Demand Response Actualization in the Energy Market

Jinjin Lu, Dr. Judith Cardell
Picker Engineering Program, Smith College

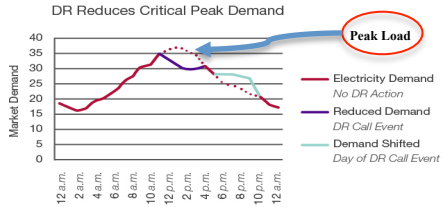
Demand Response

Motivation

- Wholesale Electricity Price changes over time.

Definition – Change consumption patterns (reduce demand)

- when the wholesale price is high
- when the reliability of the system is in jeopardy



Demand Response Programs Proposal

❑ Peak Load Threshold

- One-hour Peak Load Events
- Multiple-hour Peak Load Events

Table 1. Summary of Top 100 peak load hours (05/01-10/31)

	2010	2011	2012
Lower limit (MW)	10192	9926	9834
Number of total events	17	15	17
Number of above 4 hour peak load events	11	10	11
Percentage of event days with peak intervals >4hr (%)	65	67	65

Figure 2. The Pie Chart of peak hour distribution on multiple-hour peak load days (05/01-10/30) 2010-2012

❑ Rates

▪ Flat Rate

	Off-peak (12 Mid – 8 AM)	On-peak (8 AM – 12 Mid)
Summer	1.34	19.01
Non-summer	1.34	7.04

▪ TOU (time of use) Rate

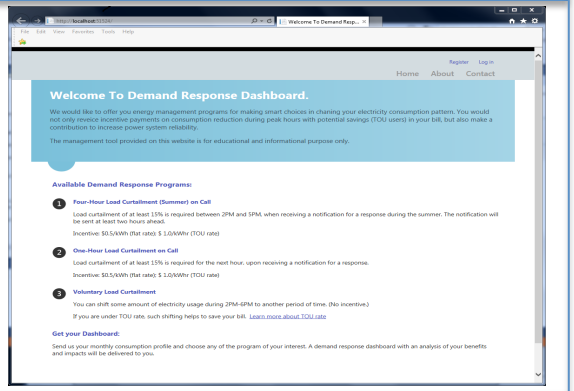
	Non-summer		Summer		
				On-peak	
	Off-peak (mid-8am)	On-peak (8am - mid)	Off-peak (mid-8am)	(8am-2pm) (6pm-mid)	(2pm-6pm)
Residential	6.7	24.7	6.7	36.7	55.7
Small Commercial	6.5	23.5	6.5	35.5	54.5
Large Commercial	6.5	14.2	6.5	26.2	45.2

Purposes

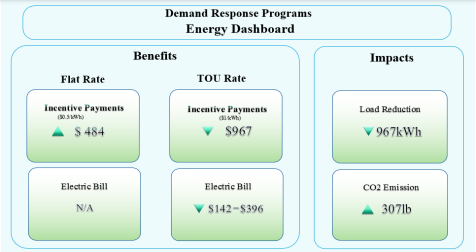
- Provide Educational and Informational Tool
- Propose Efficient Load Shifting Strategy

Demand Response Web App

Web Interface



Dashboard



Load Shifting Results

- The optimal shifting strategy is that customers can shift their reduced load to any hour after demand response, (DR) as long as keeping the total load under the threshold triggered for DR.
- This strategy minimizes the average daily electricity price, helps to avoid new peak load, and provides some flexibility for customers to shift load at their convenience

Acknowledgement
Deepest Gratitude to my thesis adviser, Professor Judith Cardell

Load Forecast

Artificial Neural Network (ANN) Model

❑ Architecture Design

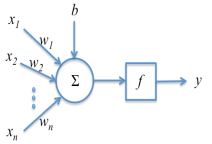


Figure 5. The Structure of an Artificial Neuron

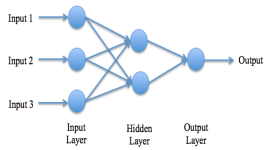


Figure 6. The Generic Three-layer Neural Network

❑ Performance Analysis

Table 2. Monthly Average & Max Mean Average Percentage Error (MAPE)

Month	Jan	Feb	Mar	Apr	May	Jun
Avg. MAPE	0.5574	0.4885	0.5289	0.4937	0.5685	0.6417
Max MAPE	3.6604	3.1296	3.0831	2.8178	4.9298	3.8933
Month	Jun	Jul	Aug	Sep	Oct	Nov
Avg. MAPE	0.6417	0.5400	0.5612	0.6236	0.5286	0.5612
Max MAPE	3.8933	3.0414	3.0785	3.7436	6.2019	3.3822

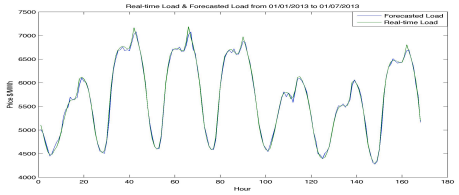


Figure 7. Real-time Load & Predicted Load (01/01/20130—01/07/2013)

Efficient Load Shifting Strategy

Multi-Agent Load Shifting Modeling