Models for Large Consumer Peak Shaving and Load Shifting

G. Zakeri and G. Pritchard

EPOCWW 2013

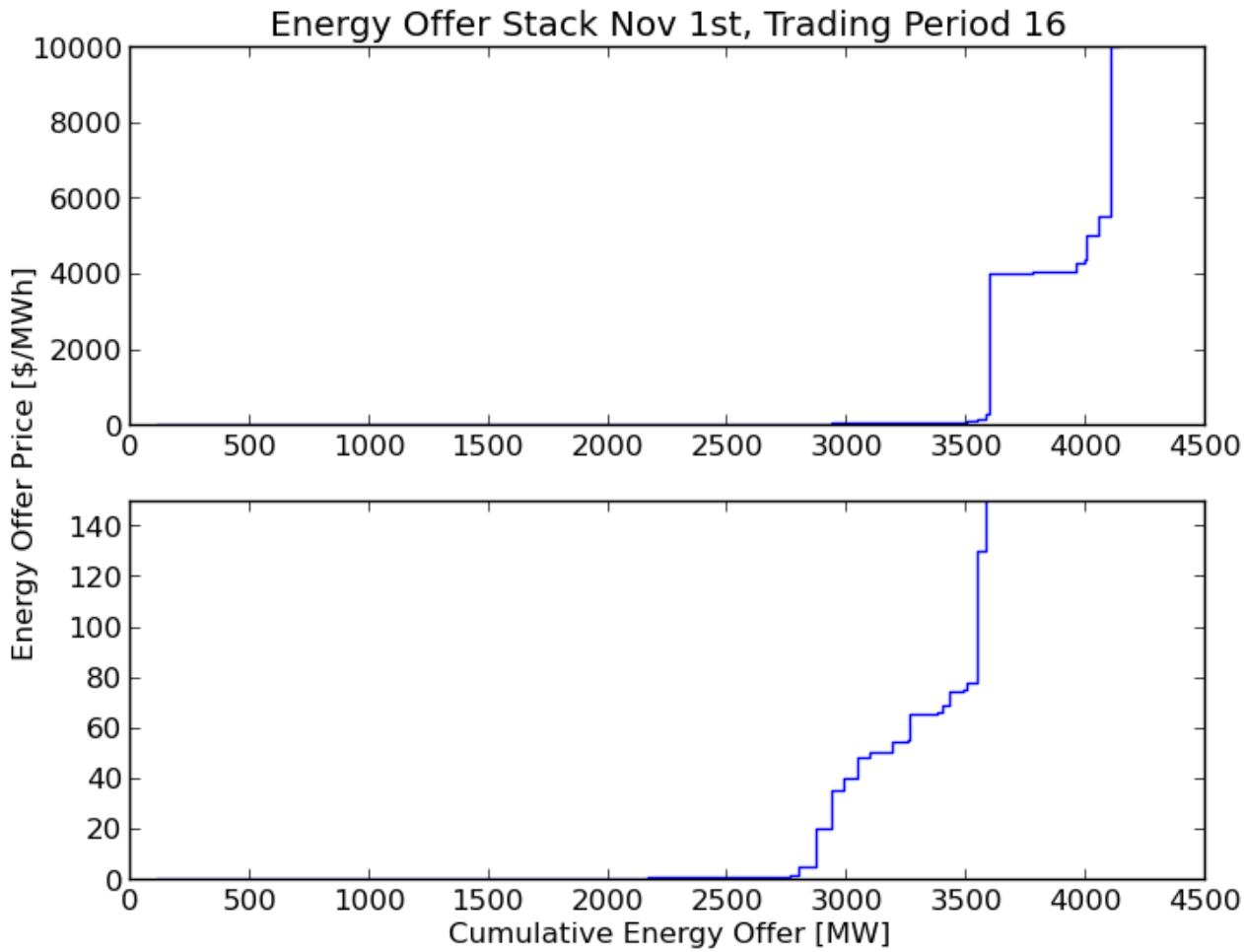
Why consumer participation is important

- Counterpart of generators so their optimization contributes to overall efficiency.
- Participation of consumers in an electricity market could eliminate relying on artificial price caps and measures such as VOLL.
- Rely on the consumer itself to signal how much they're willing to pay for electricity rather than assume certain risk attitudes.
- The better we understand the consumer's problem the more their chance of participation.
- Starting next year, demand functions will be included in market clearing.

Settings

- Consider a large price maker consumer of electricity.
- They are exposed to price spikes and need to respond.
- They face uncertainty as they make decisions.
- They may also offer in reserves into the NZEM which co-optimizes energy and reserve.
- The level of their consumption has an effect on the amount they can offer in for reserve.

Price spike: Aggregated offer stack TP16, Nov 1



NZEM's dispatch

- We have a nodal pricing system (uniform prices for each node). 250 nodes and 450 links.
- Every half hour of every day a network optimization problem is solved to determine the optimal dispatch of generation and the clearing price of electricity at each node of the market (SPD).
- Aside from transmission constraints, SPD makes reserve provisions as well.
- Furthermore, demand is stochastic, so actually every 5 minutes the solution is updated and there is also a frequency keeping station that follows the load.
- Price spikes can be due to congestion, springwasher effects, reserves or other manners of constraints.

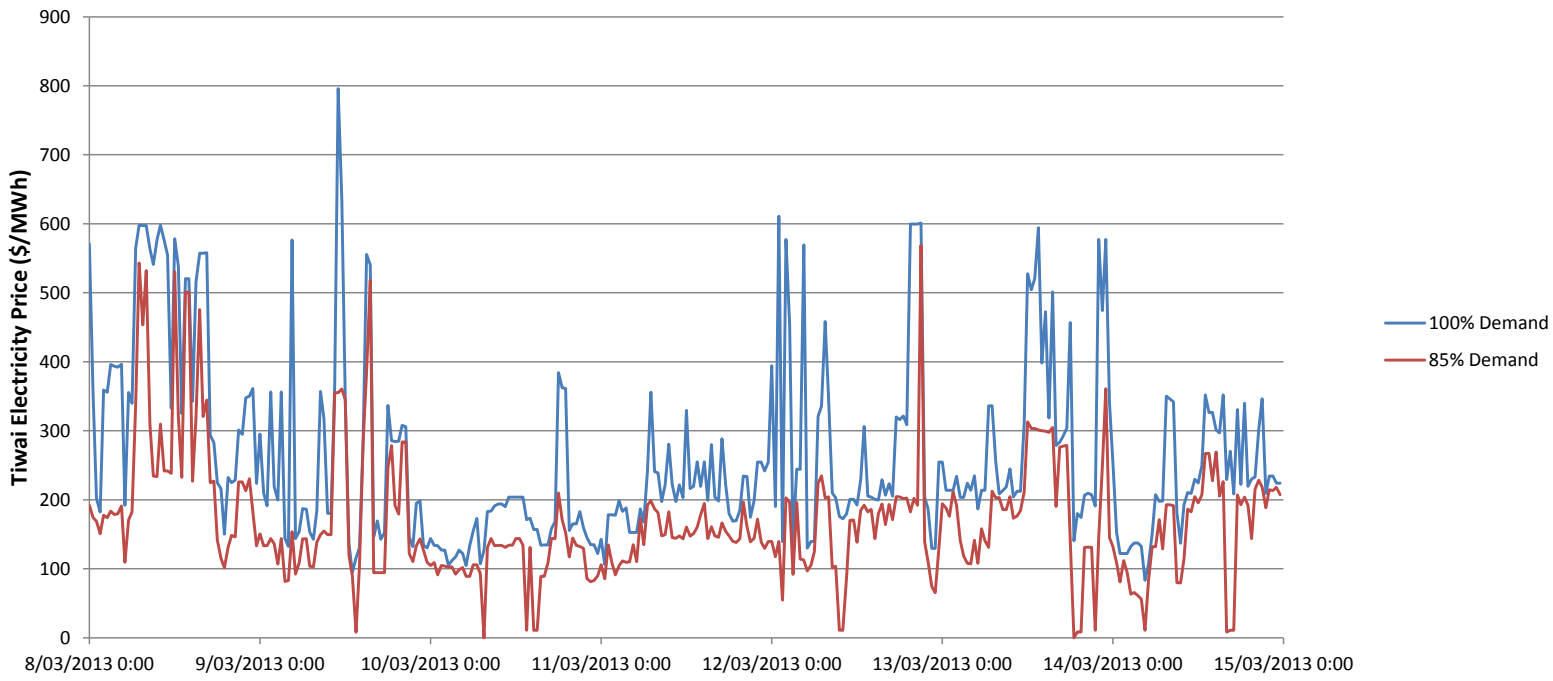
vSPD

- The *best approximation* to SPD is a software put out by the Electricity Authority called vSPD (vectorized SPD).
- Available from `http://www.ea.govet.nz/industry/monitoring/models-and-t`
- The software relies on having Microsoft Office, GAMS and a linear programing solver.
- Input data can also be obtained from the EAs website in gdx format.
- Great tool to explore what goes on in the market.

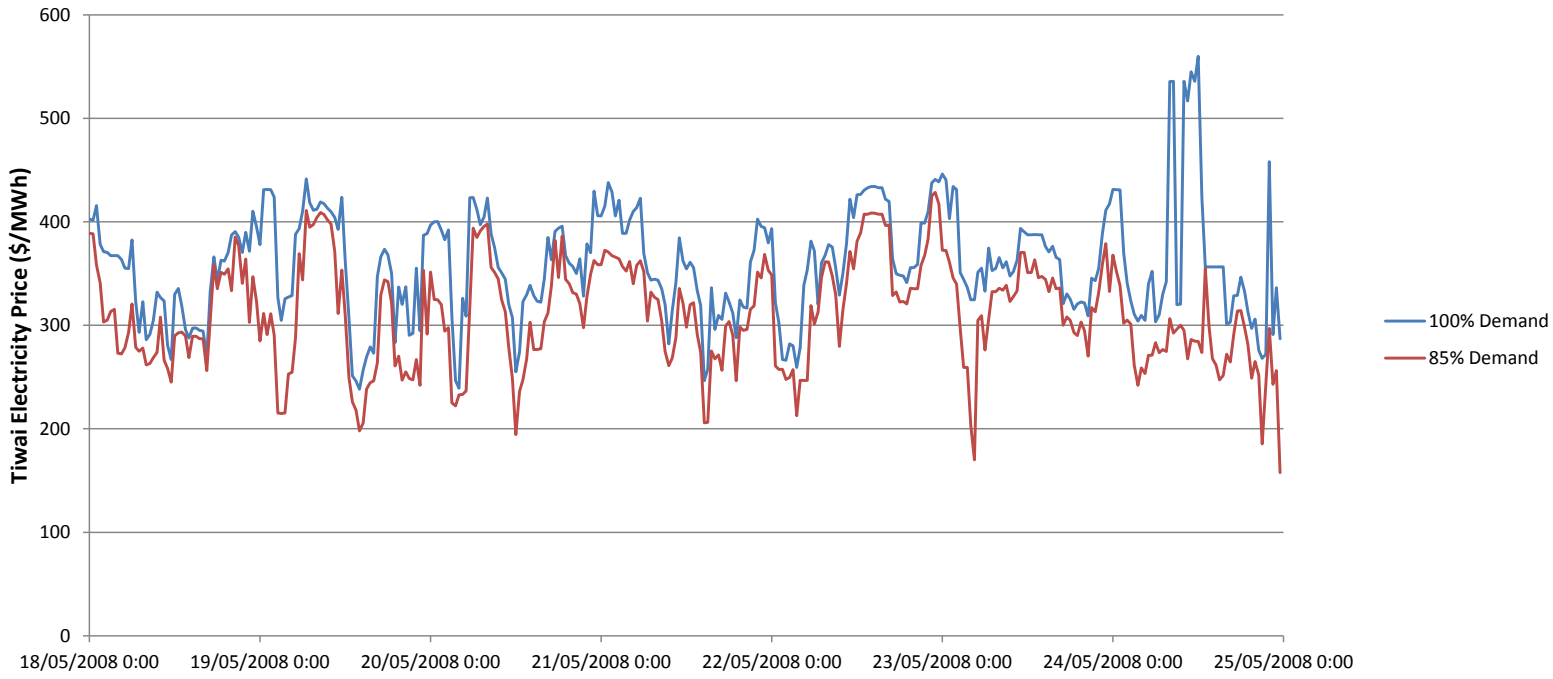
Price response

- vSPD allows for examining a historical period.
- The consumer can take the historical period and change their consumption level and observe the resulting price.

Price response to smelter load reduction 2013



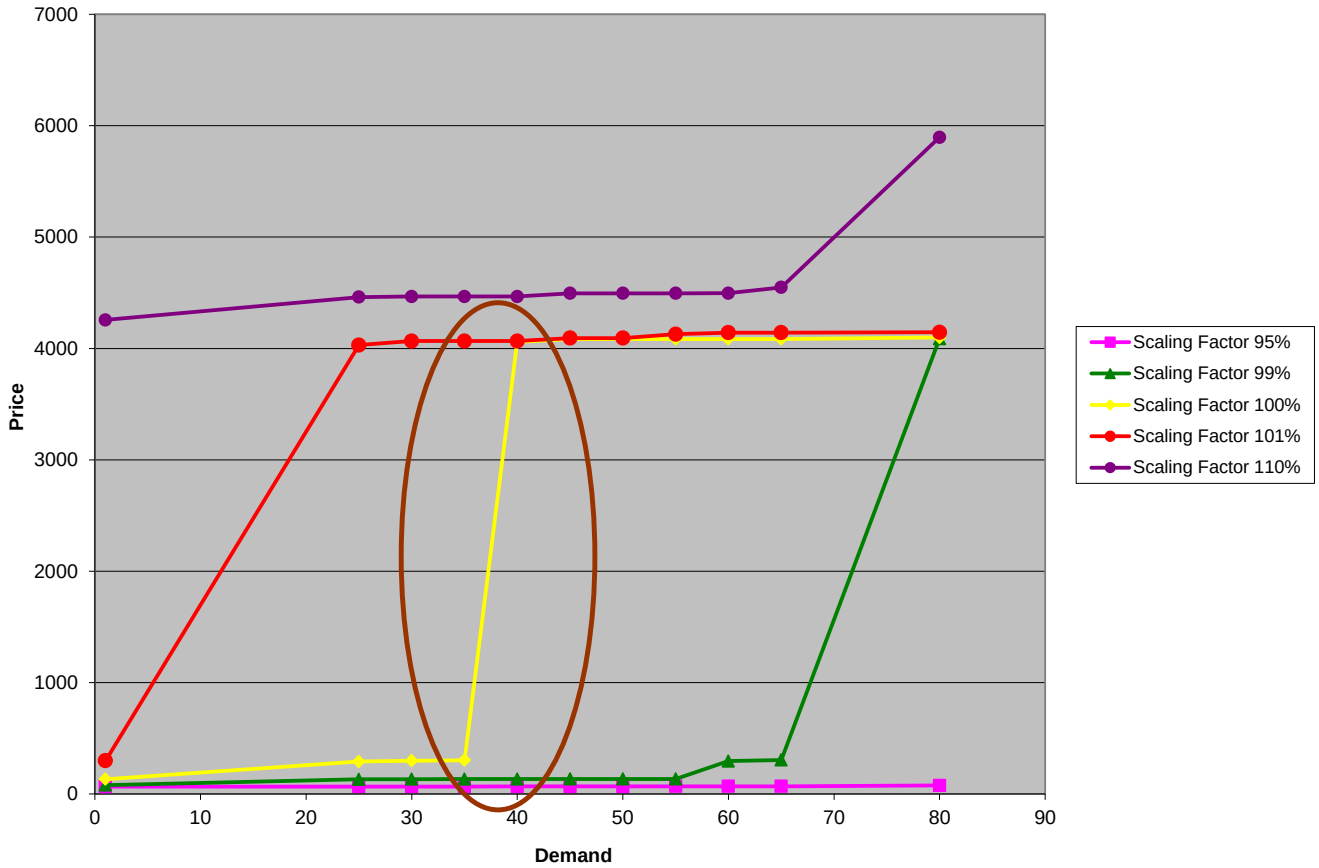
Price response to smelter load reduction 2008



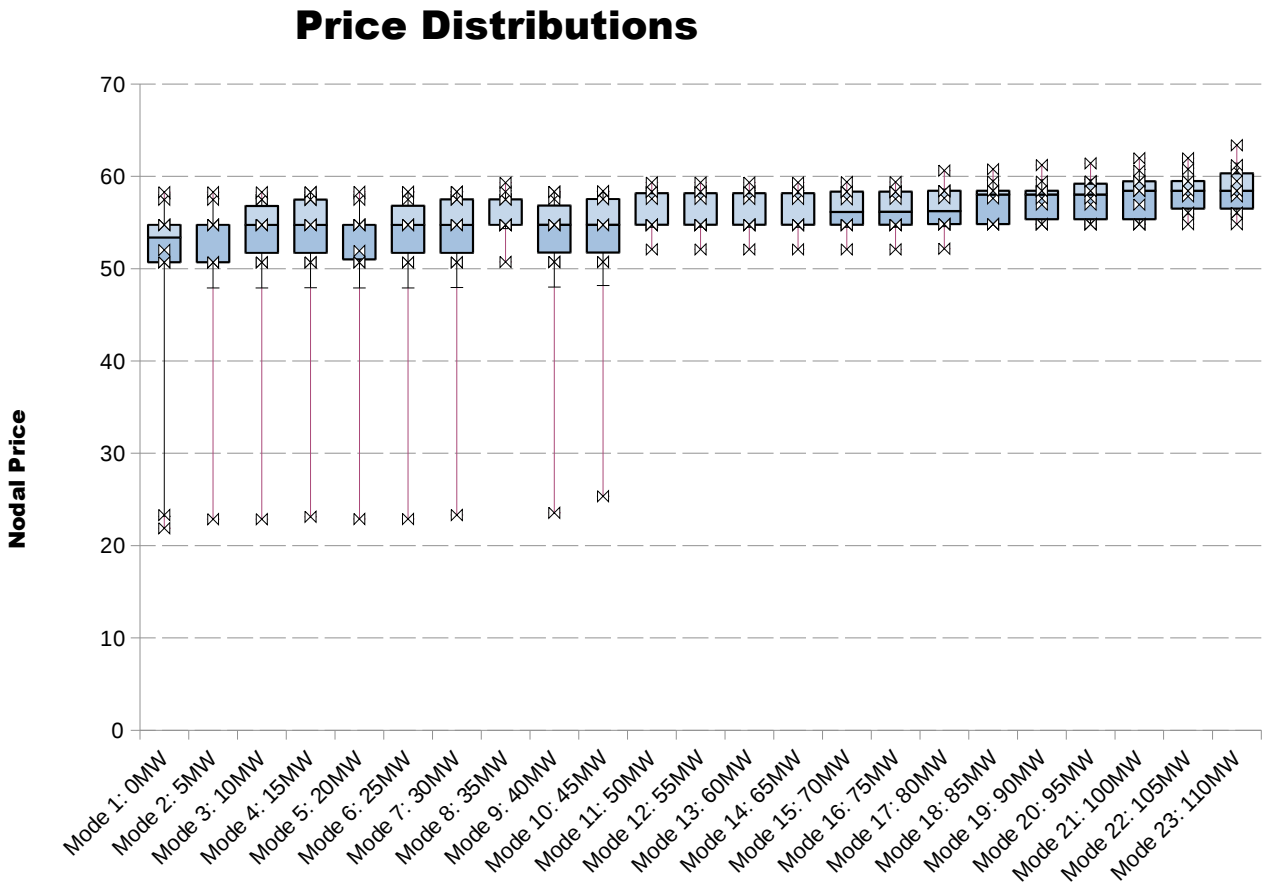
Price response under uncertainty

- Clearly the price process is stochastic, therefore price response will be stochastic.
- The single most important volatility in that time horizon is due to varying NZ-wide demand.
- So we can combine load shavings with different NZ-wide demand scenarios.

Price response – stochastic

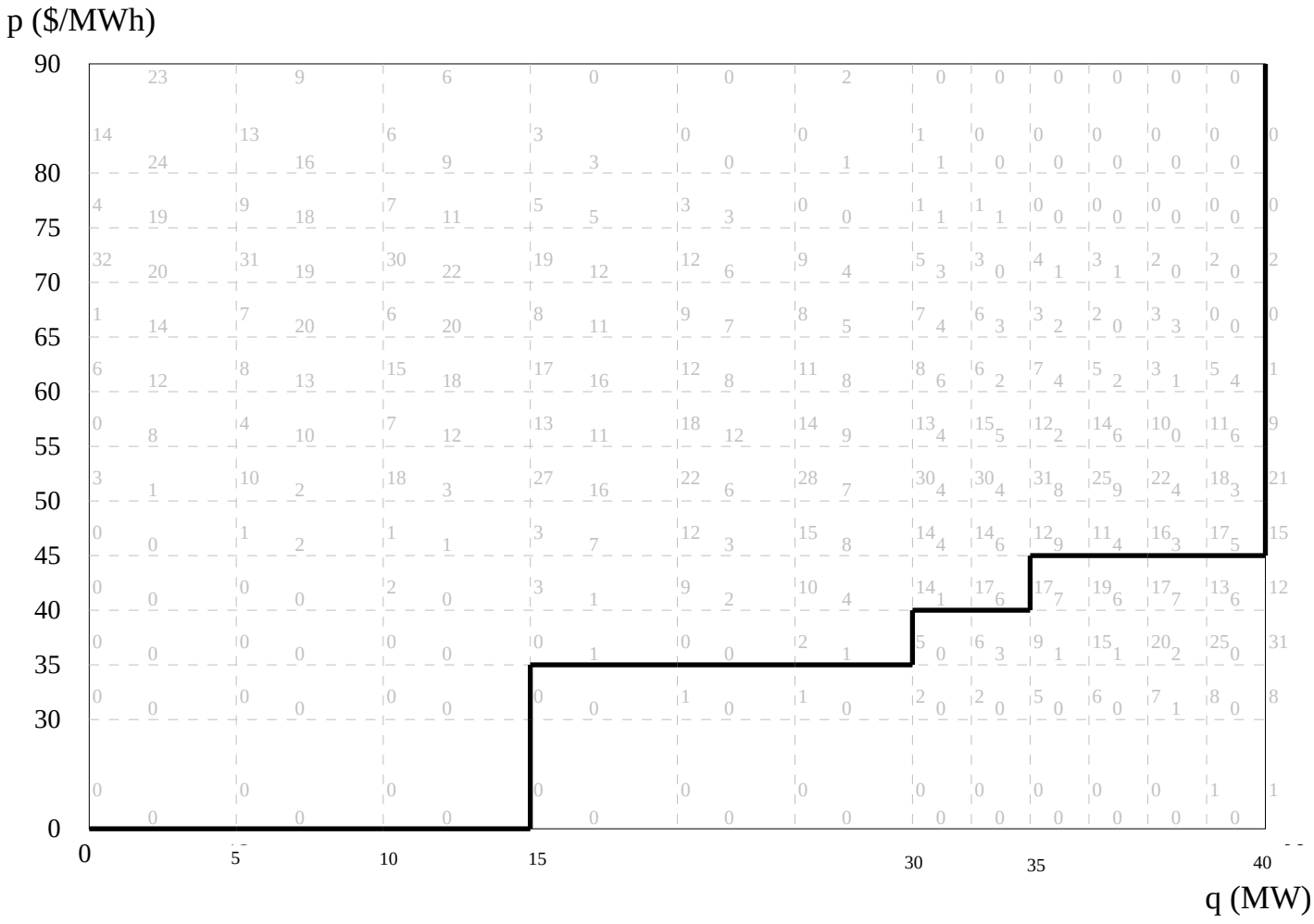


Consumer response v1



Consumer response with ILR

- Select a historical period. Have a distribution in mind for the load. For example a log-normal distribution applied to the total NZ load or NI and SI separately scaled.
- We then trace various residual demand curves for reserve (each based on a scalar multiple of overall NZ demand for instance) in a grid.
- This involves tens to hundreds of solves of vSPD.
- Then solve a "prize collecting" optimization (a DP) that would deliver the optimal stack, subject to the assumed grid.


p ($/MWh)
90
80
75
70
65
60
55
50
45
40
35
30
0
0
5
10
15
30
35
40
q (MW)

Pro-active consumer response: optimal demand functions

- Select a historical period. Have a distribution in mind for the load. For example a log-normal distribution applied to the total NZ load or NI and SI separately scaled.
- We then trace various residual *supply* curves for reserve (each based on a scalar multiple of overall NZ demand for instance) in a grid.
- This involves tens to hundreds of solves of vSPD.
- Then solve a "prize collecting" optimization (a DP) that would deliver the optimal stack, subject to the assumed grid.

Next steps

- Co-optimize consumption and reserve offer (not for discrete choices of load as we do now). I think this is hard.
- Build a price process and optimize the production schedule over a time horizon.
  - Perhaps build a Markov process (time inhomogeneous) to govern overall load.
  - From that derive prices based on vSPD.
  - Use a stochastic dynamic program to come up with decisions on when to use and when to cut down on consumption of electricity.

Chewing the fat

- Any comments, questions and discussions are most welcomed.