

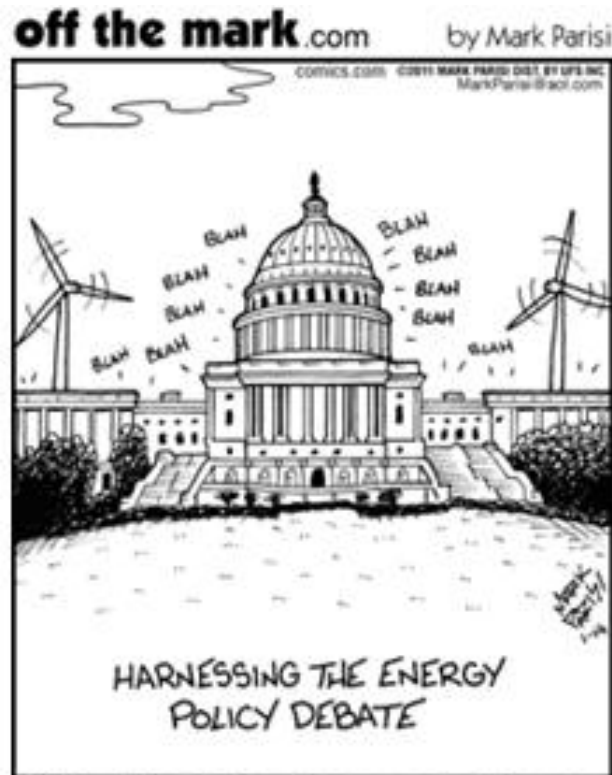
How Much Demand Response Is Too Much?

***Peak Load Management Alliance (PLMA)
Spring Conference: Demand Response: Growing
with the Smart Grid
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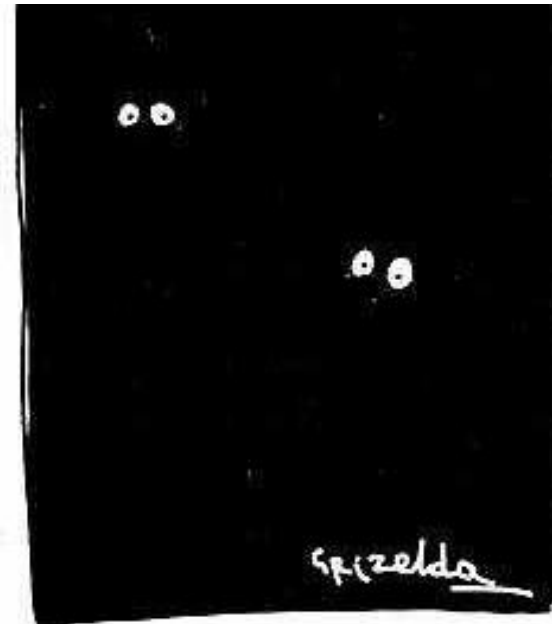


- The role of direct load control and demand response programs
 - Recognized as an underutilized
 - Capable of providing numerous benefits



- *Ongoing debate of appropriate value and quantity*
 - *Practitioners rely on protocols developed over years and accepted by regulatory commissions*

- In this paper we examine the unique characteristics that allow a direct comparison with fossil fuel generation
- *and advance the idea that these programs are better valued using supply-side methods*



“I wonder if everyone else is making as much effort as us to reduce global warming.”

- How much is enough?
 - Fundamentally, the electric system needs enough capacity to meet the coincident peak demand plus the mandated reserve margin
 - Often referred to as Resource Adequacy (RA), the DR contribution often depends on RA “counting rules”
 - But, the correct answer (viewed ex-post) depends on a lot of uncertainty and risk

- How much is enough?
 - The optimal amount of DR can be measured from several perspectives including cost-effectiveness, marginal revenue requirements and effective coincident peak coverage, among others.

- How much is it worth?
 - Fundamentally, in a least-cost regulatory framework capacity should be chosen based on the cheapest resource available
 - In an sustainable environment regulatory framework, resources are chosen based on least-cost subject to meeting portfolio targets or mandated standards
 - Again, the answer depends on a lot of uncertainty and risk

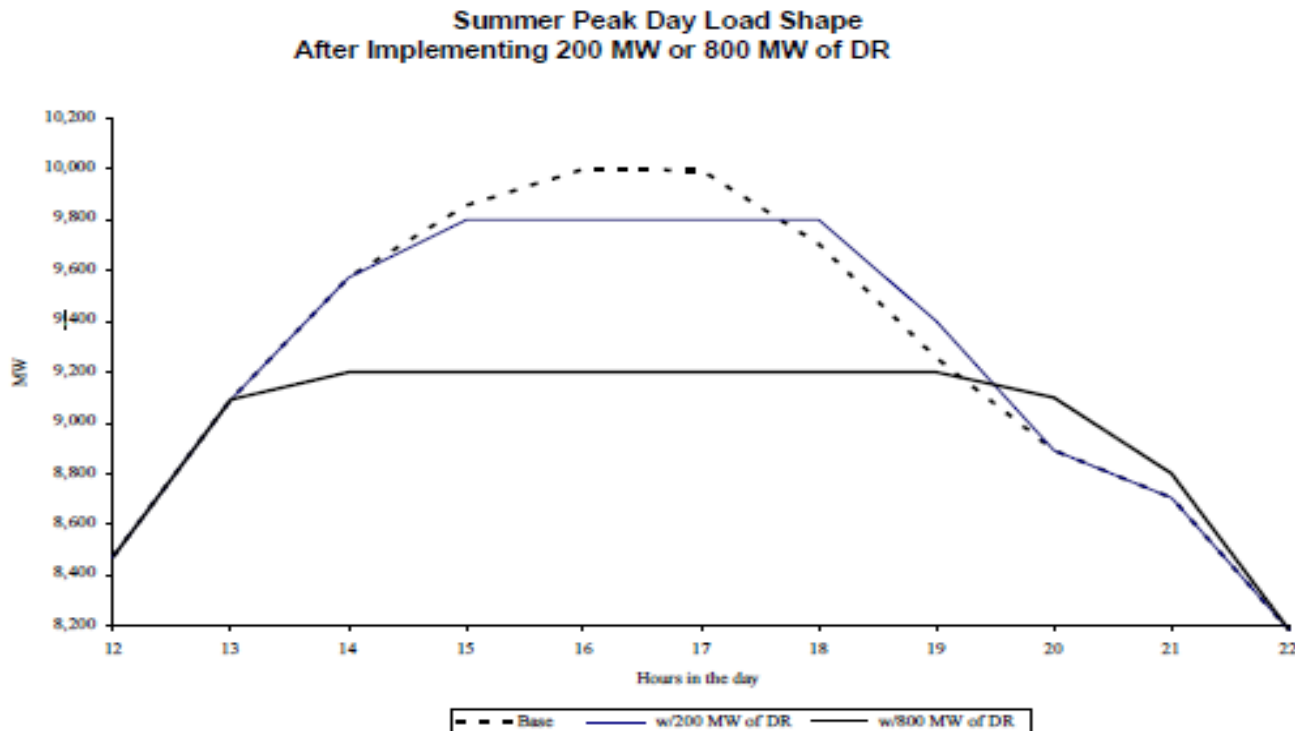
- How much is it worth?
 - In recently issued Order No. 745, the Federal Energy Regulatory Commission (FERC) establishes that a demand response resource must be compensated for the service it provides to the energy market at the market price for energy...”

- How much is it worth?
 - Other studies have sought to compare specific DR program attributes to a traditional combustion turbine (CT), and adjust the value accordingly.
 - Further research considers the integrated benefits of DSM programs in portfolios, for example the IDSM framework currently being discussed in California.

- Our coincident peak day modeling is largely patterned after the Florida Power and Light presentation to FERC.
- The FPL presentation suggests that real limits exist as increasingly more peak day load reduction is undertaken.

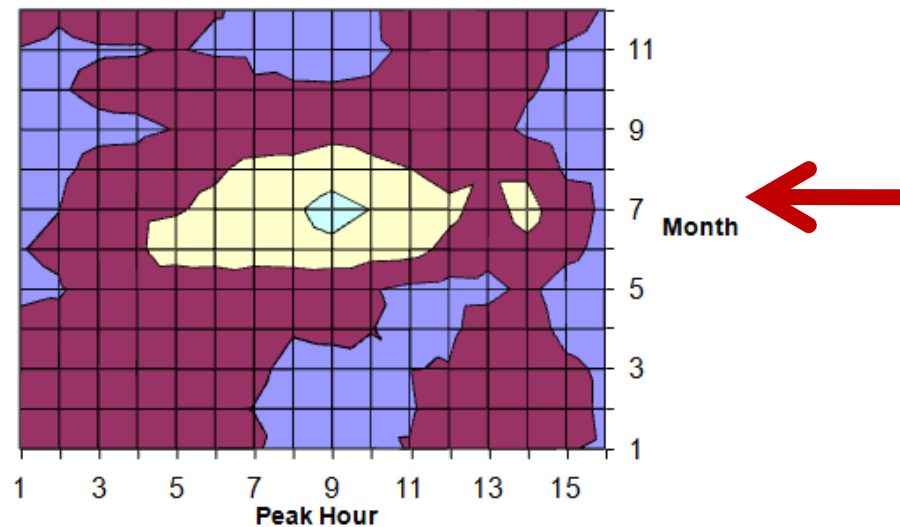
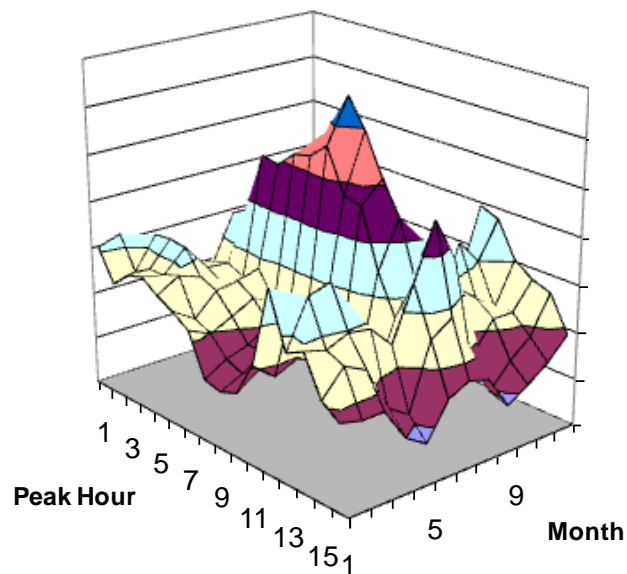
- FPL Comments to FERC
 - FPL makes the following statement: “There are practical limitations on the amount of new demand response any utility can and should use.”
 - FPL makes the argument that the physical limit to the amount of usable DR on a given utility system is essentially driven by the shape of the utilities peak day load curve.

- As the utility signs up more and more DR load reduction capability, each incremental participant must respond for longer and longer periods.

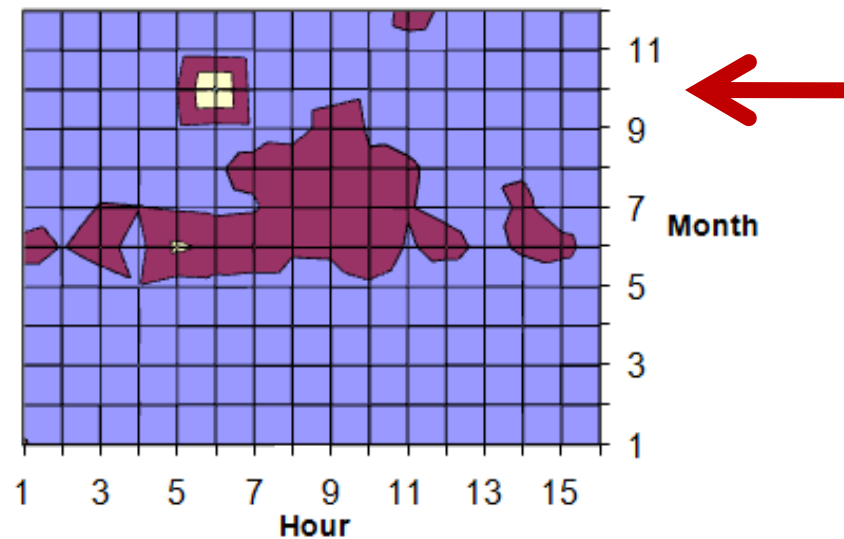
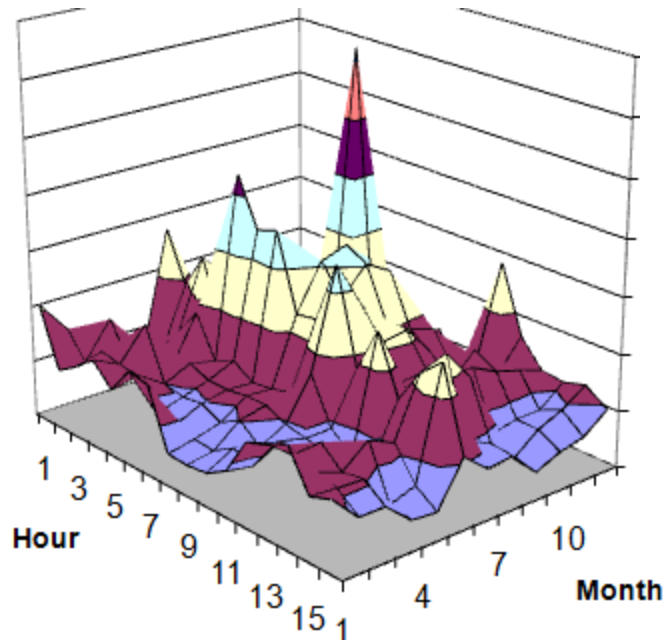


- But the argument overlooks uncertainty of supply and demand; and fails to account for new “smart grid” technologies.
- Uncertainty of Supply and Demand
 - Viewed using average or expected values, or viewed using coincident-day load, will give a very different result than viewed from a supply and demand balance or LOLP (loss of load probability) perspective

- For example, using historic data, the expected coincident day system impact occurs at peak hour 9 (5 pm) in July



- But the critical hour happens at the supply and demand imbalance extreme – peak hour 6 (2 pm) in October.



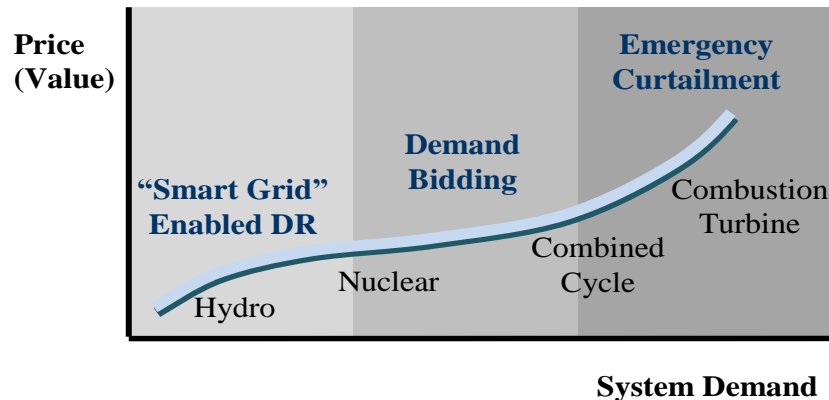
- Further, the magnitude of the avoided cost benefits depends on uncertain future conditions.
 - In a weather mild year, DR programs may not be needed
 - In a weather extreme year, DR programs may be extremely important for system reliability
- Others have referred to this as the Option Value of Demand Response

- Smart Grid Technology
 - The benefits of DR can extend to all peak hours through demand bidding and “smart dispatch” with supply resources
 - Smart technology allows dynamic dispatch (DD)
 - See for example “Duke Virtual Power Plant”
Google Search for the McAlpine Smart-Grid Pilot

- As DR benefits more closely resemble peak hour supply resources, programs are better valued using the methods and tools of the supply-side commodity markets
- Supply-side models can be used to measure an important aspect of value not currently captured by the standard tests

- In our approach we utilize the standard practice tests as an acceptable measure of *intrinsic* value, and utilize financial engineering methods to value the *extrinsic* value
- These two methods combined provide a better measure of the overall value of demand response

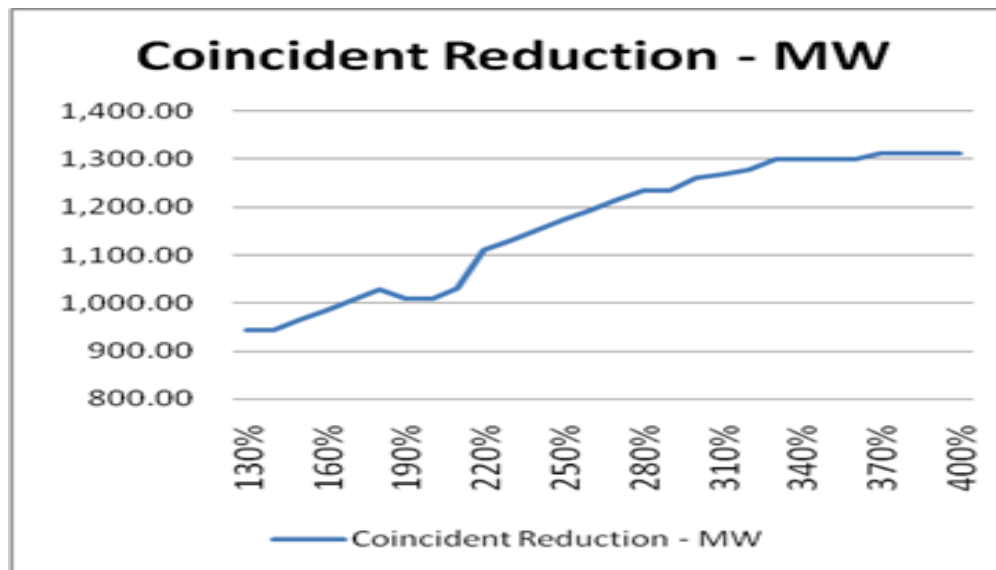
- The unique characteristics of different demand response programs allow direct comparison to unique fossil resources



- For example, we use this approach to measure the appropriate incentive payments for a new construction demand response program

- The appropriate incentive payment, calculated using **DRPricer**, equates to the difference between the DR equipped facility, and the alternative supply-side resource that would be called upon in the absence of the demand-side resource.
- The resulting \$/kW-yr avoided capacity value can then be used to calculate the traditional Standard Practice Manuel ratios in **DSMore**.

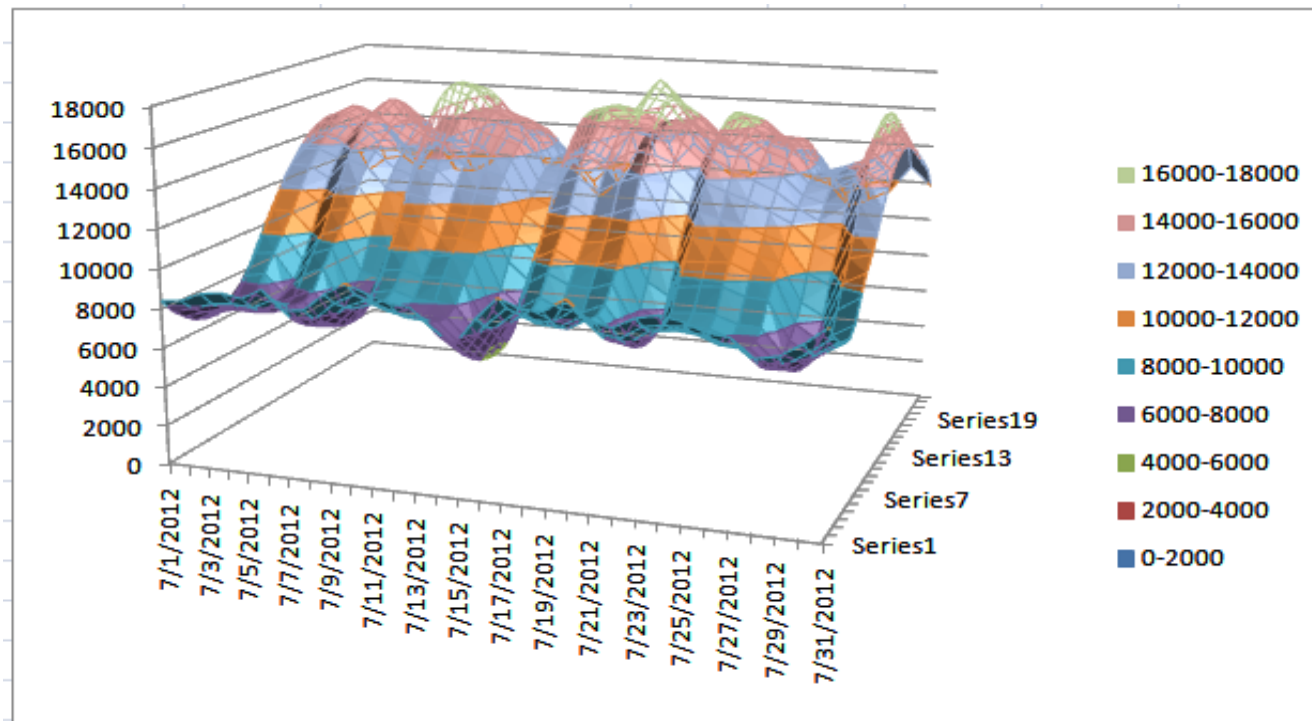
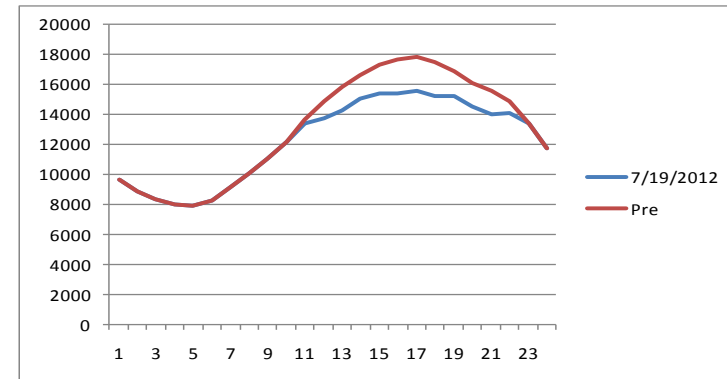
- Viewed from the perspective of coincident peak reduction, we found that effective limits do exist.



- As the portfolio we tested is scaled up, coincident peak reduction is limited to about 1300MW for the base case and 1420MW for the high load scenario.

- The 1420MW limit (for the high load case), and 1300MW limit (for the base load case), are highly dependent on the characteristics of the program.
- Regardless of the capacity, for the portfolio we tested only 45 interruptions were allowed, covering a max of 381 hours.
- As we reduce peak load, more and more days/hours start to compete for the limited DR resource as the new post-DR coincident peak shifts.

- **Peak Day Load Reduction**
- **July Portfolio Coverage**

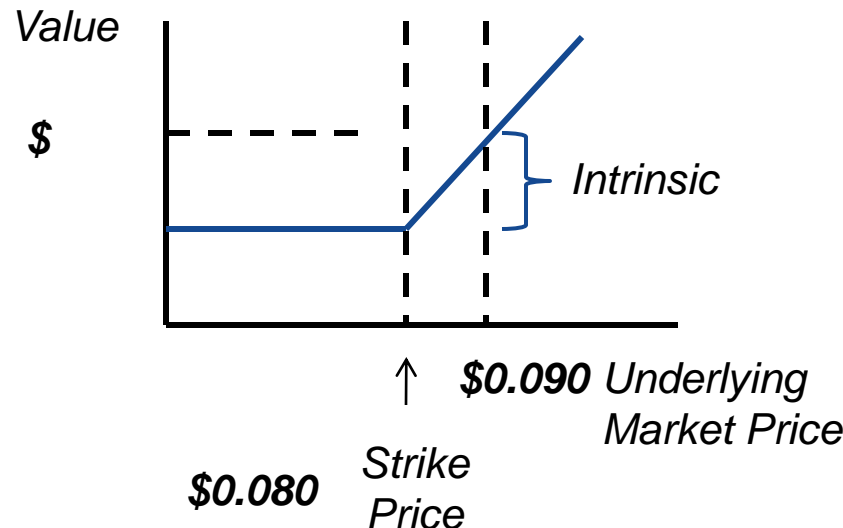


- Viewed from the perspective of cost-effectiveness or revenue requirements, an optimally sized portfolio is highly dependent on accurately pricing the avoided capacity and avoided energy benefits.

- Using Monte Carlo simulation, we test three different price processes.
- We test two price scenarios:
 - Scenario 1:
 - The curtailment lasts four continuous hours
 - Price volatility equals 68%, and
 - Underlying bilateral forward price equals \$0.080/kWh ATC (around the clock).
 - Scenario 2:
 - The curtailment lasts four continuous hours
 - Price volatility equals 98%, and
 - Underlying bilateral forward price equals \$0.120/kWh ATC.

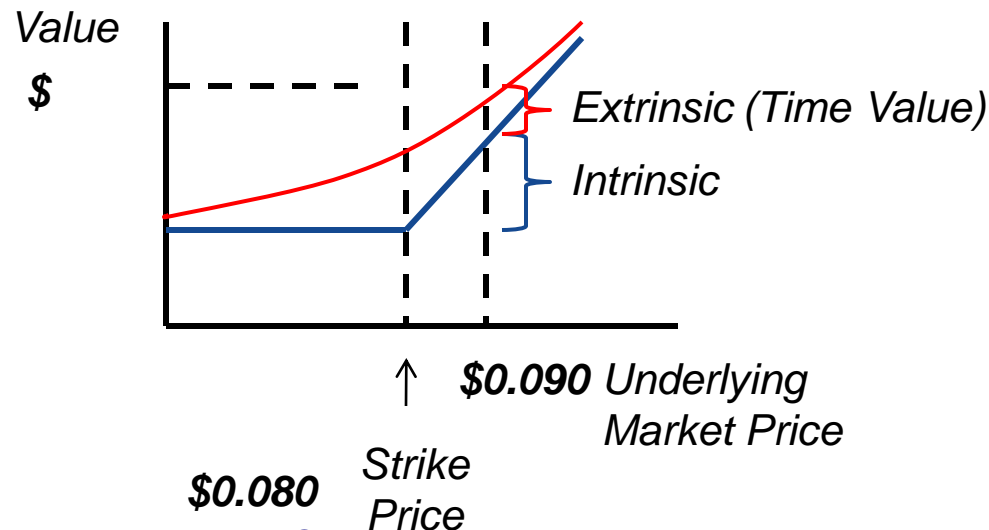
- A financial option contains both an intrinsic and an extrinsic component.
 - For example, if the underlying bilateral value of forward summer peak electricity is 9 cents per kWh, and the strike price is 8 cents per kWh, the option is “in-the-money” by one cent.
 - Its intrinsic value is one cent.

*Option Value Payoff
Diagram*



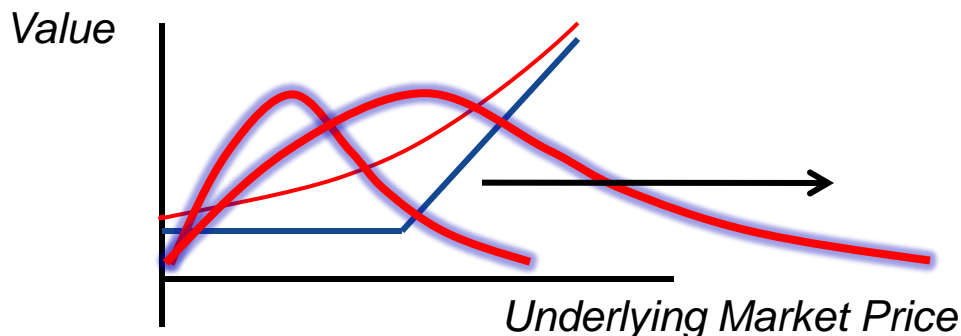
- A financial option contains both an intrinsic and an extrinsic component.
 - The extrinsic value depends on the market volatility, time to expiration, etc. The extrinsic value measures the probability of prices exceeding 9 cents on the expiration date of the option. In our example, the monthly premium payment is equal to the sum of the intrinsic value *and* the extrinsic value of the option.

*Option Value Payoff
Diagram*



- As expected, the results indicate that demand response is more valuable in markets with **higher underlying prices and higher price volatility**.

	<i>Mild Market Conditions</i>			<i>Extreme Market Conditions</i>		
	68% Vol and %0.080 Underlying			98% Vol and \$0.120 Underlying		
	Mean Reversion w/ Jumps	GBM	GBM w/ Jumps	Mean Reversion w/ Jumps	GBM	GBM w/ Jumps
Strike		\$ 0.058			\$ 0.058	
Intrinsic	\$ 0.022	\$ 0.022	\$ 0.022	\$ 0.062	\$ 0.062	\$ 0.062
Extrinsic	\$ 0.041	\$ 0.031	\$ 0.037	\$ 0.078	\$ 0.065	\$ 0.083
Total (Option) Value	\$ 0.063	\$ 0.053	\$ 0.059	\$ 0.140	\$ 0.127	\$ 0.145

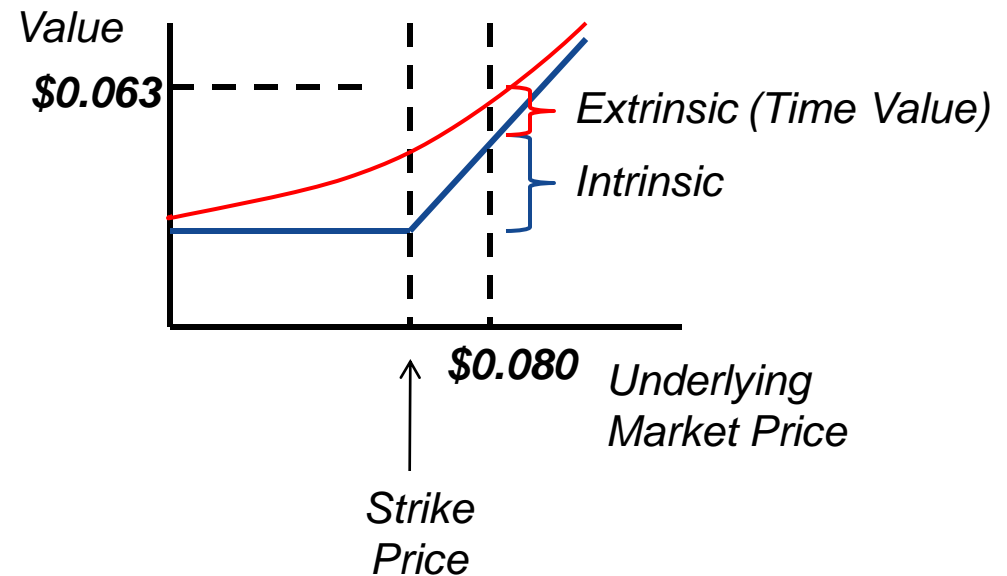


The Underlying Price Distribution driving value is wider

Example 1 - Strike Price is “In the Money”

Strike	\$0.058
Extrinsic	\$0.041
Intrinsic	\$0.022
Total (Option) Value	\$0.063

68% Volatility, \$0.080 Underlying



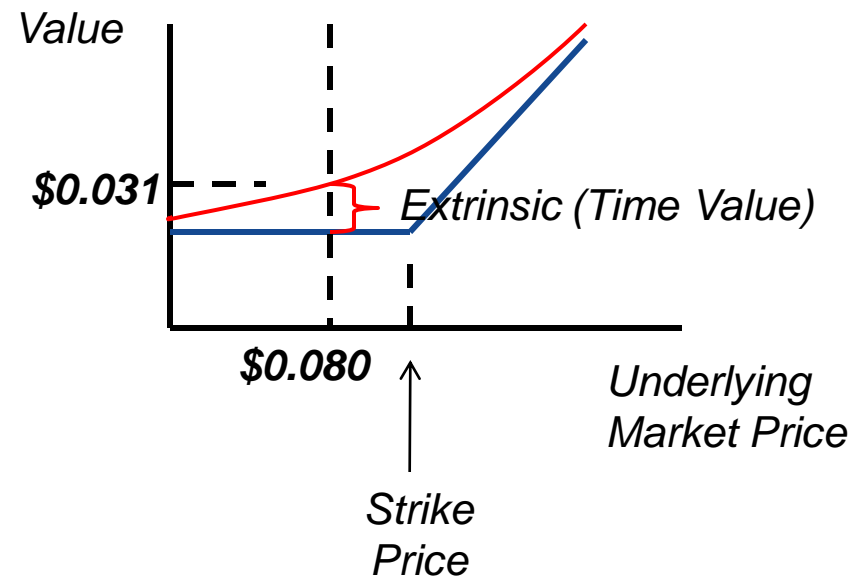
Option Value Payoff Diagram

- Additionally, we see that at some point, a participant can set their strike price so high as to eliminate any value.

Example 2 - Strike Price is “Out of the Money”

Strike	\$0.090
Extrinsic	\$0.031
Intrinsic	
Total (Option) Value	\$0.031

68% Volatility, \$0.080 Underlying



Option Value Payoff Diagram

- We can use the table shown above to determine a participant's monthly capacity premium and energy credit by multiplying the value shown by the number of times curtailed every month and the amount of demand curtailed when the option is called.
- If, for example, in the case of a high volatility, we use the results reported from the Mean Reversion Jump Diffusion model, we can value demand response participation from the table shown in the next slide.

Monthly Premium Credit

Curtailed Energy

		100 kW	200 kW	300 kW	400 kW	500 kW
Number of Times Called	1	\$ 52.16	\$ 104.32	\$ 156.48	\$ 208.64	\$ 260.80
	2	\$ 104.32	\$ 208.64	\$ 312.96	\$ 417.27	\$ 521.59
	3	\$ 156.48	\$ 312.96	\$ 469.43	\$ 625.91	\$ 782.39
	4	\$ 208.64	\$ 417.27	\$ 625.91	\$ 834.55	\$ 1,043.18
	5	\$ 260.80	\$ 521.59	\$ 782.39	\$ 1,043.18	\$ 1,303.98

Fixed Energy Credit if Called

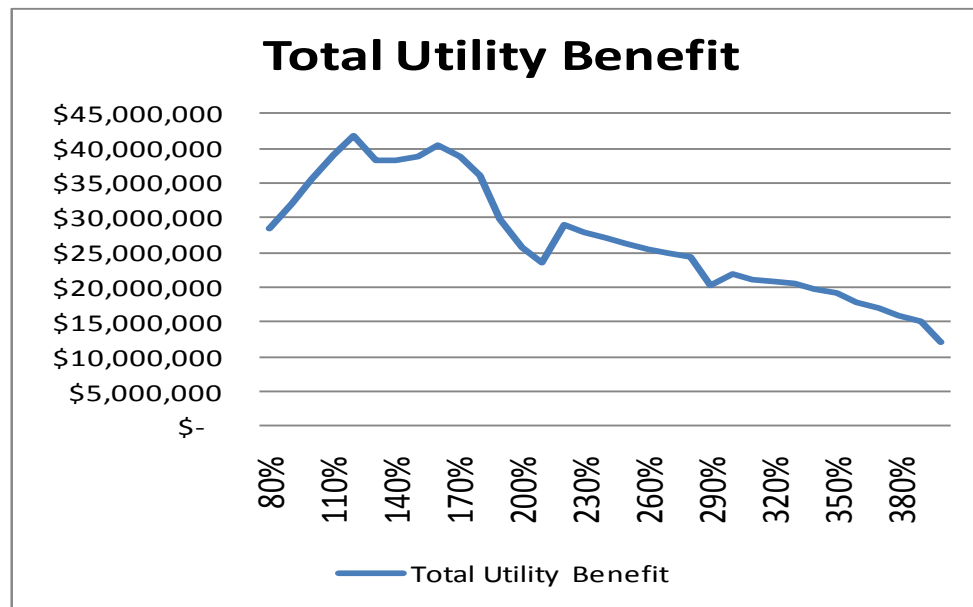
Curtailed Energy

		100 kW	200 kW	300 kW	400 kW	500 kW
Number of Times Called	1	\$ 27.20	\$ 54.40	\$ 81.60	\$ 108.80	\$ 136.00
	2	\$ 54.40	\$ 108.80	\$ 163.20	\$ 217.60	\$ 272.00
	3	\$ 81.60	\$ 163.20	\$ 244.80	\$ 326.40	\$ 408.00
	4	\$ 108.80	\$ 217.60	\$ 326.40	\$ 435.20	\$ 544.00
	5	\$ 136.00	\$ 272.00	\$ 408.00	\$ 544.00	\$ 680.00

98% Volatility and \$0.120 Underlying – Mean Reversion, Jump Diffusion Option Value

- For example, if in advance of the price event the demand response participant chooses a strike price of 6.8 cents, a 500 kW curtailment for four hours, and permits five curtailments per month, in our higher volatility market (representing critical supply deficit and high market prices) the participant would receive a guaranteed \$1,303.98 Capacity Credit and up to an additional \$680.00 Energy Credit if called five times.

- Using these prices we find that although marginally decreasing, the DR programs remain cost effective beyond the affective coincident peak day limits.



- As direct load control and demand response programs are increasingly added to long-term resource adequacy plans, the need to accurately measure the value and appropriate quantity of these benefits will intensify.
- In this paper we advance the idea that these programs are better valued as supply-side equivalents using the methods and tools of the supply-side commodity markets together with the traditional demand-side Standard Practice Manual tests.

- What is the optimal amounts of DR?
- How can utilities better integrate DR programs into long-term resource plans?
- How should \$/kW capacity and \$/kWh energy benefits of DR resources be measured?
- Can DR be as reliable as traditional supply-side resources? How are utilities quantifying the “forced outage” or “de-rating” equivalents for DR?
- What are the best resources to include in a forward-looking portfolio?

- What should be the timing and size of DR deployment, including expansion and/or maintenance?
- Do different DR products (e.g., TOU and AC cycling) within a portfolio have positive and/or negative synergies?
- What benefits (if any) result from DR due to increased diversity in resources, location at loads, and reduced demands?
- Are there impacts on the electricity market – e.g., lower market prices, and reduced market power.