Value of Demand Responsive Load

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Project Objectives

- **Quantify the value of Demand Response capability from various perspectives:**
    - **Customer**
    - **Load Aggregator or ESCO**
    - **ISO**
- **Motivation**
    - Customer Market Research: information needed on methods to assess and value load curtailment potential
    - ISOs: develop tools that can expand participation by load aggregators & help overcome barriers to day-ahead market DR programs

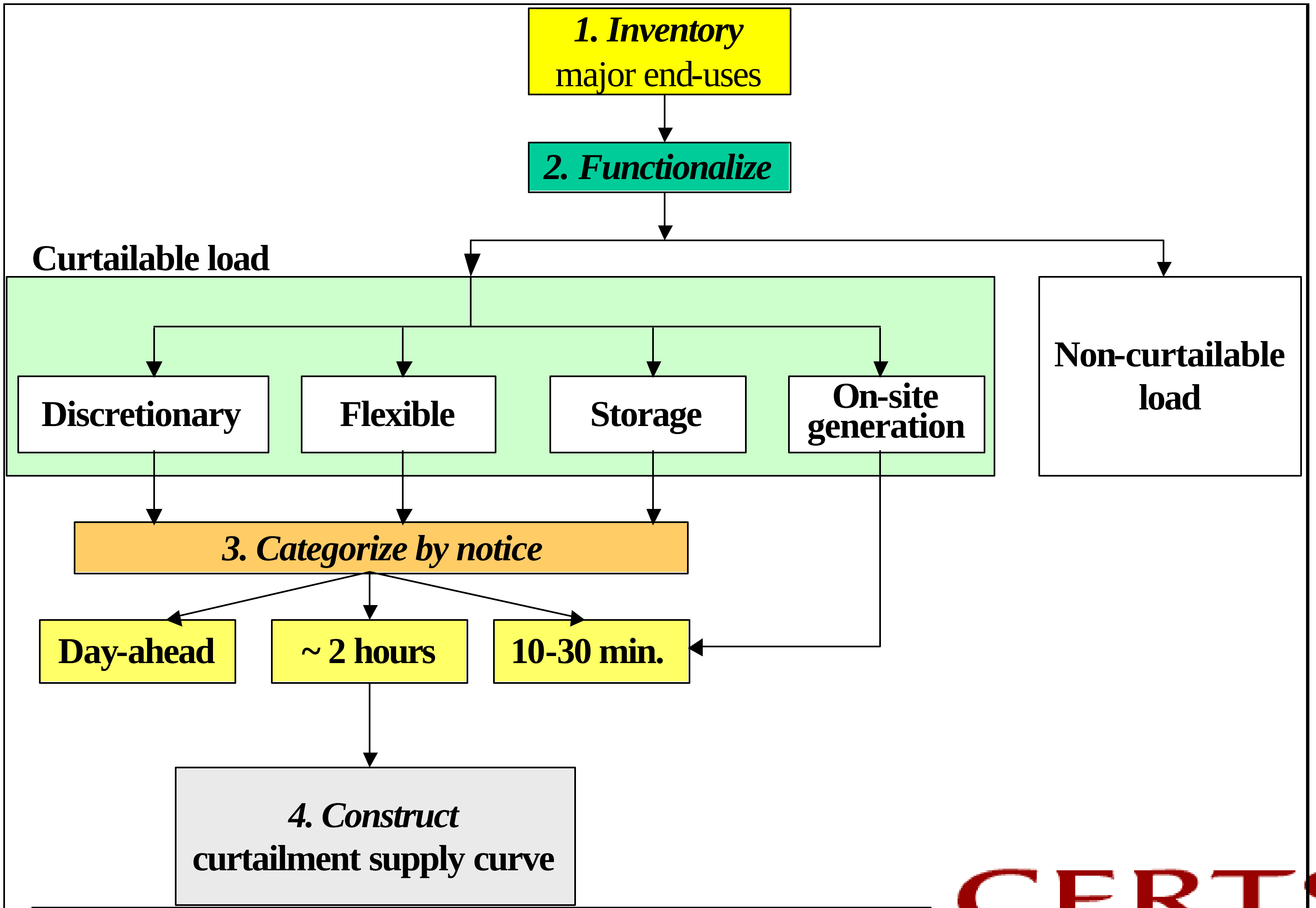
Approach: Develop New Analytic Tools and Methods

- **Customers:**
  - Methods to self-assess DR Capability and identify opportunities to participate in different wholesale markets
  - Methods for assessing the value of investments in DR Technology and quantifying future revenues from these markets using real-options models
- **Load Aggregators**
  - Case study of New York market to assess business opportunities for load aggregators

Opportunities for Customers to Participate in Wholesale Markets

Feature	ISO Market DR Programs			
	Emergency	Day Ahead Electricity	ICAP	Ancillary Services
Notice	2 hrs	Prior afternoon	2 hrs	5 - 30 minutes
Duration	4 hrs	As bid by customer & scheduled by ISO	2 hrs	As bid by customer & dispatched by ISO
Frequency	As dispatched by ISO		Unlimited, most likely in summer	
Reservation Payment	None	None	Yes - 6-mnth mrkt value	Yes - daily markets
Performance Payment	Yes	Yes	In some cases	Yes
Payment Value ($/kWh)	~0.50	0.05 – 0.99	0.05 - 0.50	0.01- 0.99
Penalty	None	Market price	Cash, participation privilege penalties	Market price
Reference	NYISO EDRP	NYISO DADRP	NYISO ICAP 2002	CAISO & ISO-NE Class I

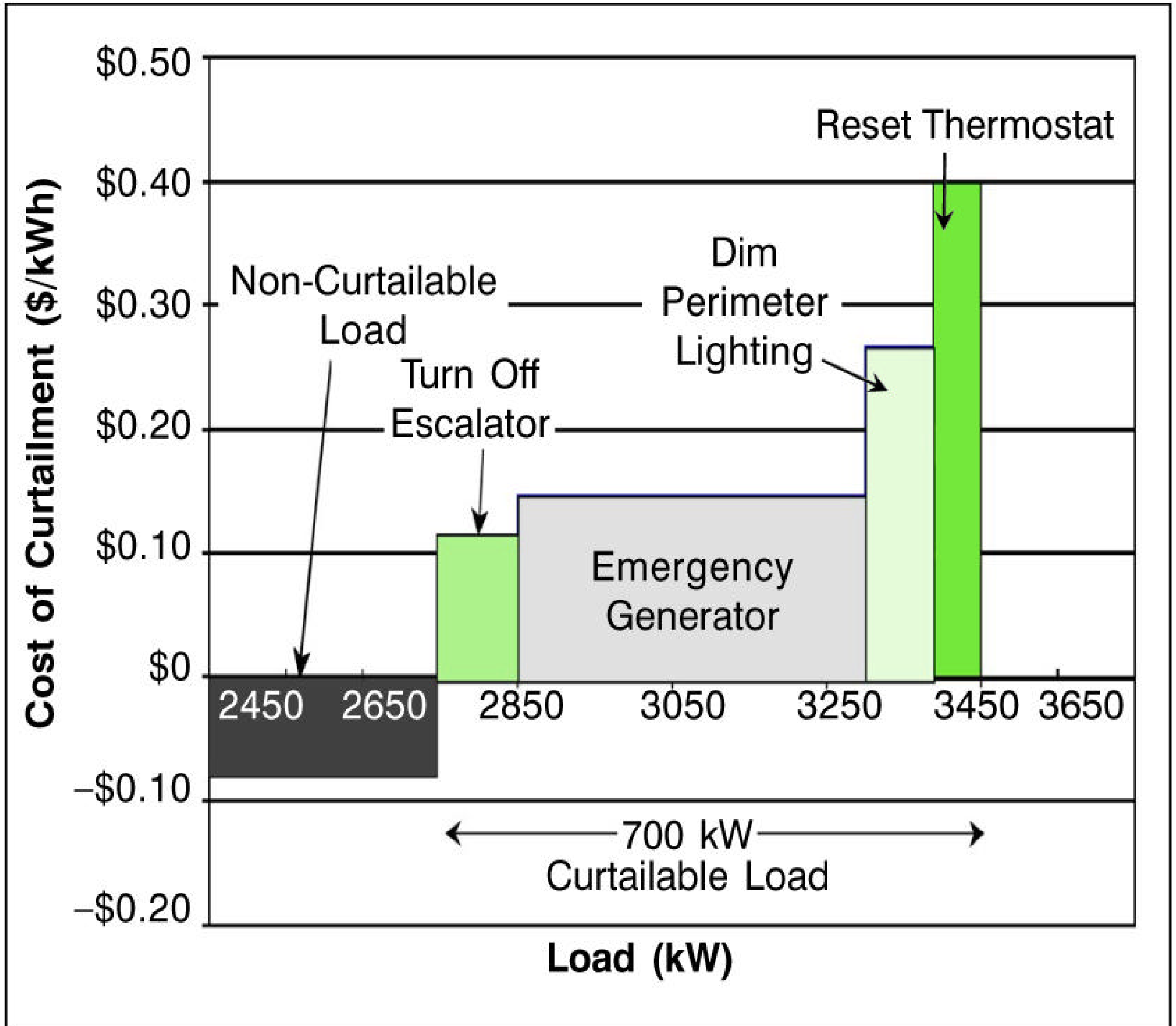
Assessing Customer's Demand Response Capability



Example: Estimated Load Curtailment Capability for Commercial Facility

End-use inventory (kW)		Load Reduction Capabilities				Cost	
		Discretionary (kW)		Self-supply (kW)	Labor hrs	Labor for load reduction/fuel cost	Cost ($/kWh)
HVAC	1000	Reset thermostat	60		2	$120	0.40
Lighting	900	Dim lighting at perimeter	90		2	$120	0.27
Escalators, elevators	270	Shut off escalators	100		1	$60	0.11
Office equip/other	850						
Emergency generator	450			450	1	$60 + 12 ¢/kWh for fuel	0.15
Total (Load)	3000		250				
Total (Gen)				450			
Total (Load+Gen)			700				

Example: Load Curtailment Supply Curve



Assessing Investments in DR Technology

- **Investment in DR technologies leads to enhanced DR capability**
  - faster response time
  - lower costs to participate
  - higher frequency of participation

- **Enhanced DR capability could allow customers to participate in more ISO markets and/or increase revenues from participation**

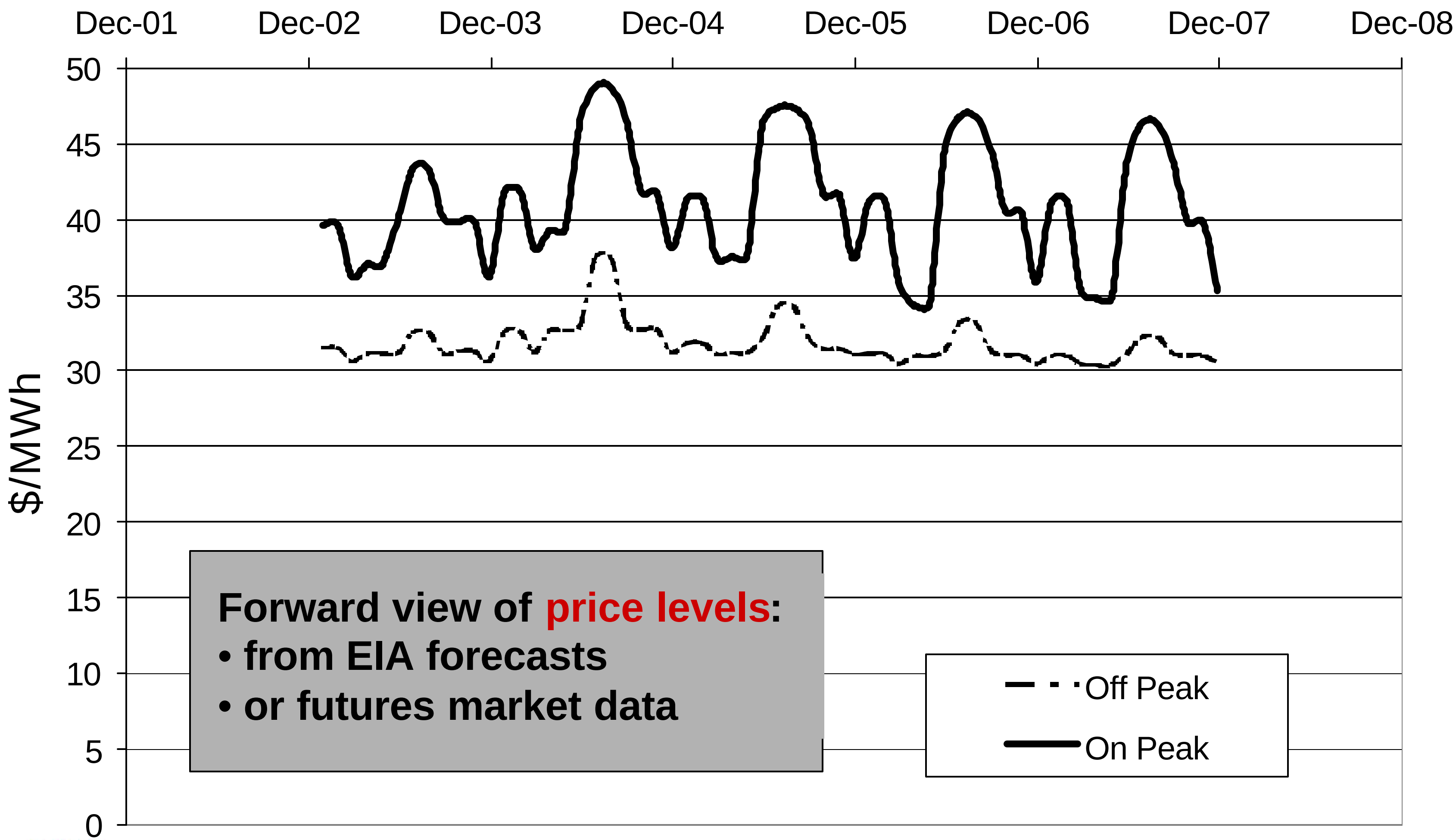
Example: Impact of DR Technology on Load Response Capability and Customer Revenues

				Day Ahead			ICAP	2001 summer profits ($)
	Measures	Programs	Op. costs ($/kWh)	Day ahead bid ($/kWh)	Reve-nues ($/kW)	Events	ICAP Commitment (kW) & Revenues ($/kWh)	
Manual Load Curtailment *Automated Load Curtailment (with DR Investment)*	Turn off escalators	DAM	0.11 *0.02*	0.144 *0.05*	13.4 *39.9*	14 *98*		500 *2,800*
	Turn emergency gen-set on	ICAP	0.15 *0.13*				450 and 52.5 *450 and 52.5*	23,600 *23,600*
	Dim lights in perimeter zones	DAM	0.27 *0.03*	0.4 *0.05*	4.1 *39.9*	1 *98*		200 *2,400*
	Reset thermostats	DAM	0.40 *0.04*	0.4 *0.05*	4.1 *39.9*	1 *98*		100 *1,200*
							Total (day ahead)	800 *6,400*
							Total	24,400 *30,000*

Value to the Customer

- **Significant opportunities calculated for a prototypical facility in New York**
- **But revenues estimated using historical ISO prices (2001)**
- **Need for Improved Revenue Model**
  - Future prices are uncertain and are best modeled as a stochastic process (with forward price and volatility views)
  - DR opportunities are real-options that are exercised when the prices are right; valued as options

Electricity Market Prices: Forecasting Future Price Levels



Forward view of price levels:
- **from EIA forecasts**
- **or futures market data**

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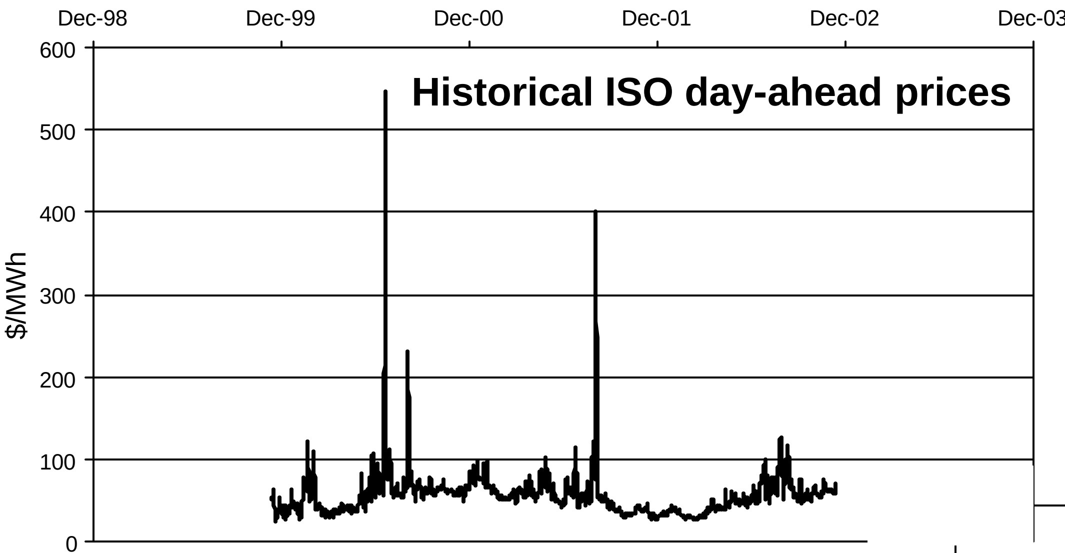
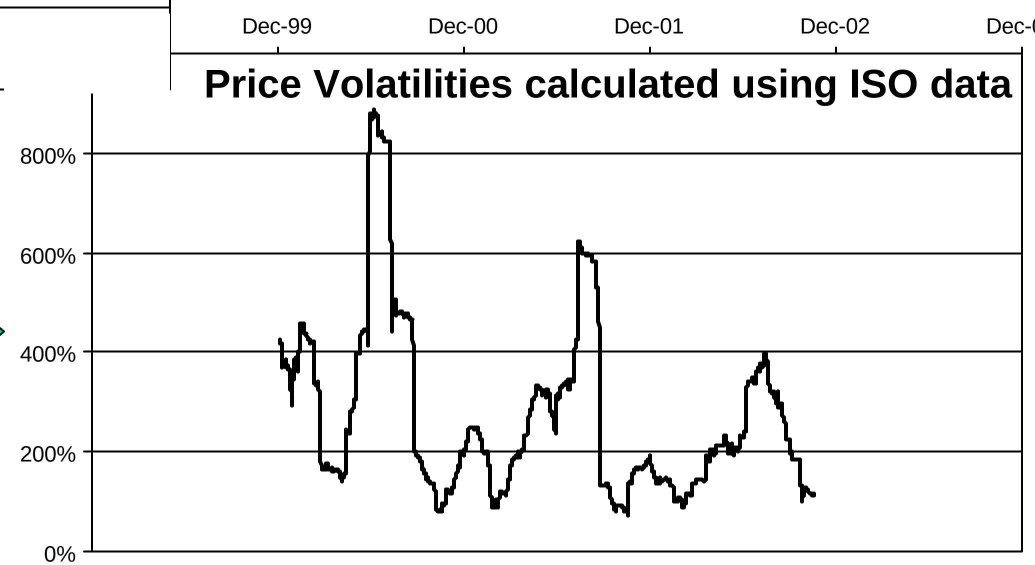
Electricity Market Prices: Volatility



Forward view of volatilities: calculated from historical price data or backed out from options prices



Value of Demand Flexibility: Options Market Perspective

- **Customer with ability to curtail load in essence owns a strip of options, one for each time period (e.g., hour) during which load can be curtailed**

- **For a day-ahead market participant, value of these options depends on future prices in day-ahead market**

- **Option value is the expected payoff where**

  payoff = max [(day ahead price – strike) , 0]

- **Strike price includes customer's variable operating cost (and/or revenue losses and reduced service levels)**

Value of Future Revenue Stream

Monthly Limit (hours)	Strike Price ($/kWh)				
	0.10	0.20	0.30	0.40	0.50
20	14	9	6	5	4
100	70	44	32	25	21
200	139	87	64	50	42

- Option value of customer load curtailment for 5 years of operation (thousand $/MW)

Value of DR Technology

Monthly Limit (hours)	Strike Price ($/kWh)				
	0.10	0.20	0.30	0.40	0.50
20	14	9	6	5	4
100	70	44	32	25	21
200	139	87	64	50	42

D = 70 – 9 = $61,000/MW ($61/kW)

- **Assume that DR Technology investment reduces the operating costs from $0.20/kWh to $0.10/kWh and also allows the customer to be available to curtail 80 hours more, then the market value of the technology is $61,000/MW (or $61/kW)**
- **Assume 3 year payback: customer would make capital investment if DR technology cost less than ~$180/kW**

Assessing Business Opportunities for Load Aggregators (i.e, CSP)

Estimate future cash flows for a CSP with 50 MW of load curtailment capacity (5 years)

Revenue Side

- **DADRP Payments**
- **ICAP/SCR Payments**

Scenario analysis:

- **Number of hours that the customer can participate**
- **Upstate vs. Downstate NY**
- **Persistence of ICAP/SCR program (3 vs. 5 years)**

Cost Side

- **Payment sharing arrangement with customer**
- **Cost of operating as a CSP**
- **Customer acquisition costs (several scenarios considered)**

Net Present Value

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CSP "Business Case" Analysis: Key Inputs

- **Revenues**
  - Payment sharing arrangement with Customer
    - Assume 40% for CSP & 60% for customer
  - DADRP Option Value
    - Customer willing to curtail ~100-200 hours/month
    - Customer Strike Price assumed to be $100/MWh
  - ICAP Payment Stream
    - Upstate and Downstate NY
    - Term = 3 or 5 years
- **Costs**
  - Operating Costs
  - Customer Acquisition Costs
    - Range between $15, $30 or $60/kW
    - Assume 500K/yr for 50 MW

CSP "Business Case" Analysis: Scenarios

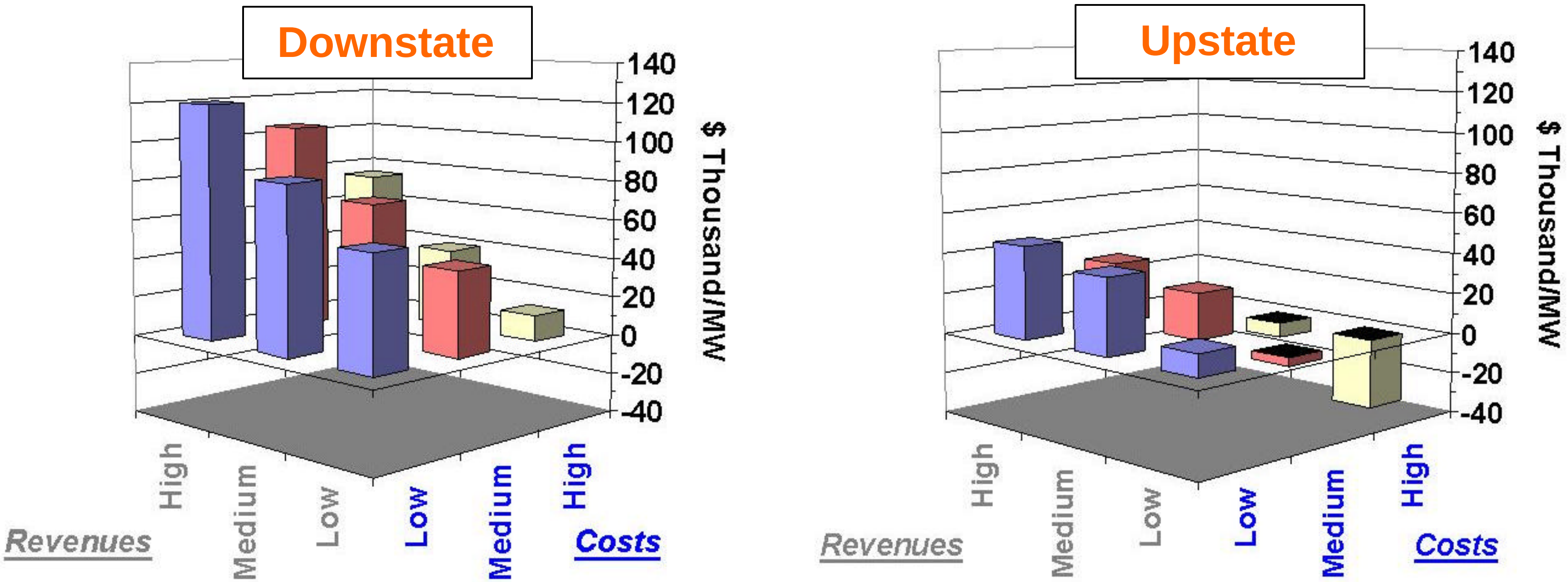
Table 7-3 Scenario Cost & Revenue Components

DADRP and ICAP

Revenues		Costs: Low	Costs: Medium	Costs: High
High	DADRP Bids (Hrs/Month)	200	200	200
High	ICAP Duration (Yrs)	5	5	5
High	Load Acquisition Cost ($/kW)	15	30	60
Medium	DADRP Bids (Hrs/Month)	200	200	200
Medium	ICAP Duration (Yrs)	3	3	3
Medium	Load Acquisition Cost ($/kW)	15	30	60
Low	DADRP Bids (Hrs/Month)	100	100	100
Low	ICAP Duration (Yrs)	3	3	3
Low	Load Acquisition Cost ($/kW)	15	30	60

CSP "Business Case" Analysis: Results

NPV of Revenues under Various Scenarios



- **Potentially profitable business opportunities in downstate NY, driven by higher ICAP/SCR payments**
- **Profitability very sensitive to customer acquisition costs, particularly in upstate NY**
- **Retail service providers with an existing customer base may have a better chance**

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Significance: Impacts on ISOs and Public Benefits Administrators

- Significance
  - ISOs: helps establish viability of CSPs as a “Stand-alone” business”
  - Public benefit administrators: shows value of various DR enabling technologies and helps establish incentive levels
    - Helped NYSERDA target their DR programs to load aggregators
- Next Steps
  - Apply to other regional markets
  - Incorporate option value of intra-day flexibility and more customized representation of customer’s actual operational constraints for shorter time periods – to show value of participating in real-time and ancillary services markets

Deliverables

- Publications
  - **“Dividends with Demand Response.” M. Kintner-Meyer, C. Goldman, O. Sezgen, and D. Pratt. *ASHRAE Journal* (Oct. 2003)**
  - **“Value of Electricity Demand Responsiveness—a Real Options Approach.” O. Sezgen, C. Goldman, and P. Krishnarao, submitted to *Energy, the International Journal* (Oct. 2003)**
  - **“Social Welfare Implications of Demand Response Programs in Competitive Electricity Markets.” Boisvert, R.N. and B.F. Neenan, sub-contractors to LBNL (August 2003)**

Extra Slides

Option value equation

$$OptionValue_t = e^{-rt}[P_t \, N(d) + Strike \, N(d - s\sqrt{t})]$$

$$d = \frac{\ln(P_t / Strike) + 0.5 \, s^2 \, t}{s\sqrt{t}}$$

$$P_t = \text{ forward price of power}$$

$$r = \text{risk free discount rate}$$

$$s = \text{Black} - \text{Scholes volatility}$$

$$Strike = \text{strike price}$$

$$N(.) = \text{normal distribution function}$$

Aggregator Business Opportunity

Modeling the CSP Business Opportunity