Methodologies for Estimating the Capacity Value of Demand Response Resources

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Introduction

- Demand response - change in electrical energy use from normal consumption patterns in response to various signals from the power system.
- **Capacity value represents contribution** any resource can make to system adequacy.
- Appreciation of the capacity value → **better understanding of the potential economic value** of DR

Data

- Indicative values for **conventional plant capacity** and **availability rates**.
- Annual hourly load profiles
- Load profiles were evaluated and filtered
- Four systems were examined

Methodology

- **Capacity outage probability table (COPT)** created iteratively
- COPT compared with load time series → loss of load probability (**LOLP**)

$$LOLP_t = prob\ (Gen_t < Dem_t)$$

- Summing the LOLPs → **reference loss of load expectation (LOLE)**

$$LOLE_{ref} = \sum_t (LOLP_t)$$

- DR availability times series modeled as **negative load**
- LOLPs and LOLE are recalculated
- **Non-dispatchable load** added incrementally until $LOLE_{new} = LOLE_{ref}$

$$\sum_t prob(Gen < Dem) = \sum_t prob(Gen < Dem - DR + \Delta L)$$

- Additional load → **capacity value** of DR

Cases for Examination:

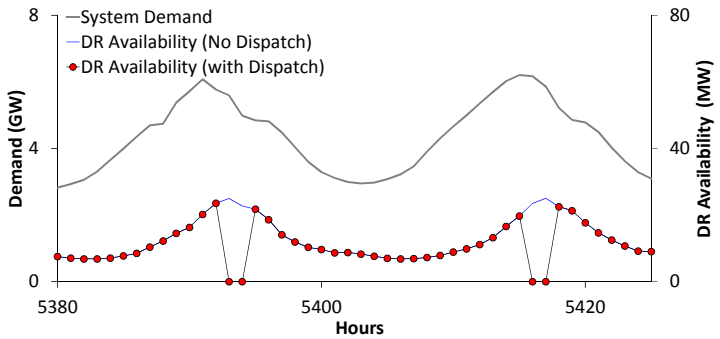
a) **Unconstrained DR Profile** – 'technical' CV of DR resource

b) **Top 20 Load Hours and 1 Hour Energy Constraint** - perfect foresight

c) **Top 20 Load Hours and 2 Hour Energy Constraint** – perfect foresight

d) **Top 40 Load Hours** and **e) Top 100 Load Hours** – Perfect foresight assumption is relaxed

Impact of 2 Hour Energy Constraint on DR Availability



Results

TABLE 1: ESTIMATED CAPACITY VALUES FOR COMMERICAL COOLING IN A SUMMER PEAKING SYSTEM

Case	% of Peak Capacity	% of Peak Demand
a)	90 %	0.6%
b)	71%	0.45%
c)	57%	0.35%
d)	44%	0.3%
e)	31%	0.2%

TABLE 2: COMPARISON OF RANGE OF CV FOR WINTER AND SUMMER PEAKING SYSTEMS AS A PERCENTAGE OF THE PEAK DR CAPACITY

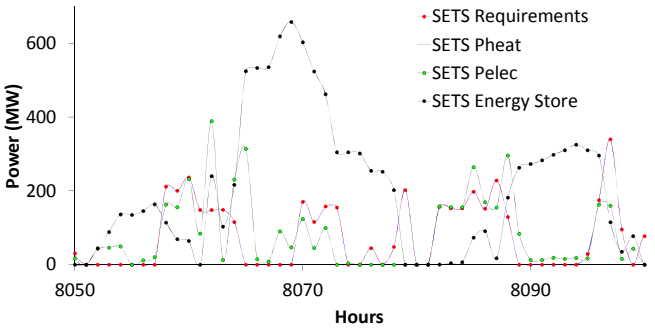
Demand Response Resource	Winter System 1 (AVA)	Winter System 2 (PSE)	Summer System 1 (LDWP)	Summer System 2 (NEVP)
Commercial Heating	5-41%	27-35%	4%	N/A
Data Centers	67-73%	52-60%	47-80%	78%
Municipal Pumping	14-18%	20-29%	29-39%	41-47%
Residential Water Heating	24-43%	27-38%	13-22%	25-27%
Waste Water Pumping	36%	52%	46-69%	78%

- Most valuable DR resources differ from system to system
- DR resources can have small capacity values

Current Work

- Building on preliminary methodology
- Re-examining the definition of capacity value
- Developing and comparing a number of **methodologies**
- **Case study**: smart thermal storage devices
- **Unique characteristics** of DR resources

Aggregate Smart Thermal Device Operation



- Varying levels of DR penetration
- Examining the **interactions with demand response resources and wind generation** and impact on capacity value

References

Sheila Nolan, Mark O' Malley, Marissa Hummon, Sila Kiliccote, and Ookie Ma. *A Methodology for Estimating the Capacity Value of Demand Response*, In the Proceedings of the IEEE Power and Energy Society General Meeting 2014.

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