A Multi-agent Modeling and Investigation of Smart Homes With Power Generation, Storage, and Trading Features

Team: DJO

Jie (Jay) Cheng
Omid Ziaee
Daniel Brown

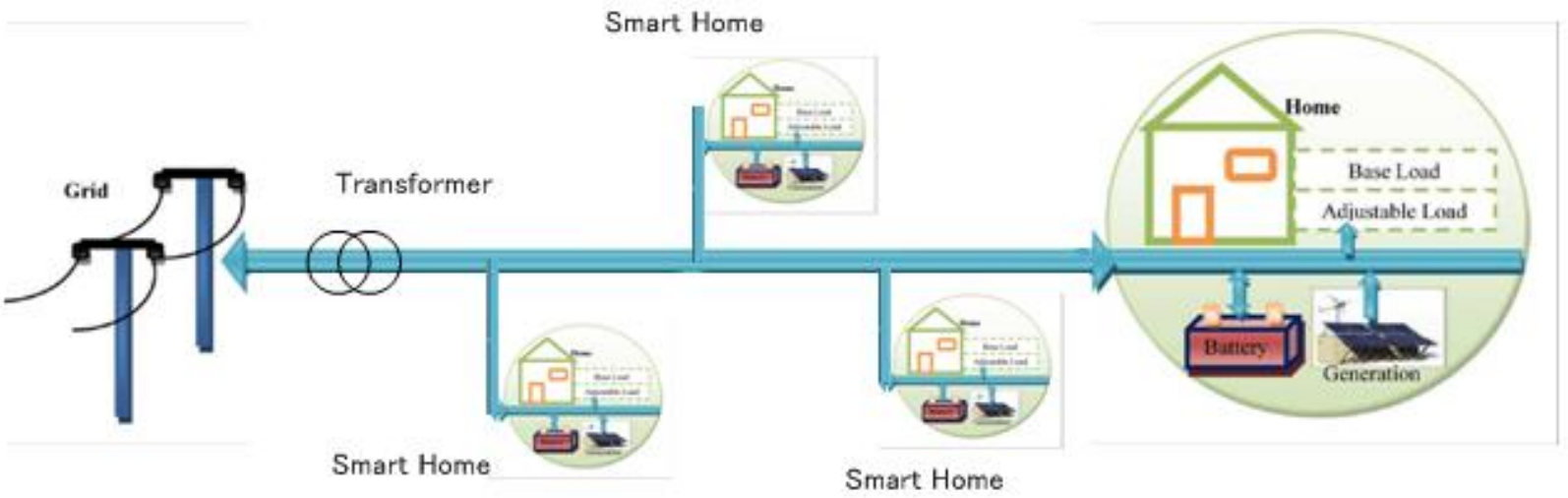
Source

- Salman Kahrobaee, Rasheed A. Rajabzadeh, Leen-Kiat Soh, and Sohrab Asgarpoor,"A Multiagent Modeling and Investigation of Smart Homes With Power Generation, Storage, and Trading Features",IEEE TRANSACTIONS ON SMART GRID, VOL. 4, NO. 2, JUNE 2013

Outline

- Background
- Multi-Agent System Factors
- Model Structure
- Case Study
- Conclusion
- Further Discussion
- Questions

Background



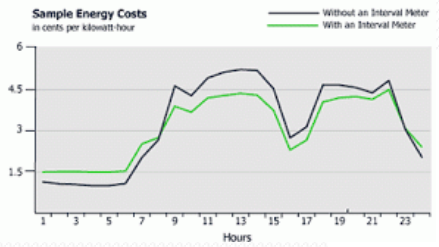
- Power System Overview

- Load Balancing
- Load Shedding
- Peak Shaving

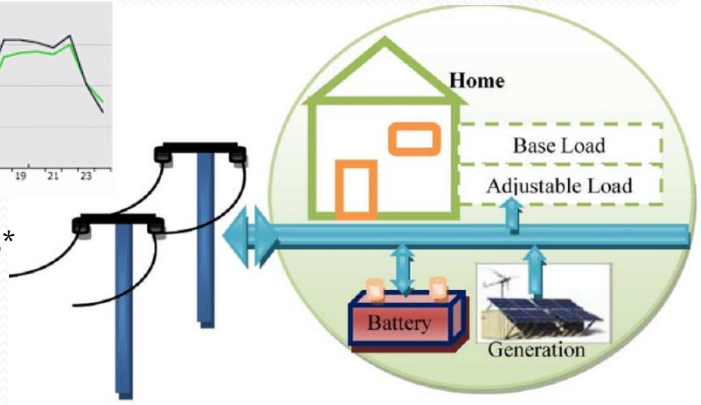
Multi-Agent System Factors

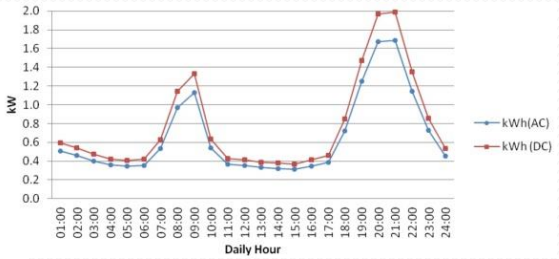
- Global Goal
  - Minimize power costs for homes
  - Alleviate overall peak load
- Local Decisions
  - Buy, sell, use and store electricity at any time segment
- Assumptions
  - Infinite supplying bus- no limit for buying from grid
  - Finite absorbing bus- limit for selling to grid

Model Structure

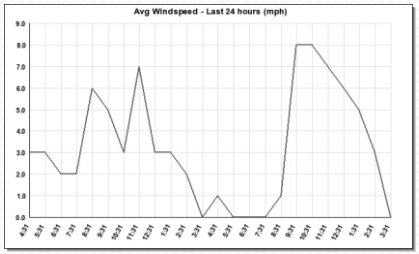


Electricity rates*





Daily Load Profile*



Wind Speed*

- Variables
  - Wind speed
  - Electricity rates
  - Home agent
  - Grid constraint

*Some of pictures are from following link for demonstration purposes only,

http://www.bryentonenergyservices.com/blog/page/5

http://www.intechopen.com/books/energy-storage-technologies-and-applications/estimation-of-energy-storage-and-its-feasibility-analysis

http://www.bathmaineweather.com/weather-graphs-24hour.php

Model Structure

- Load utility
  - Priority of load to be satisfied at a certain hour
- Selling utility
  - Incentive to sell excess electricity to the grid
- Store utility
  - Incentive to store electricity into battery

Model Structure

- Evaluation Metrics
  - Demand Deviation(DD)

    Mean fluctuation of overall demand

    Less means flat demand

  - Diversity Factor(DF)

    Diversity of home peak demand

    Less means coincident peak load

  - Home Cost of Electricity(DCoE)

    Electricity cost for a home

    Less means low cost

Case Study

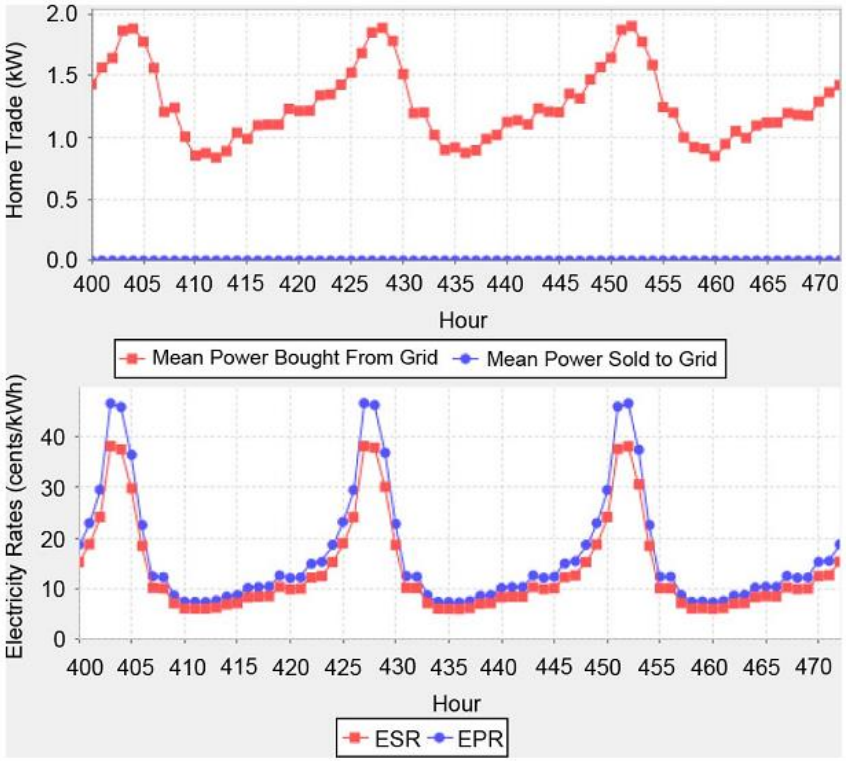
- Case 1: Homes Without Generation-Storage Capability

- All conventional homes,

I. Unable to respond to price signal

II. Demand stays unchanged

III. Suffer from high rate in peak hours



Case Study

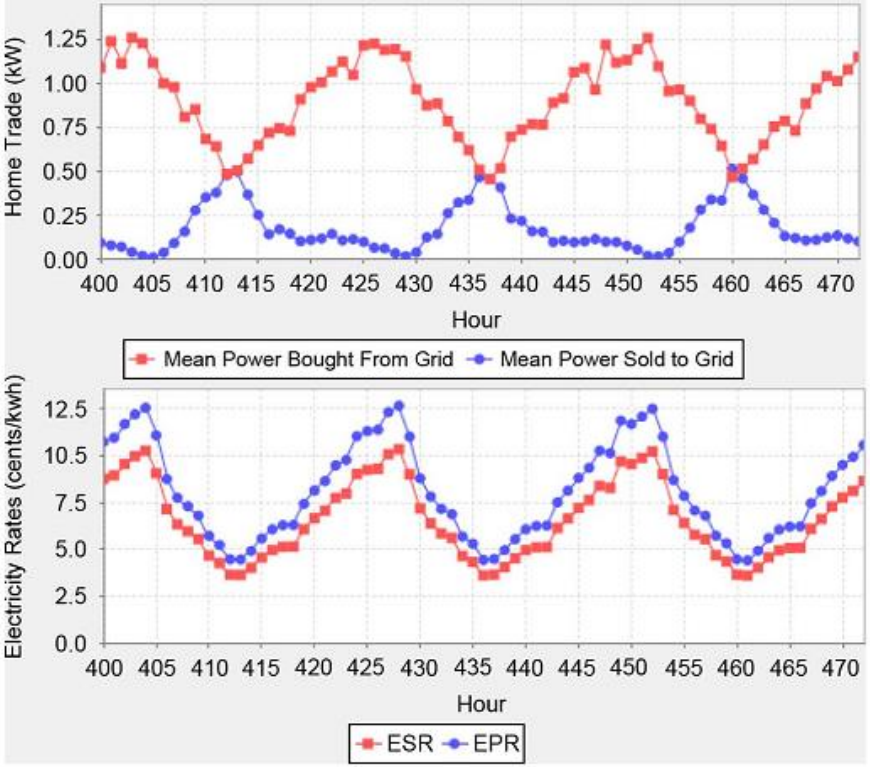
- Case 2: Homes With Wind Generation-Battery System

- Home agent has its own generation and storage,

I. Can make decision to buy, store and sell electricity

II. Load profile stays the same, but peak demand to grid decrease by 30%

III. Avoids high rates in peak hours



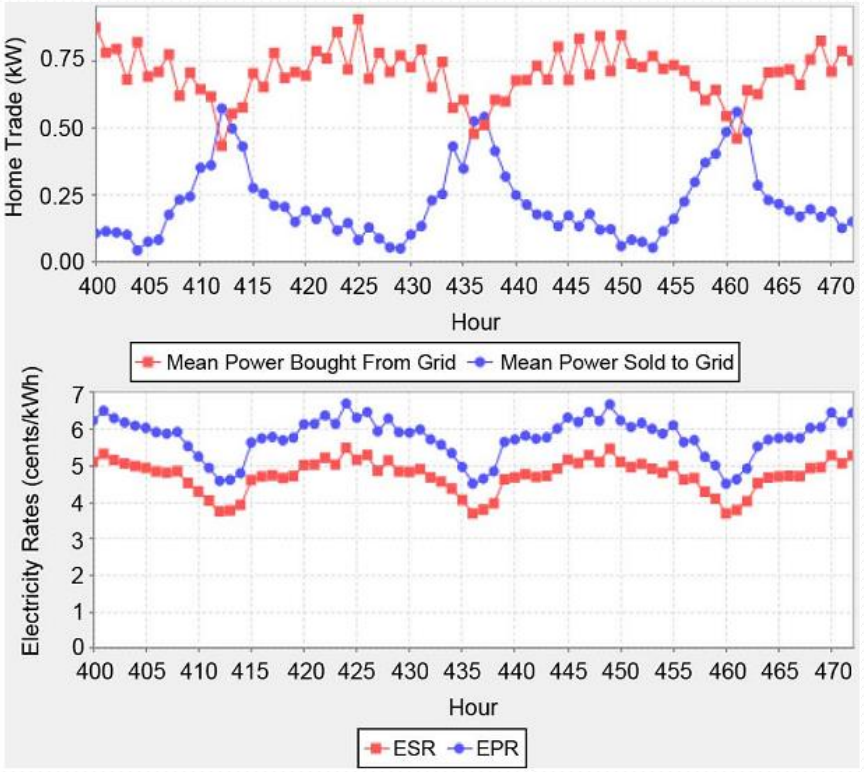
Case Study

- Case 3: Homes With Wind Generation-Battery System and Load Priority Consideration

- Home agent has its own generation and storage; and load shedding is allowed,

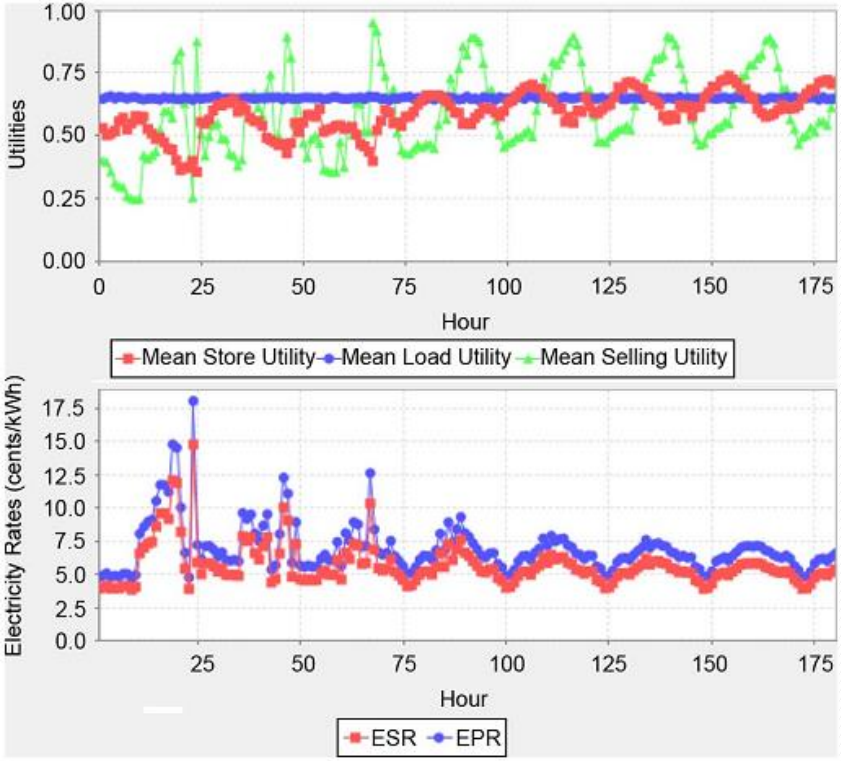
I. High price artificially decreases load utility by up to 50%

II. Load profile stays the same, but peak demand to grid decrease by 25%



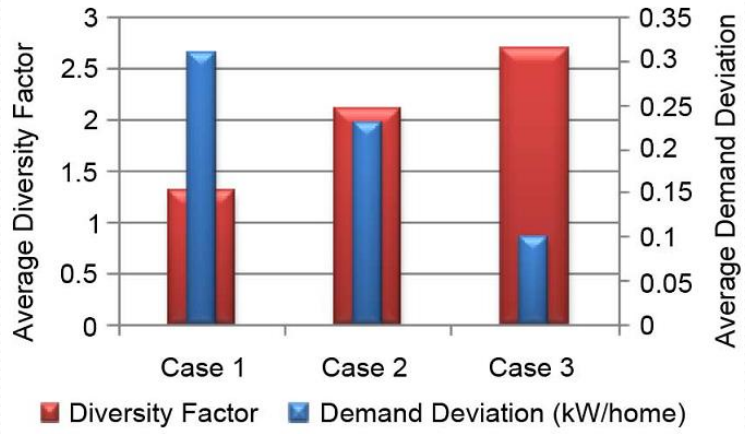
Case Study

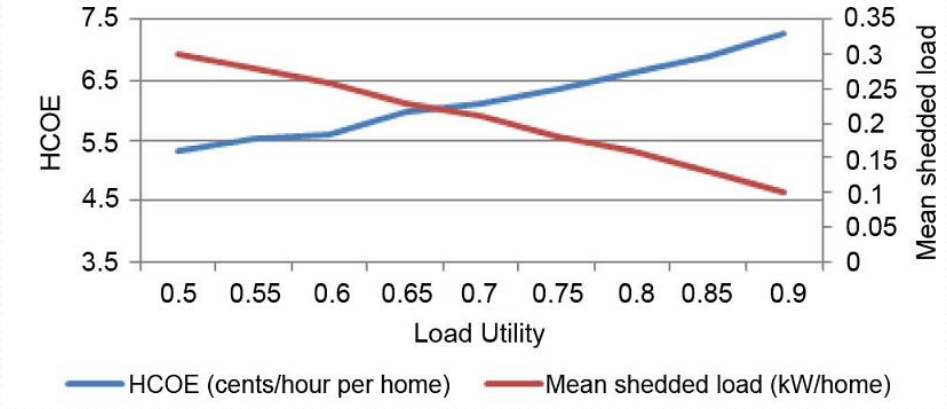
- Case 3, cont'd
  - After 100th hour, agent's decision converges to a equilibrium
  - Power rate also converges to a steady state



Case Study

- Case Comparison
  - Diversity Factor increases
  - Demand Deviation drops

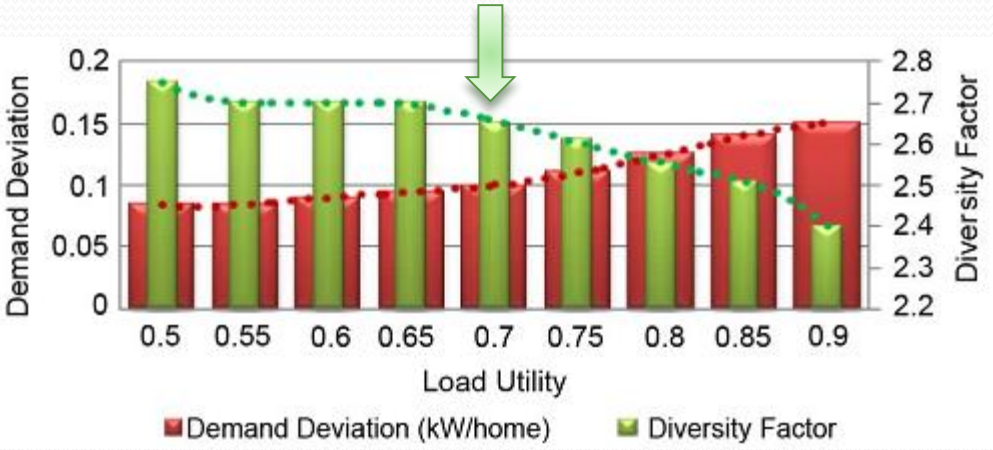


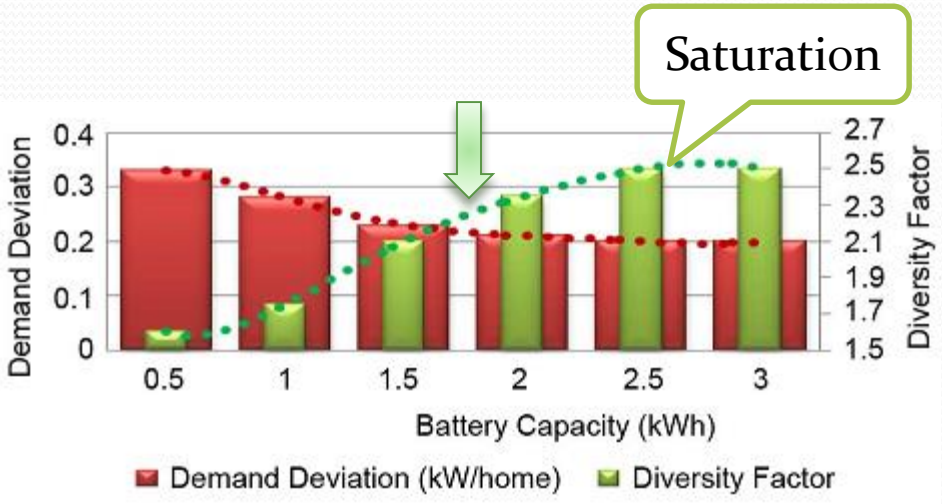


- Load Utility Sensitivity

Case Study

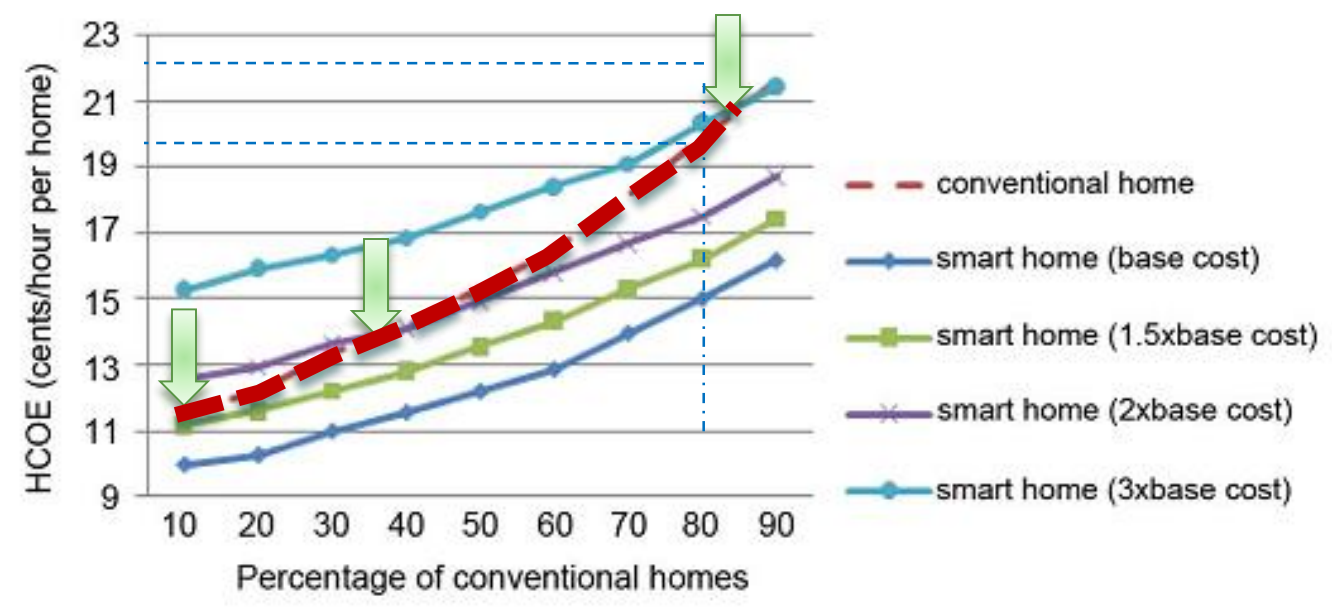
- Load Utility Tradeoff





- Battery Capacity Tradeoff

Case Study



- Cost Sensitive Analysis

Whether smart homes benefit from the installation of generation- battery system depends on the percentage of conventional homes.

Conclusion

- A smart home, as an intelligent agent, can make autonomous decision to alleviate grid peak load.
- Electricity rates can be the signal to align local decision with global goal.
- Generation- battery system can help to flatten the electricity rates.
- Slight reduction of load priority can improve DD and DF significantly.
- Moving from conventional home to smart home depends a lot on cost of generation and storage system.

Further Discussion

- Lack of variation of wind speed, which affects availability of incoming energy.
- Lack of information and analysis about daily house load.
- Missing the situation: buy and store when price is low and generation is low.
- Role of electricity retailers were missed.
- Impropriate assumption that loads are inelastic to price. Households can shift load rather than cutting load.

Questions?

Thank you !

Team: DJO

Dec. 2nd.2013