Ackoff Fellowship Application

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How did you learn about the Ackoff fellowship: email

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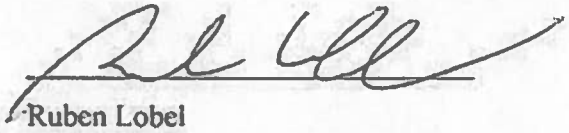
Faculty Department: OPIM

Project Title: Demand Response in Energy Markets: Voluntary and Involuntary Contracts

Amount of Request: $1286

Other sources of support for your research:

Travel: $800



Ruben Lobel

Description:

As technology advances and energy consumption grows, electricity generators struggle to meet peak demand. In the last decade both Texas and California were subjected to rolling blackouts and New York State experienced rolling brownouts, all as a result of excessive heat. In each case extreme energy consumption during record heat events caused energy demand to exceed generation capacity, forcing generators to ration power.

The energy grid's inability to meet demand is largely a result of the current electricity market structure. Since the deregulation of utilities in 1978, many generators have organized themselves into pools with centrally managed markets and transmission. In these pools, each generator submits bids indicating an amount of energy it is willing to produce at a specified price, which, in aggregate, construct the energy supply curve. Due to the inelasticity of energy demand, the price of the last unit of energy required to satisfy demand determines the market strike price. All energy bids below the strike price are accepted and paid the per-unit strike price for the energy they produce. Consequently peak load generation includes more expensive technologies in its mix than off-peak generation, causing the market price to increase. However, the vast majority of electricity consumers do not respond to market prices. Their energy is provided by an electricity retailer, who buys energy from the independent system operator (ISO) at a wholesale market price but charges fixed tariffs to consumers. End users cannot respond to

market price signals they never receive. This poses challenges during peak load events caused, for example, by a heat-wave; at these times the marginal cost of generating an extra unit of energy is high but end user consumption costs do not reflect this expense.

With the development of smart-grids, demand response (DR) is becoming an increasingly popular solution to the disconnect between demand and market price in electricity markets. Under DR contracts, consumers reduce their energy consumption in response to explicit requests from their DR provider. For example, many utilities offer summer programs that pay consumers in return for the ability to remotely adjust their thermostats. In this example, once consumers decide to participate in the DR contract (summer program) they do not have a choice in whether or how much to reduce their load. This *involuntary* contract has been thoroughly studied in the context of service differentiation through reliability. We extend this literature to *voluntary* DR contracts. Voluntary load reduction arrangements enable service providers to make any number of load reduction requests within a given time frame, but allow consumers to decide whether to comply with each request without penalty. Voluntary contracts are offered in markets today by energy service providers such as EnerNOC. Such contracts afford flexibility to consumers who are risk averse or whose load reduction costs vary over time. Load reduction costs may fluctuate when a consumer performs diverse operations, or when operations have varied sensitivity to delay. Additionally peak events are often unpredictable, hence the flexibility of voluntary contracts can be more appealing to consumers uncertain of their curtailment costs.

This project examines the performance of voluntary DR contracts relative to their involuntary counterparts. We begin with a model of individual consumer behavior under a voluntary DR contract. At each peak event a consumer chooses her load curtailment based on her random curtailment cost realization and her per-unit payment as specified under the contract. The value of the contract to the consumer is the discounted sum of payments and curtailment costs over an infinite horizon. Knowing the consumers' behavior, the provider chooses the contract structure and the number of consumers with which to contract in order to maximize his profits. There is a cost associated with increasing the customer pool which we model as a linear acquisition cost. This term represents the cost of load monitoring devices which are usually provided to consumers by the DR provider, as well associated advertising and operational costs. We derive the provider's optimal choice of incentive scheme and consumer pool size subject to a reliability constraint imposed by the ISO. When the provider offers an involuntary contract he knows perfectly the aggregate load reduction he will be able to offer the market, and so the reliability constraint becomes trivial. However, a provider offering a voluntary contract must trade off the cost of increasing his pool of contracted consumers with the improved reliability associated with such an increase. In spite of the reliability disadvantage of the voluntary contract we find that under certain parameter regimes the provider earns higher profit under the voluntary contract than under the involuntary contract. In particular, voluntary contracts earn higher profits when consumers have highly variable curtailment costs. We also find that the minimum variability threshold required for voluntary contract dominance decreases as the market's exogenous demand grows. We conclude that under these parameter regimes voluntary contracts improve total welfare. The difference in performance between the voluntary and involuntary contracts is driven by the acquisition cost. Absent such a cost, the voluntary contract provider would choose to contract with infinitely many consumers for negligible payment, effectively behaving as an involuntary DR provider with perfect knowledge of his aggregate load reduction.

This project aims to understand the market conditions under which DR contracts, both voluntary and involuntary, succeed. We observe that voluntary contracts are typically offered to

industrial and commercial entities whereas involuntary contracts target residential consumers. This market division is consistent with our findings as businesses face higher and more variable curtailment costs than residential consumers. We believe recognizing the best contract structure for a given market will allow providers to make better contracting decisions, and hence better alleviate the risk of black- and brown outs.

I am seeking funding to present this research at the MSOM conference at INSEAD (Fontainebleau) July 28-30, 2013. The conference will be an opportunity to receive feedback from and to connect with peers interested in energy markets and risk. Unfortunately my travel stipend will not fully cover the expenses associated with this trip. Hence I have requested the funds detailed below.

Budget

Airfare:	
Roundtrip PHL-CDG	$1676
Lodging:	$240
Shared double room $60/night x 4	
Food:	$120
Transit:	$50
SUBTOTAL:	$2086
Less OPIM Travel Stipend	-$800
TOTAL:	$1286