Flicking the Switch: Retail Demand-Side Response under Alternative Electricity Pricing Contracts

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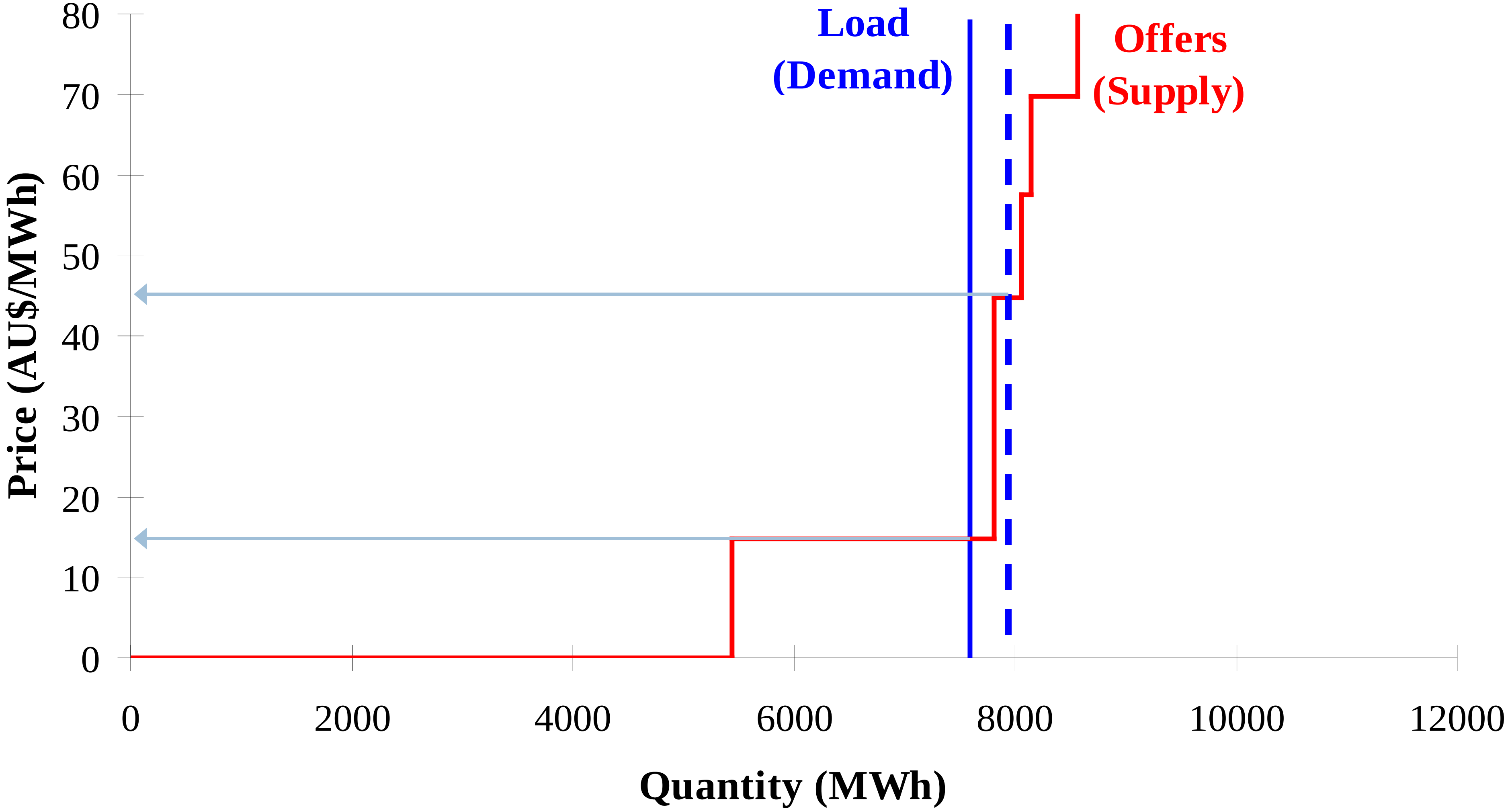
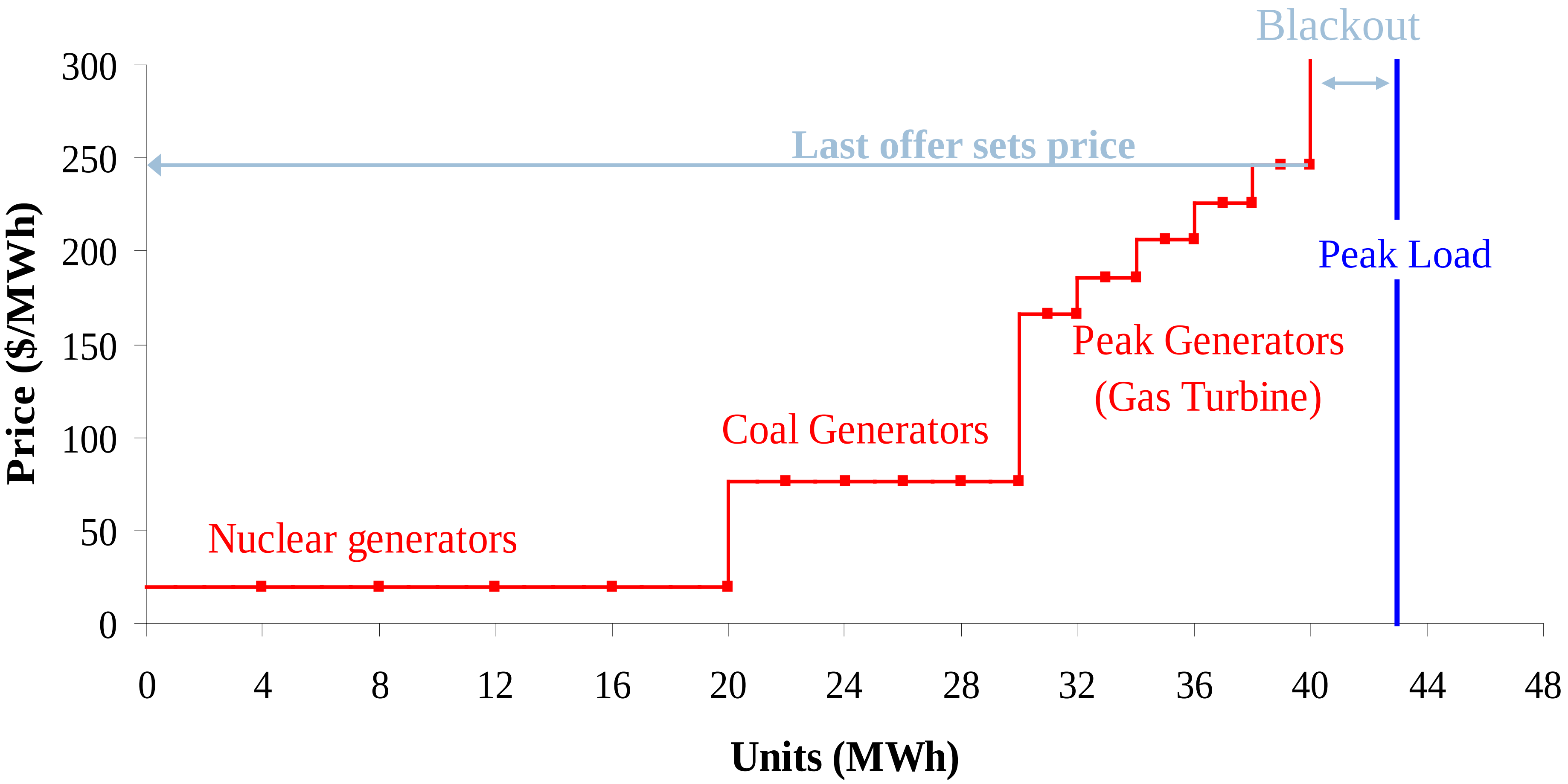
Motivation: Price Determination in Australia

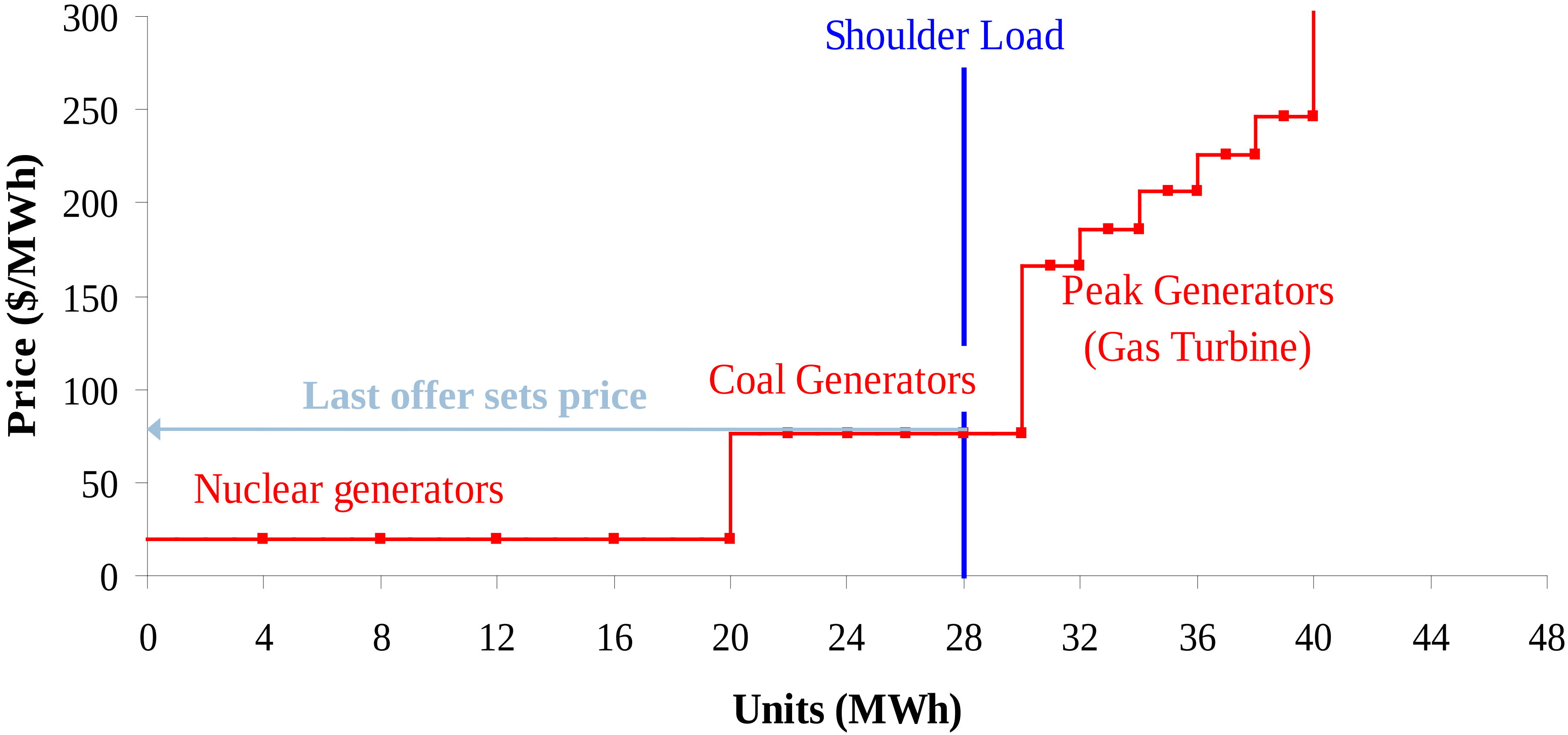
Rassenti, Smith & Wilson (2003)



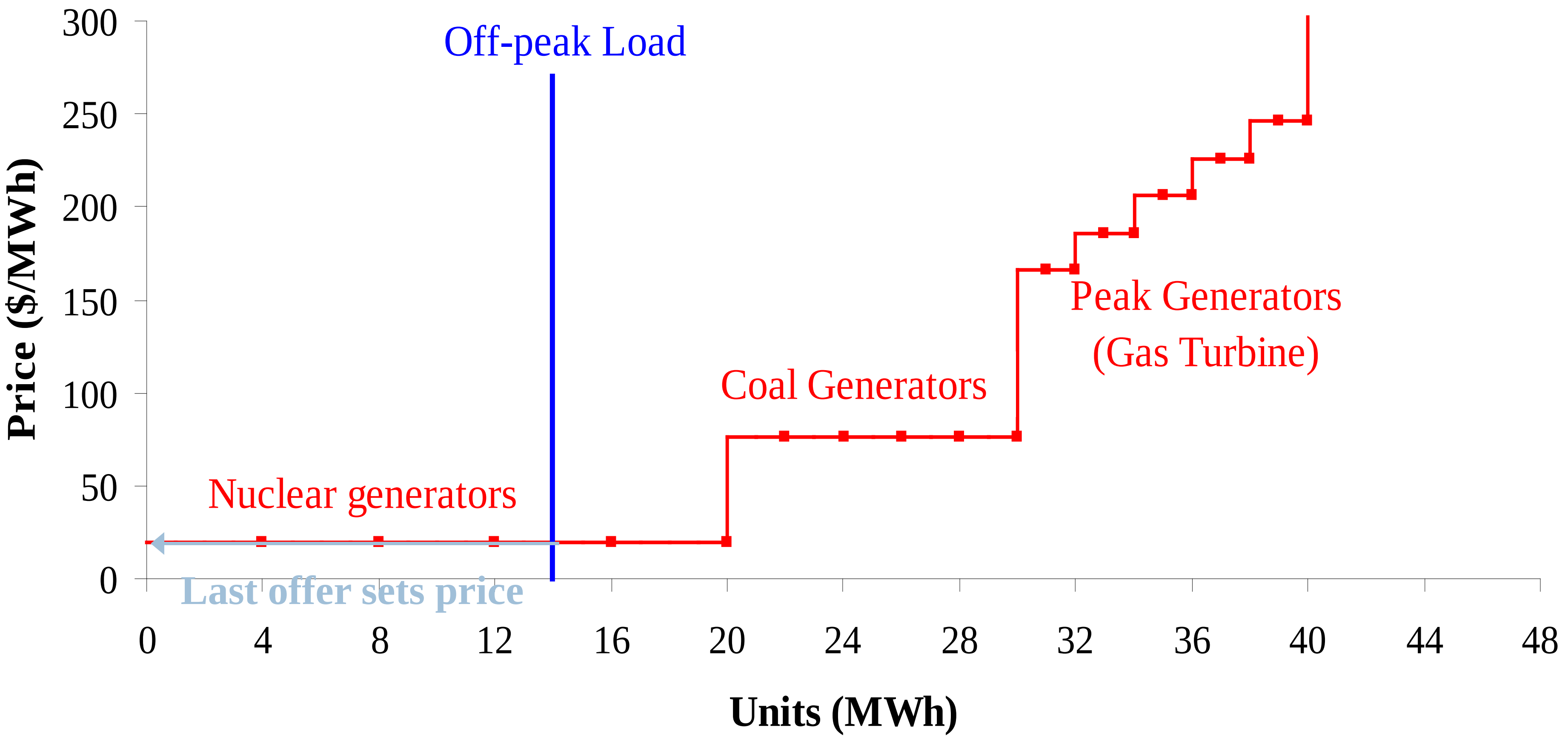
Electricity Market



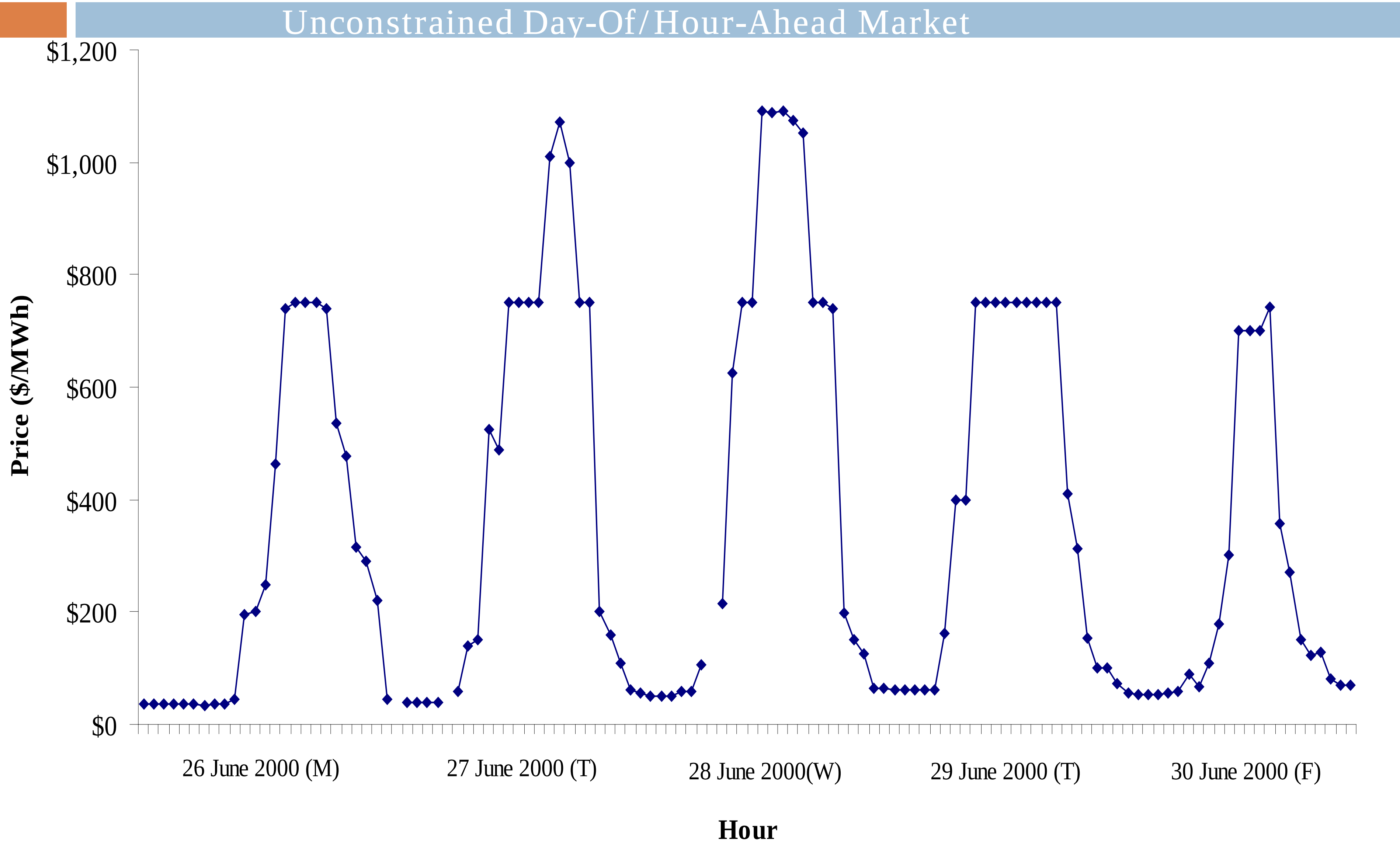
Electricity Market



Electricity Market



California Power Exchange Prices

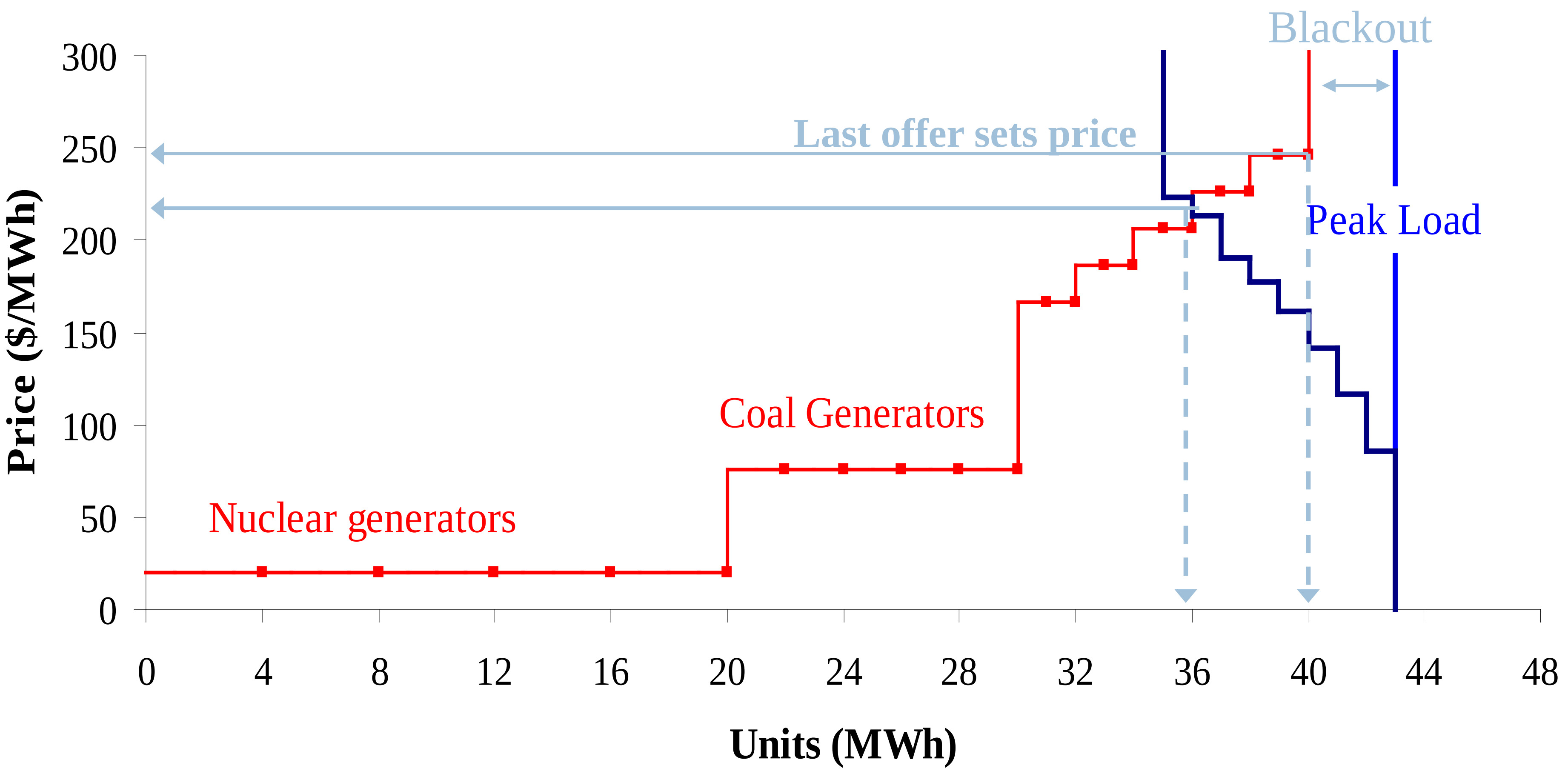


Electricity Market

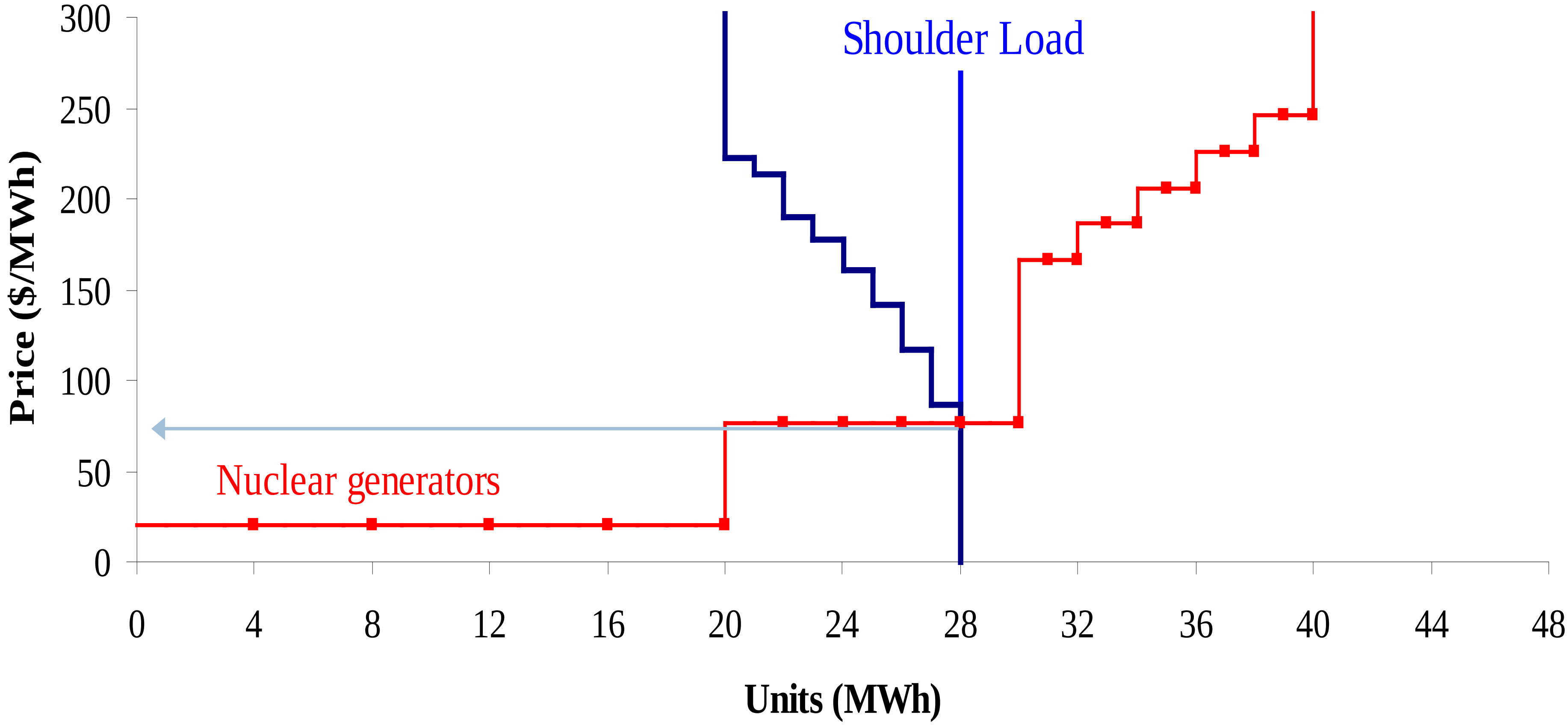
Rassenti, Smith & Wilson (2003):

- What is missing in this market?

A Responsive Demand on Peak

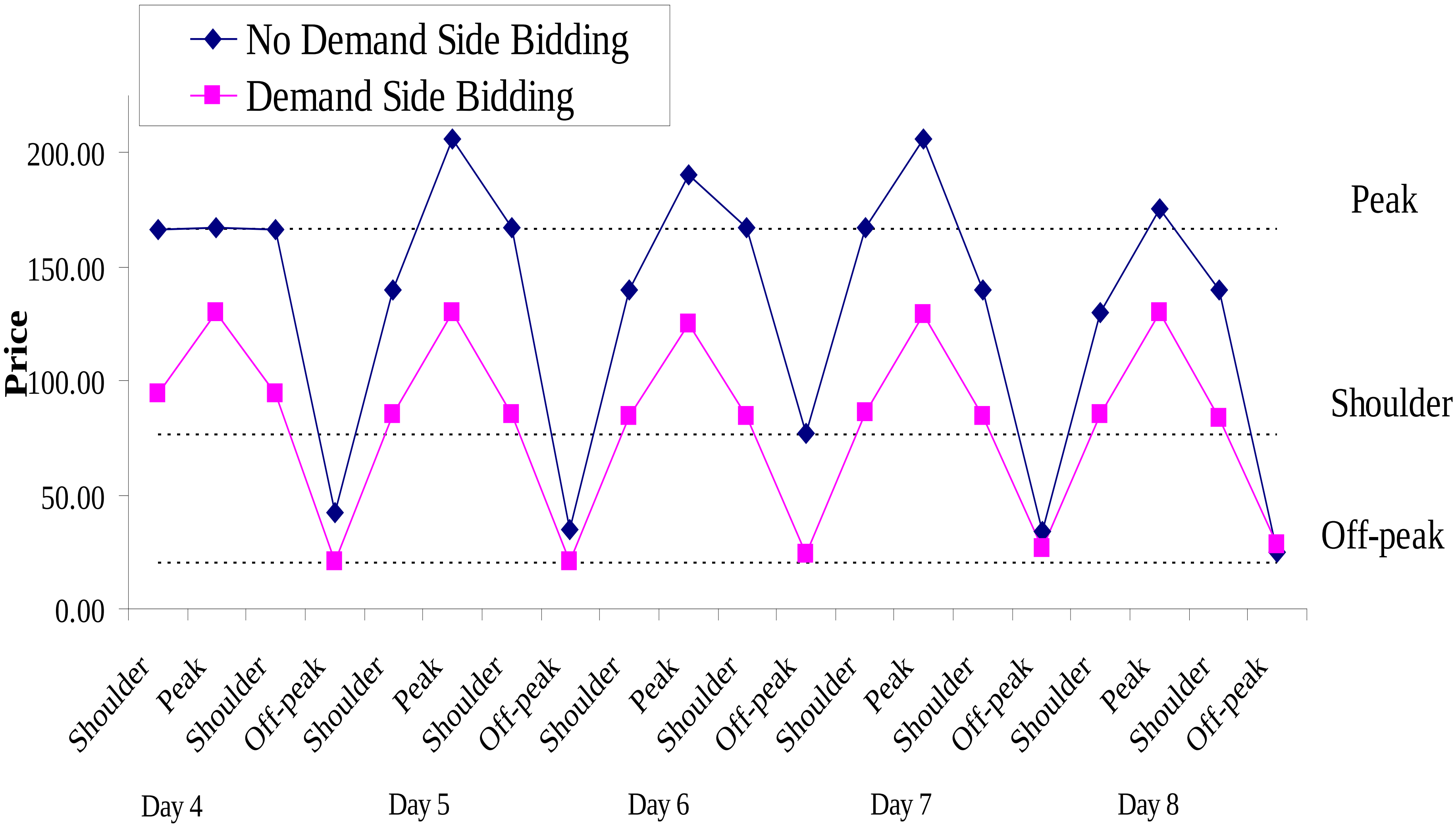


A Responsive Demand on Shoulder



Demand Side Bidding

Lower Prices & Less Volatility



Need for Reduced Demand

- In US alone, peak demand without demand response programs is estimated to grow at an annual average growth rate of 1.7%, reaching 950 GW in 2019
- To avoid need for new generation and transmission, demand response can decrease demand, leading to fewer blackouts, lower costs, and less need for new generation
- Under highest level of demand response, peak load could be reduced by as much as 150 GW
  - Typical peaking power plant about 75 megawatts
  - Reduction equal to 2000 such power plants

Environmental Benefits

- Smart grid technology could reduce CO_2 emissions by 12%

- In Australia, implementation of smart grid could reduce country's carbon emissions by as much as 3.5 megatons

- Dynamic pricing eliminates/reduces subsidy needs for solar generation

A Question

- How exactly should we implement demand-side response into electricity markets?

Different Retail Electricity Pricing Contracts

- Flat rate pricing (FRP)
- Time of use pricing (TOU)
- Critical peak pricing (CPP)
- Real time pricing (RTP)
- Peak time rebates (PTR)
- Automated demand response
- Enabling technology
- Demand aggregation and curtailment

California Statewide Pricing Pilot

California Automated Demand Response System Pilot

Community Energy Cooperative's Energy-SmartPricing Plan

GridWise Olympic Peninsula Project

Smart Meter Rollouts

- In U.S. (2009): $11 billion from the stimulus package for smart grid investments
- In Victoria (2010): a big issue in recent elections

Our Questions

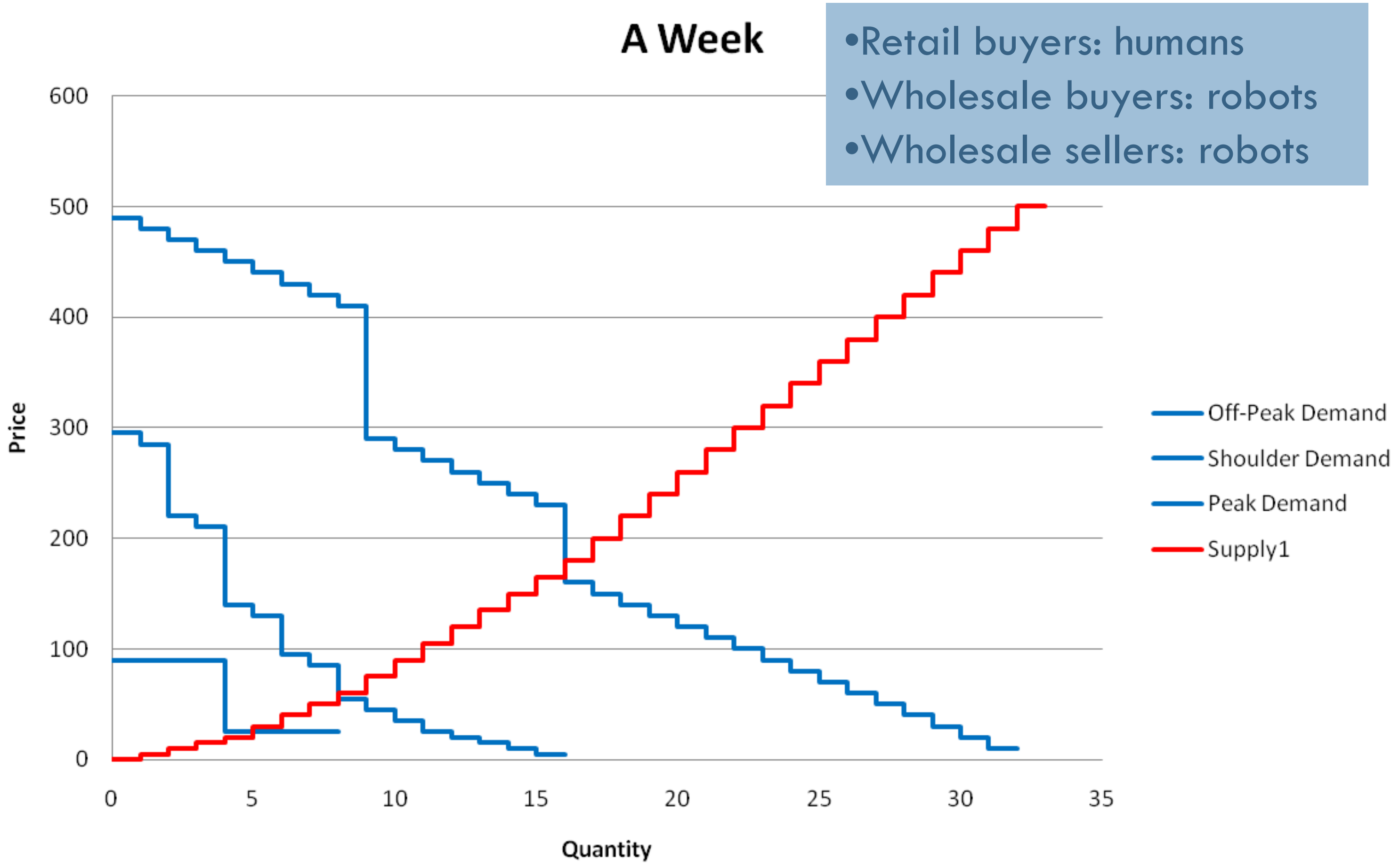
- 1) How do different retail electricity pricing contracts affect market allocative efficiency?
- 2) How good (bad?) are the consumers at responding to supply-side cost shocks under different pricing contracts?
- 3) How does the access to market information affect consumer behavior?

Laboratory Experimental (why?) Approach

We consider four types of pricing contracts:

- 1) FRP
- 2) TOU-L
- 4) TOU-H
- 3) RTP

Experimental Environment: Months 1-15



- Retail buyers: humans
- Wholesale buyers: robots
- Wholesale sellers: robots

Experimental Treatments

		FRP	TOU-L	TOU-H	RTP
Market Information Access	*No*	(5; 33)	(5; 33)	(5; 33)	(5; 33)
	Yes				(5; 33)

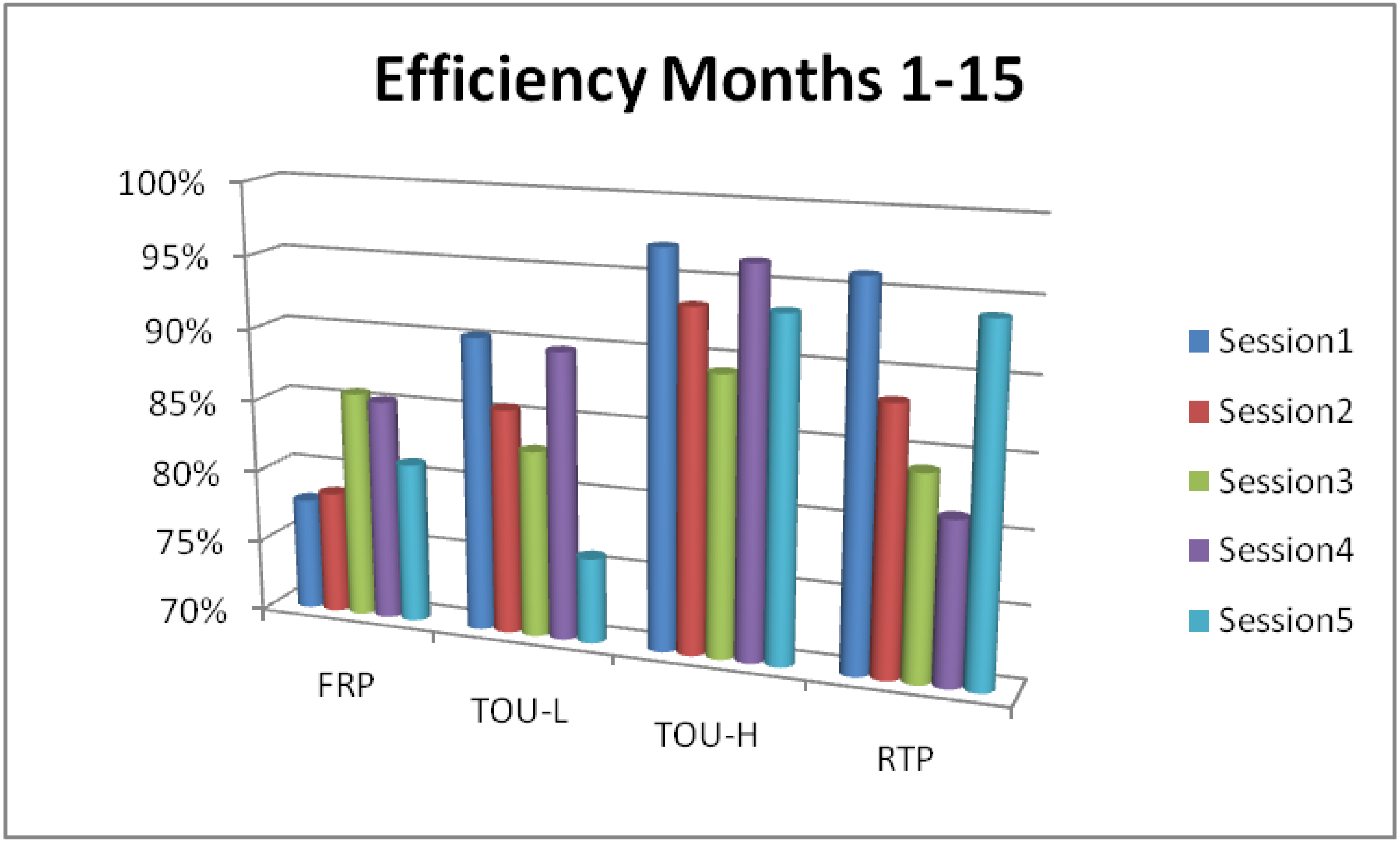
- Total number of subjects: 100
- Average subject earnings: 33.03 AUD
- Participation fee: 10 AUD

Predicted Efficiency Levels for Months 1-15

- Efficiency = (Realized Total Surplus / Maximum Total Surplus) * 100

	FRP	**TOU-L**	**TOU-H**	**RTP**
Efficiency	88%	92%	100%	100%

Results



Efficiency Months 1-15
100%
95%
90%
85%
80%
75%
70%
FRP
TOU-L
TOU-H
RTP
Session1
Session2
Session3
Session4
Session5

A Behavioral Puzzel

- Why is RTP less efficient relatively to TOU-H?

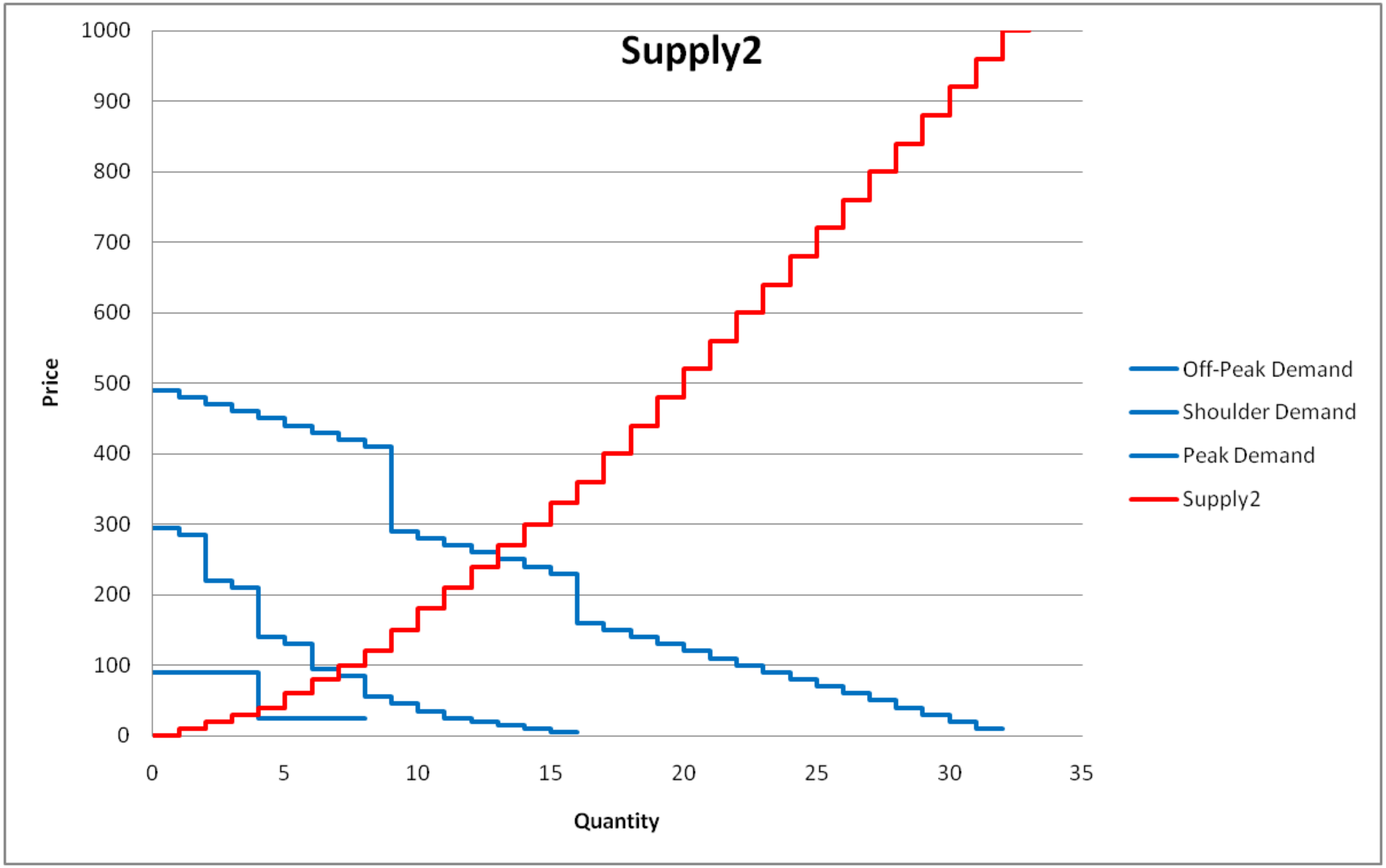
Varying Information

- Introducing instantaneous market information access
- Treatment RTP+

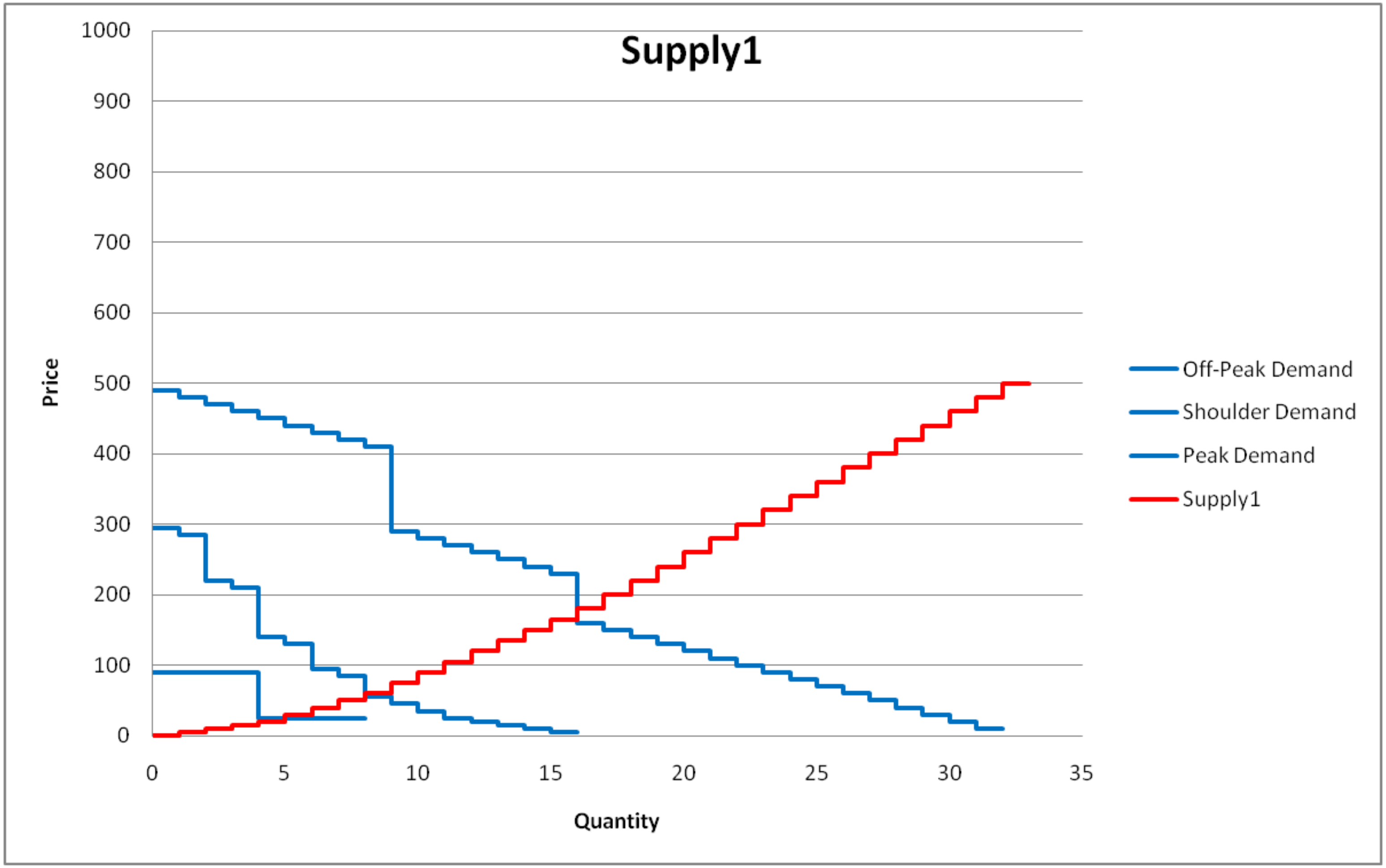
Results: Efficiency Levels for Months 1-15

	FRP	**TOU-L**	**TOU-H**	**RTP**	**RTP+**
Predicted Efficiency	88%	92%	100%	100%	100%
Observed Efficiency	82%	85%	94%	89%	98%

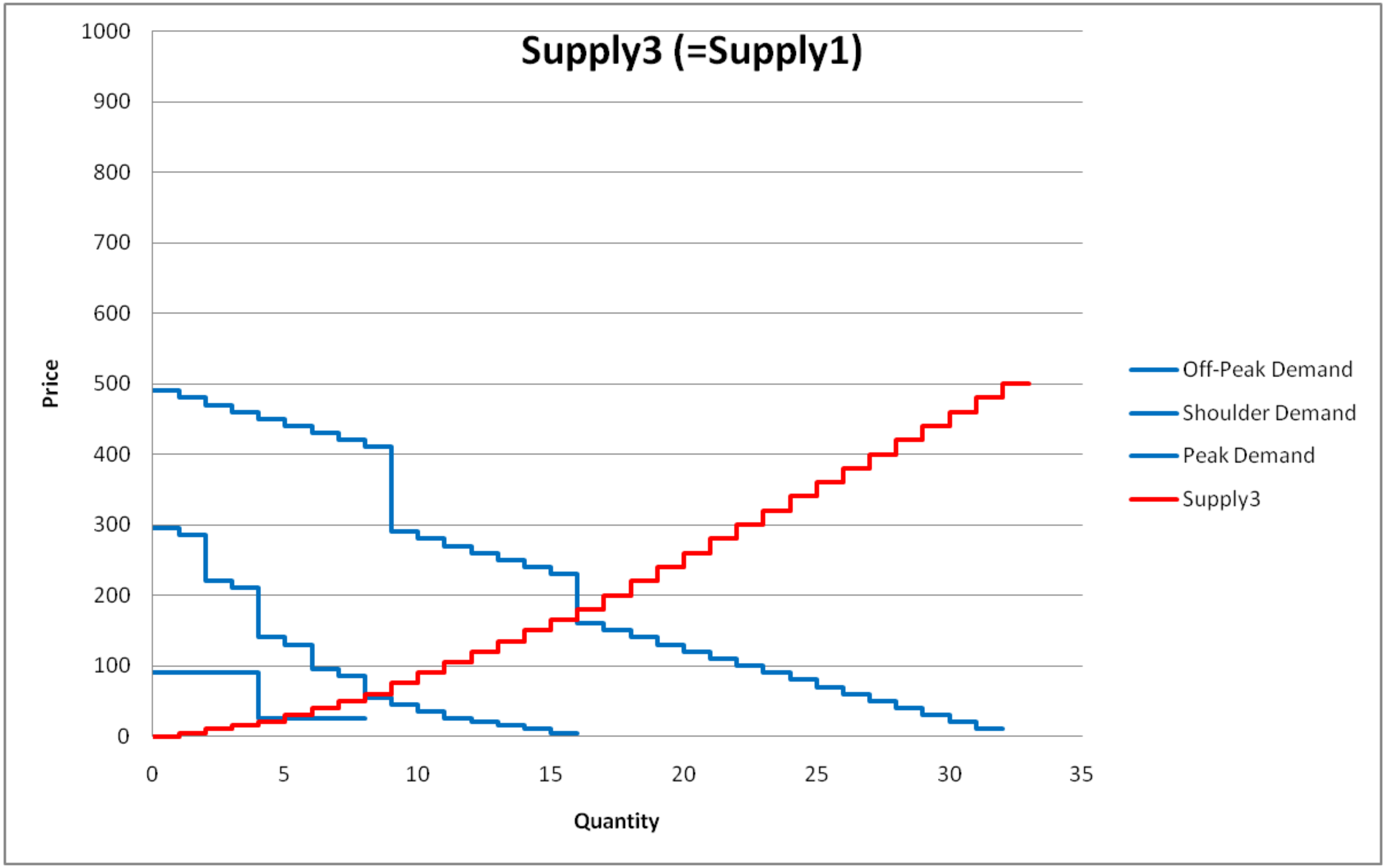
Experimental Environment: Months 16-21



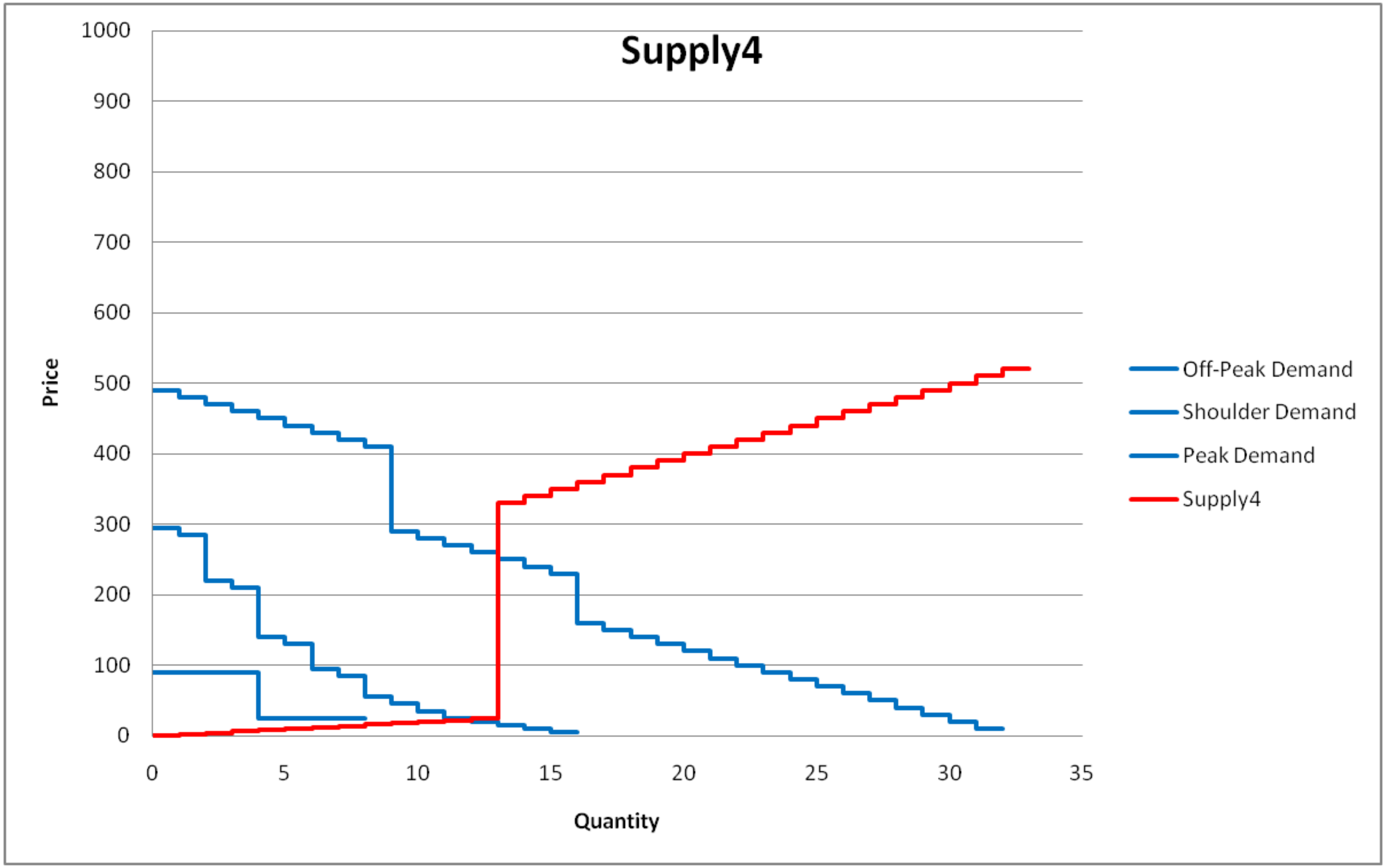
Experimental Environment: Months 1-15



Experimental Environment: Months 22-27



Experimental Environment: Months 28-33



Results

Efficiency		**FRP**	**TOU-L**	**TOU-H**	**RTP**
Month 10-15	*Predicted*	88%	92%	100%	100%
	Observed	84%	88%	98%	92%
Month 16-21	*Predicted*	78%	93%	95%	100%
	Observed	81%	86%	91%	89%
Month 22-27	*Predicted*	88%	92%	100%	100%
	Observed	74%	88%	91%	88%
Month 28-33	*Predicted*	72%	89%	98%	100%
	Observed	76%	78%	92%	90%

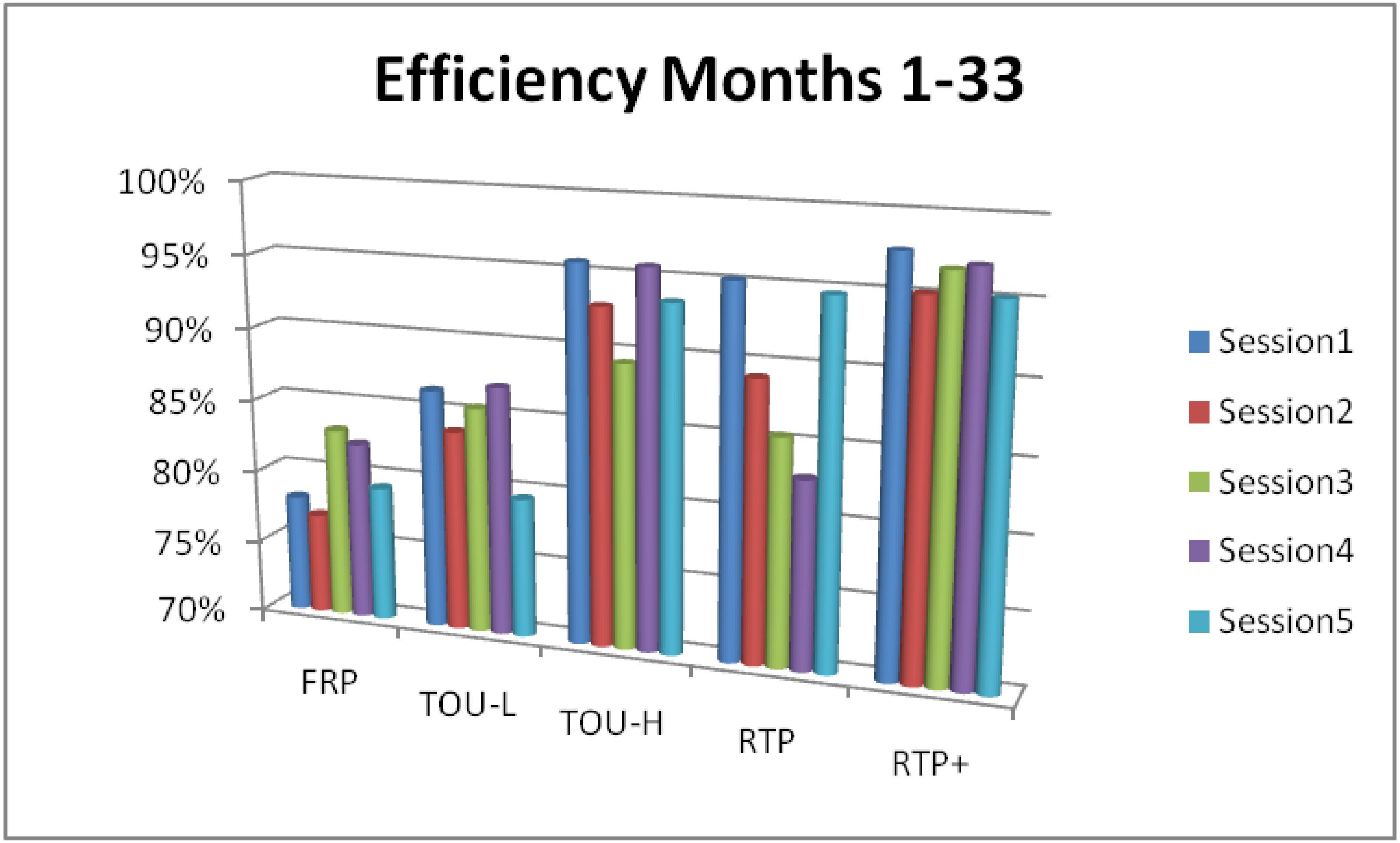
Varying Information

- Introducing instantaneous market information access
- Treatment RTP+

Results

Efficiency		FRP	TOU-L	TOU-H	RTP	RTP+
Month 10-15	*Predicted*	88%	92%	100%	100%	100%
	Observed	84%	88%	98%	92%	98%
Month 16-21	*Predicted*	78%	93%	95%	100%	100%
	Observed	81%	86%	91%	89%	97%
Month 22-27	*Predicted*	88%	92%	100%	100%	100%
	Observed	74%	88%	91%	88%	98%
Month 28-33	*Predicted*	72%	89%	98%	100%	100%
	Observed	76%	78%	92%	90%	95%

Results


Efficiency Months 1-33
100%
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RTP+
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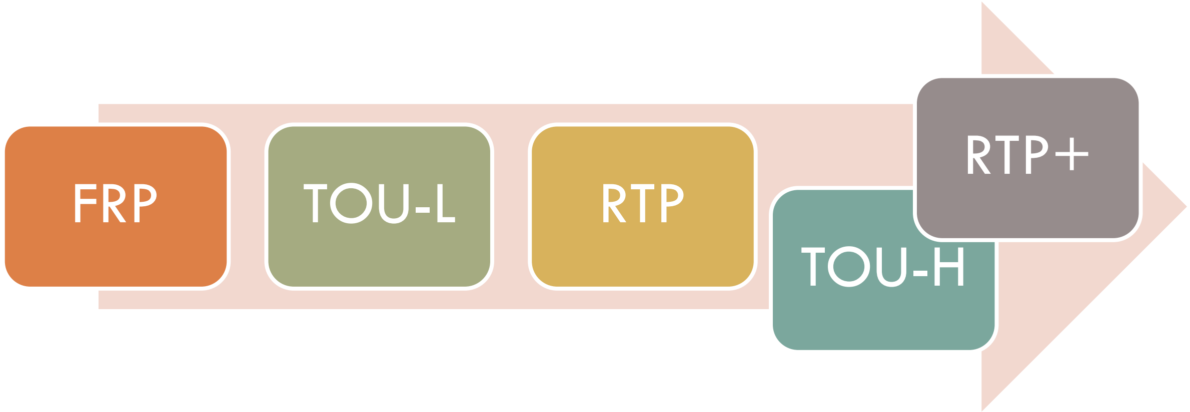
Conclusions



- 1) Contracts with simply more dynamic pricing do not necessarily increase allocative market efficiency: RTP produced relatively low efficiency when compared to TOU-H.

Conclusions

- 2) The type of TOU pricing matters. Separate price for peak demand is better.

Conclusions

- 3) Contracts with more dynamic pricing allow customers to respond to supply-side shocks better (?)

Conclusions

- 4) Providing an instantaneous access to market information significantly improves allocative efficiency with RTP contracts.

LET'S TAKE A LOOK AT YOUR DATA!