market

- Shows several price bands, rather than normal distribution…







Generally, PRISM appears to match bands

- $40-100…Spare capacity
  Thermals setting price (most off peaks)
- $150-200…Scarce capacity.
  Thermals v. high. Hydro stacks setting. Usually in Winter Peak
- $400+ Unsustainable.
  Thermals at maximum, Hydro stacks probably on unsustainable lake drawdown...
  Dry year winter peak…

Caveats:

- "Annualising" factors have been used!
- Calibration only done for winter prices
- For summer, calibration would require maintenance scheduling

PRISM graphs above are 50/50 normal and dry for demonstration

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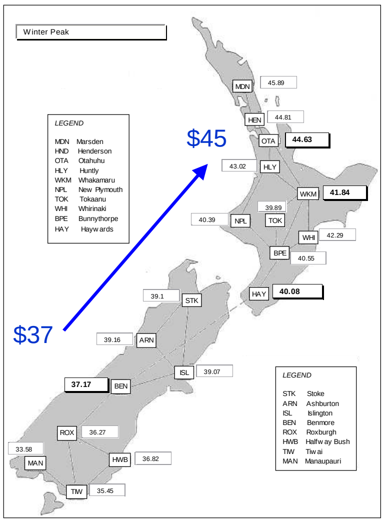
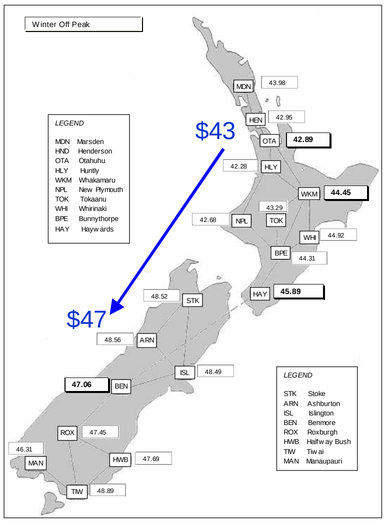
Understanding flow patterns

Wet Winter - Peak



Dry Winter - Off Peak



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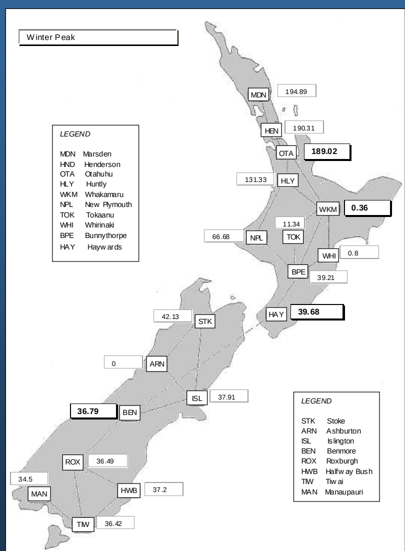
Understanding grid constraints

A grid constraint

- Otahuhu: $189
- Whakamaru: $0.36
- Haywards: $40
- Benmore $37



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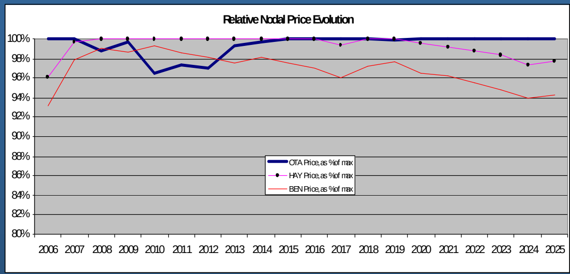
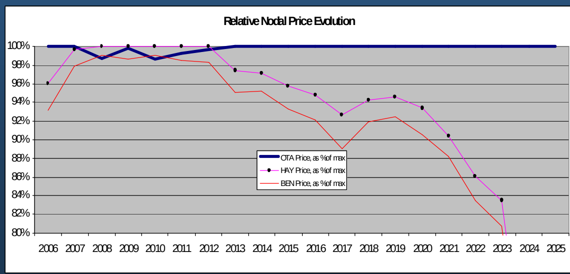
Observing long term average price dislocation

Averages show price divergence…

– With grid upgrade



– Without grid upgrade, dislocation occurs



Examining lumpy new investment

Case 101 Gas Thermal, No Grid, MED Fuel Outlook, SRMC Gen:SOO Gas Thermal Scenario…Grid:ISL, DC Only…Demand:2%…No New Loads…No LNG,

Dispatch, by Station		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
HLY-Huntly	avg	**74%**	**75%**	**57%**	**64%**	**72%**	**69%**	**72%**	**36%**	**39%**	**63%**	**70%**	**75%**	**33%**	**49%**
	WP - Dry	100%	100%	100%	100%	100%	100%	100%	75%	79%	97%	90%	100%	76%	88%
	WP - Normal	100%	100%	98%	100%	100%	95%	100%	71%	79%	99%	93%	100%	76%	97%
	WP - Wet	100%	100%	79%	85%	92%	90%	100%	66%	71%	95%	85%	100%	67%	86%
	WOP - Dry	75%	75%	74%	75%	75%	75%	68%	21%	24%	56%	69%	73%	12%	28%
	WOP - Normal	74%	75%	37%	42%	65%	64%	68%	15%	18%	49%	69%	72%	10%	29%
	WOP - Wet	61%	71%	22%	36%	56%	50%	67%	12%	15%	47%	68%	72%	8%	25%
	SP	50%	50%	44%	48%	50%	50%	50%	23%	23%	46%	50%	50%	10%	23%
	SOP	35%	41%	7%	33%	41%	39%	38%	0%	0%	19%	44%	46%		2%
OTB-Otahuhu B	avg	**51%**	**57%**	**90%**	**80%**	**66%**	**47%**	**47%**	**96%**	**96%**	**94%**	**50%**	**52%**	**95%**	**89%**
	WP - Dry	96%	96%	96%	96%	96%	96%	85%	96%	96%	96%	91%	89%	96%	96%
	WP - Normal	86%	93%	96%	96%	96%	90%	87%	96%	96%	96%	93%	95%	96%	96%
	WP - Wet	68%	79%	96%	96%	96%	68%	76%	96%	96%	96%	88%	83%	96%	96%
	WOP - Dry	96%	96%	96%	96%	96%	83%	29%	96%	96%	96%	32%	22%	96%	86%
	WOP - Normal	6%	10%	88%	82%	34%		16%	96%	96%	96%	16%	16%	96%	80%
	WOP - Wet	1%	2%	82%	58%	17%		21%	95%	96%	94%	13%	12%	96%	81%
	SP	79%	89%	96%	96%	96%	58%	51%	96%	96%	96%	52%	65%	96%	96%
	SOP	1%	2%	[illegible]	10%	3%			95%	95%	82%			85%	76%
E3P-e3p	avg	**0%**	**16%**	**17%**	**22%**	**33%**	**7%**	**10%**	**83%**	**84%**	**25%**	**9%**	**11%**	**71%**	**3%**
	WP - Dry		100%	100%	100%	100%	100%	42%	100%	100%	59%	43%	45%	100%	13%
	WP - Normal		28%	32%	45%	74%	10%	18%	100%	100%	58%	19%	24%	100%	8%
	WP - Wet					1%		32%	100%	100%	45%	32%	34%	100%	11%
	WOP - Dry		61%	55%	59%	68%	11%	4%	89%	90%	10%	0%	0%	68%	
	WOP - Normal							7%	90%	90%	12%	1%	1%	64%	1%
	WOP - Wet							1%	80%	81%	5%			48%	
	SP		11%	3%	14%	27%	1%	1%	79%	79%	4%			79%	
	SOP								33%	33%				1%	

Observing generator dispatch shows:

– Lumpiness of new investment (see E3P below). Size of plant is very important.

– SRMC-based dispatch is unrealistic, from dispatching profile, pricing, and excessive sensitivity to relative fuel prices

Simulating a Grid Investment Test

Context:

- In May 2005, Electricity Commission's "Statement of Opportunities" included spot market simulation of alternative generation scenarios, using proposed grid upgrade. Simulation appeared to be foundation for a future "Grid Investment Test"

We used model to explore that question:

What is the impact on prices of a major grid upgrade?

- 1. What is NPV of a major grid upgrade? In segments & as a whole?
- 2. What are distributional aspect, to consumers and producers

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Simulating a Grid Investment Test (cont)

Health Warning!

- Previous disclaimers apply to the simulation
- Plus…
  - Cost of grid upgrade are rough estimates, as are timings of unannounced phases of the grid 'backbone' which we have assumed (ie Whakamaru to Haywards)
  - Cost of Grid not integrated into pricing – just counted as separate cost
  - Grid investment has many costs and benefits that are not included, such as the impact on reliability, optionality for new investment, reserve sharing, environmental effects, etc…

Focus of tests:

- The grid's role as an enabler of lowest price dispatch.
- The distributional effects of an upgrade.

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PRISM USE: Grid Investment test (cont)

Simulate 2006-2025, with and without grid “backbone”

- Using SOO generation and demand scenarios, MED fuel outlook, and user-defined thermal stacks.
- Generate 20 yrs of prices and dispatch for both cases

Calculate NPV of grid backbone investment

+ Increase in Consumer Surplus (ie reduced cost)
  (Price x Demand at offtake.)
+ Increase in Producer Surplus (ie increased net revenue)
  (Price x Dispatch. Note: Capital expenses recovered through prices
- Cost of Transmission Capital

All discounted at 7%

Note: “Backbone” includes Transpower proposal, plus anticipated segment later segment from Whakamaru to Haywards

PRISM USE: Grid Investment test (cont)

In all cases, the grid upgrade provides consumers with lower cost power

However, only in the renewables case does this gain offset the cost of the upgrade

Bottom Line: The value of the grid upgrade is highly dependent on subsequent generation

Gas Thermal Scenario	Consumer Gain	509m
	Producer Gain	-74m
	Cost of Grid	-967m
	Total NPV	**-532m**
Renewables Scenario	Consumer Gain	2,025m
	Producer Gain	-286m
	Cost of Grid	-967m
	Total NPV	**772m**
Coal Thermal Scenario	Consumer Gain	790m
	Producer Gain	-399m
	Cost of Grid	-967m
	Total NPV	**-576m**

PRISM USE: Grid Investment Test (cont)

Using historic fuel prices and volatility, rather than static MED projection, affects results considerably, though they are directionally similar.

		MED Outlook	Historic Fuel Prices
Gas Thermal Scenario	Consumer Gain	509m	943m
	Producer Gain	-74m	-182m
	Cost of Grid	-967m	-967m
	Total NPV	**-532m**	**-206m**
Renewables Scenario	Consumer Gain	2,025m	2,673m
	Producer Gain	-286m	-522m
	Cost of Grid	-967m	-967m
	Total NPV	**772m**	**1,184m**
Coal Thermal Scenario	Consumer Gain	790m	773m
	Producer Gain	-399m	-396m
	Cost of Grid	-967m	-967m
	Total NPV	**-576m**	**-590m**

PRISM USE: Grid Investment Test

Distributional impacts of grid backbone are significant. Upper North Island and South Island tend to benefit proportionally more from interconnection

Gas Thermal Scenario	**Consumer Gain**	NI Upper	377m
		NI Lower	-74m
		South Island	205m
		Net Consumer Gain	**509m**
	Producer Gain		-74m
	Cost of Grid		-967m
	Total NPV		-532m
Renewables Scenario	**Consumer Gain**	NI Upper	1022m
		NI Lower	-19m
		South Island	1022m
		Net Consumer Gain	**2,025m**
	Producer Gain		-286m
	Cost of Grid		-967m
	Total NPV		772m
Coal Thermal Scenario	**Consumer Gain**	NI Upper	150m
		NI Lower	120m
		South Island	520m
		Net Consumer Gain	**790m**
	Producer Gain		-399m
	Cost of Grid		-967m
	Total NPV		**-576m**

PRISM USE: Grid Investment Test

Additional findings

- "Whole" is not always equal to "sum of the parts"
- SRMC masks grid impact in mitigating volatility from market power.
- Substantial distributional effects on producers also
- All SOO generation scenarios are fairly dispersed. More concentrated scenarios (eg from brownfield bias) show much greater prices impacts.

Implications for GIT

- Simulation for GIT purposes very complex
  - GIT for individual segments may not capture value of overall project.
  - SRMC-based simulation gives unrealistic dispatching, as well as prices
  - Fuel price outlook (baseline) alters results considerably.
- Generation scenarios is the key to the value of the grid
  - Endogenous investment models should be explored
  - Attention to minimum run-rates in market offers must be used, to capture "lumpiness" of new thermal investment.

We welcome opportunities to discuss these issues in more detail

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Overall:

While acknowledging limitations of the model ….

- Historically grounded hydro and thermal offers.
- Extrapolation of year from 4 periods

Energy Centre Model with PRISM enables:

- Detailed appreciation of the underlying drivers of the NZ Electricity system
- Manual control to observe 'realistic' behaviour & market power
- Stochastic inputs to observe true impact of uncertainty
- Some important insights into the problem of "Lumpiness"
- Easy and fast "What-if" analysis
  - Generation scenarios & grid upgrades
  - Energy price escalation: stochastic fuel prices, Carbon Tax, NZ$
  - Wind penetration

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Thank you

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