



Different Types of Loads to Participate in Demand Response and Their Dispatch with Generation Including Wind

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The 8th Annual Carnegie Mellon Conference On The Electricity Industry
Pre-Conference Workshop, Carnegie Mellon University, March 12, 2012

Contents

❖ Different types of loads for demand response

- Types of loads in the Islands
- Tariffs for different types of loads

❖ Economic dispatch of generation and demand

- Two ways of dispatch
 - ❖ Day-ahead scheduling
 - ❖ Real-time adjustment
- Numerical examples
 - ❖ Flores
 - : aggregate refrigerators
 - ❖ São Miguel
 - : air conditioning loads in a large shopping mall



Assessing The Ability Of Different Types Of Loads To Participate In Demand Response

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Types of loads in the Islands for demand response

❖ **Moderate climate** throughout the year
→ No large air conditioning or heating loads

❖ **Two ways** of demand response

- Shifting a small number of large loads
- Aggregating a large number of small loads

❖ **Flores**

- A small island with not so many large businesses
- 42% of residential consumption: refrigerators [1]

[1] MIT Portugal, Universidade dos Açores, "Characterization of the Azorean Residential Building Stock", Report, 2010.

❖ **São Miguel**

- The biggest island of the archipelago
- Large energy users
: shopping mall, cement company, dairy farms, pig farm with biofuel plants with animal waste, cookie factory with mills[¶]

[¶] Much of the survey on the loads in the two islands were conducted by CanayOzden, PhD student of History, Anthropology, Science, Technology and Society at MIT.

Types of loads in the Islands for demand response

❖ Which loads can be deployed how

- **Shopping mall**
: large air conditioning loads
→ Shifting loads by pre-cooling during off-peak
- **Cement factory, cookie factory**
: scheduling certain machines during off-peak
→ e.g. Can we run them on weekends or at night? What is the cost/benefit?
 - ❖ If Friday peak load shifted to Saturday, roughly about 185\$/MWh of savings per firm per hour on average, with a pretty large deviation by month
- **Regulatory complications and restrictions**
 - ❖ Cookie factories can not run their mills at night due to noise regulation



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Tariffs for different types of loads

Tariff	Description	Types of loads
Time-Of-Use <i>(current)</i>	Rates fixed within a season	Loads in general
Better Time-Of-Use	Better representation of seasonal or monthly changes of generation and demand resources	Loads in general
Day-Ahead Scheduling	Financial or physical commitment of consuming or curtailing loads a day ahead of actual consumption	Loads that can be scheduled a day ahead by quantity (physical commitment) or that can give the information of the price sensitivity (financial contract)
Day-Ahead Scheduling + Real-Time Adjustment	Real-time two-way communication with the appliance and the system operation	Loads that can respond promptly within a time step of the real-time operation



Economic Dispatch of Demand and Generation

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Two ways of dispatch

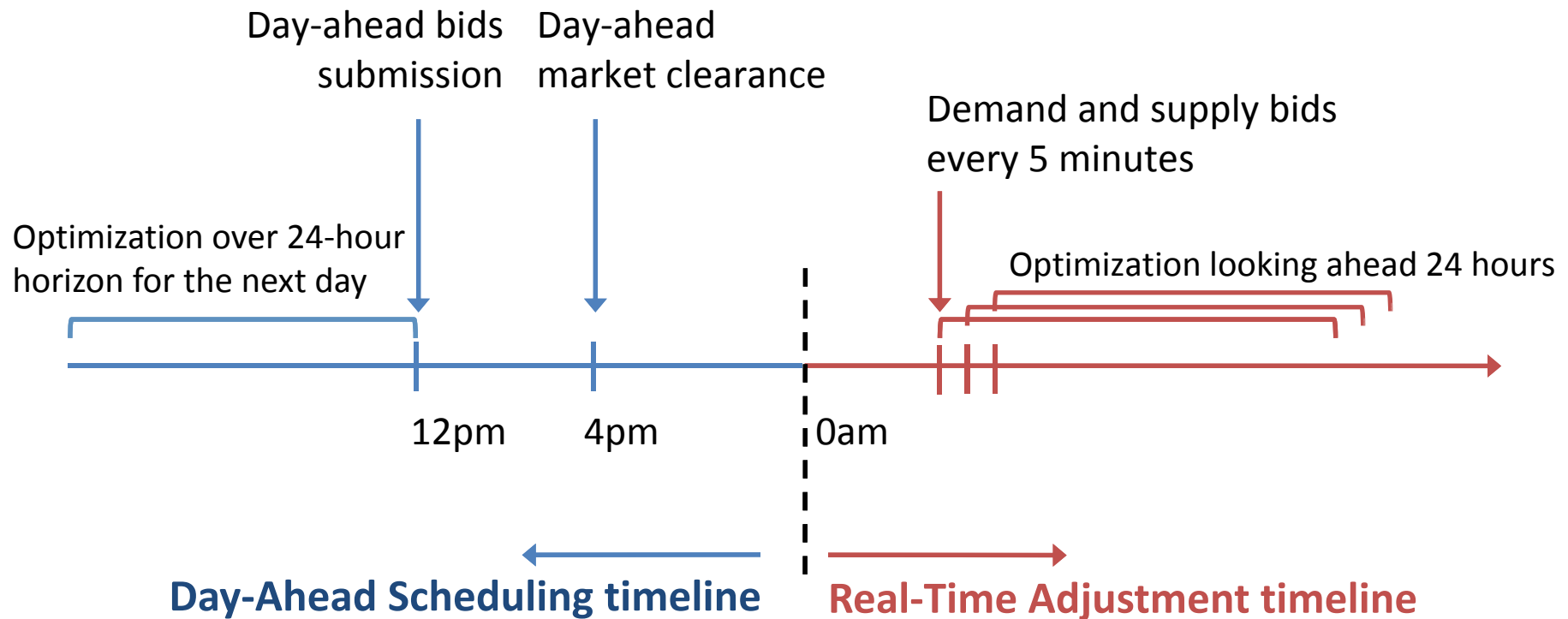
❖ Day-ahead scheduling

- Financial commitment of how much energy to produce/consume/curtail
- May not be physically implementable

❖ Real-time adjustment

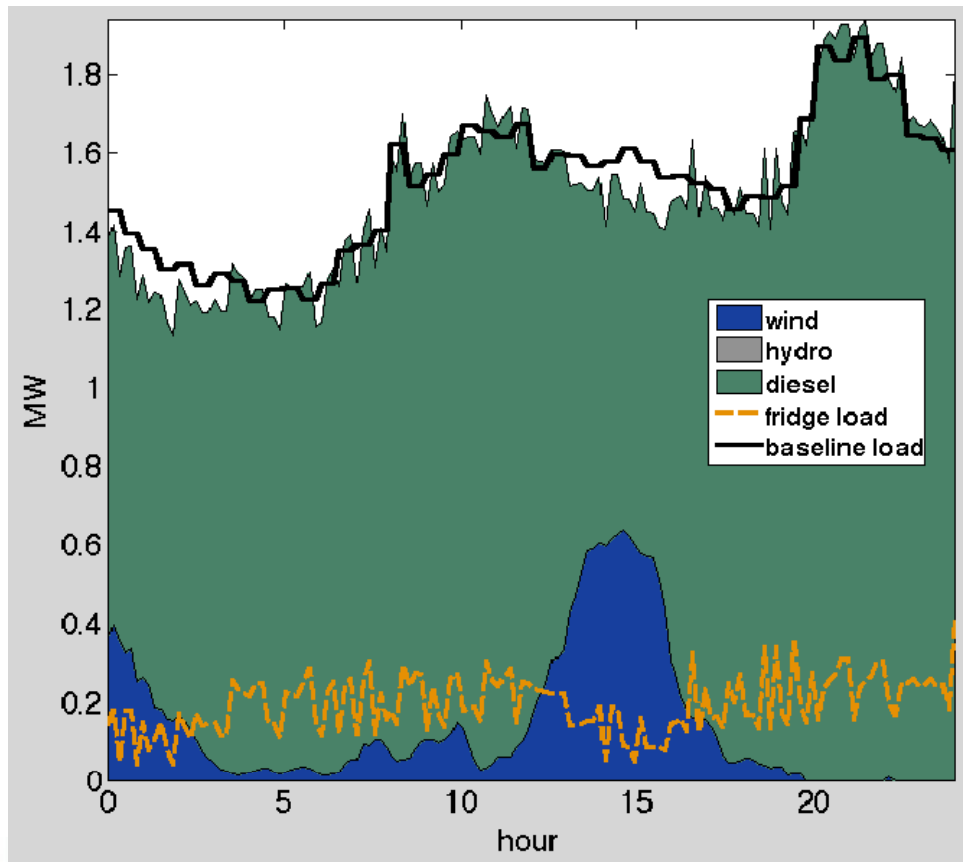
- Similar to model predictive control
: Look-ahead optimization with moving horizons and updated initial conditions
- Physically implementable with constant information exchange between the system and the generation/demand entities

Timeline of Day-Ahead Scheduling and Real-Time Adjustment

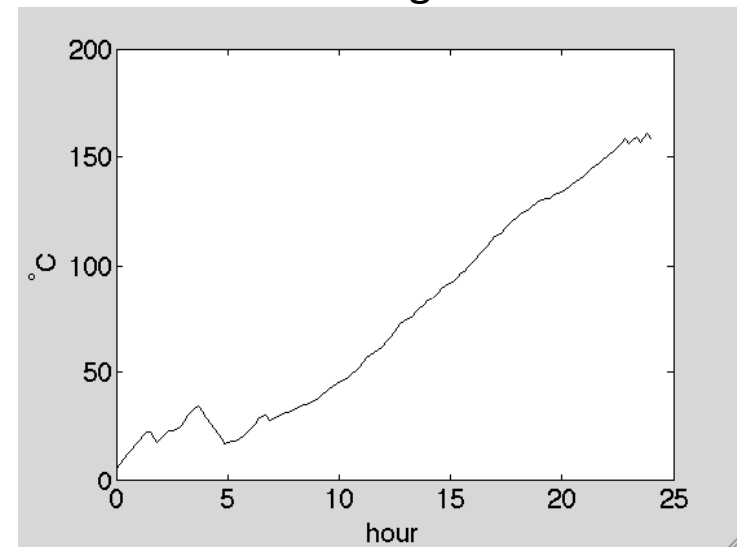


Numerical examples: Flores

- ❖ Aggregation of refrigerators : **Day-Ahead Scheduling** (October 15, 2008)

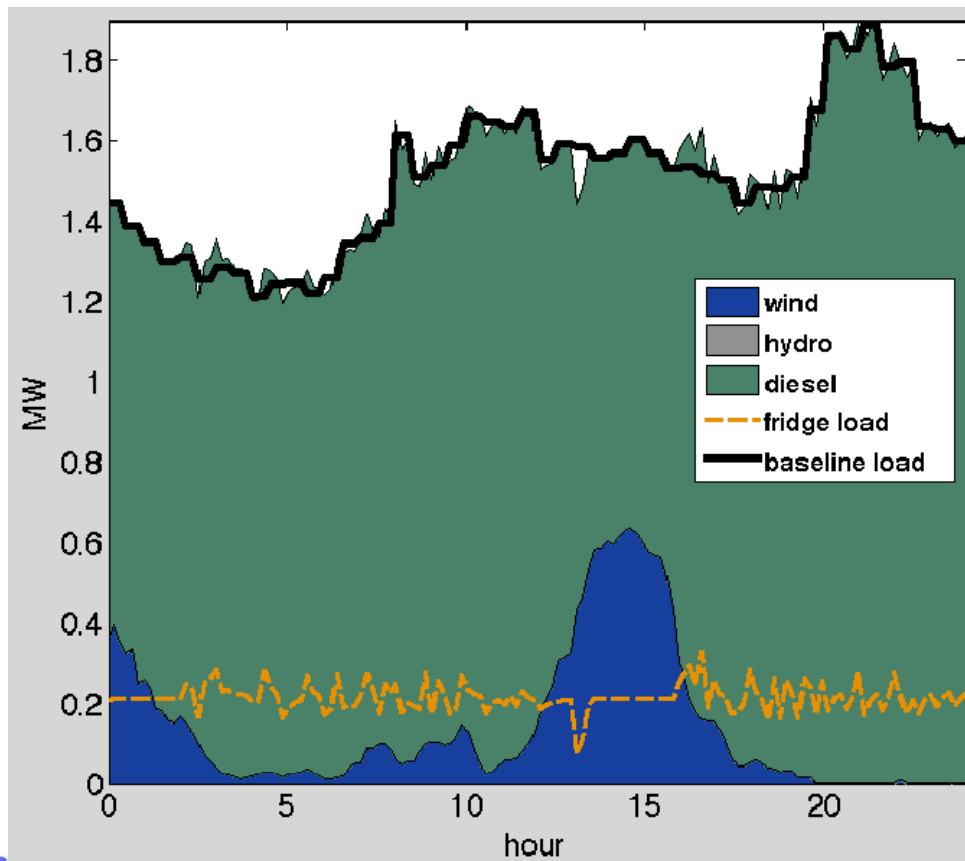


Internal temperature of the refrigerators

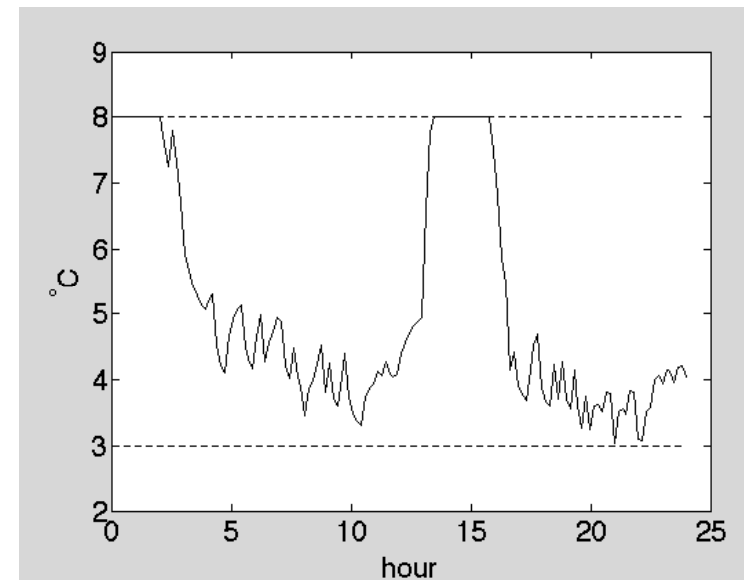


Numerical examples: Flores

- ❖ Aggregation of refrigerators : **Real-Time Adjustment** (October 15, 2008)

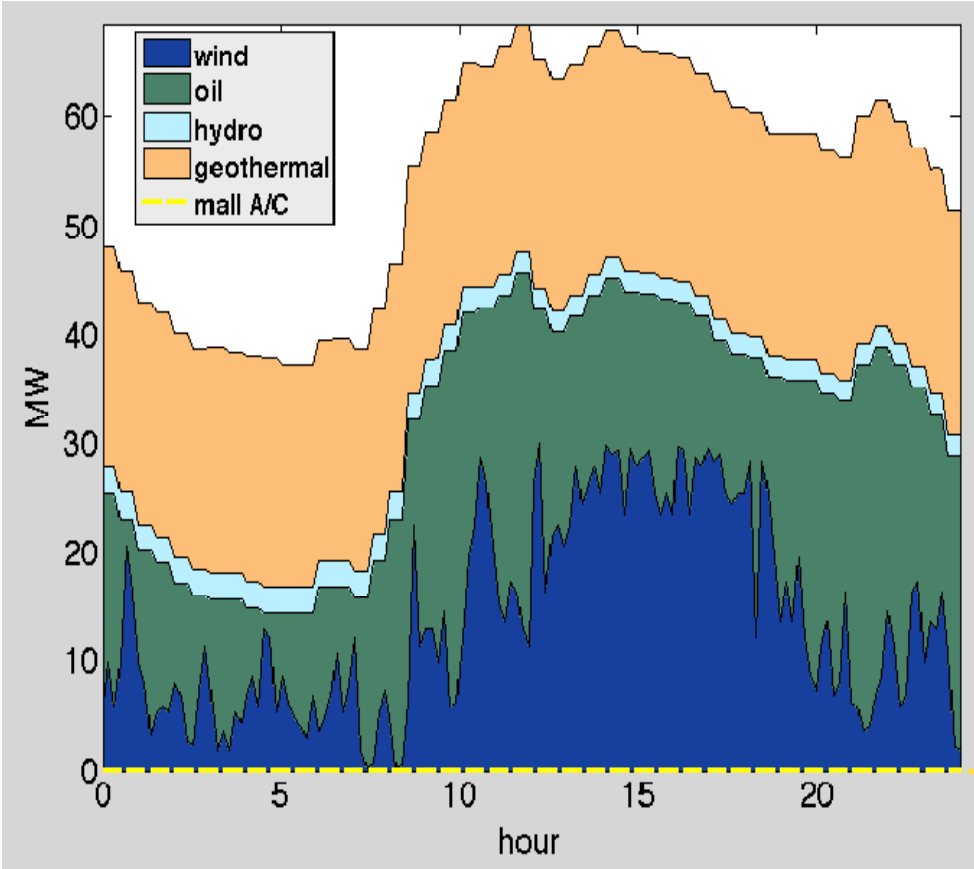


Internal temperature of the refrigerators

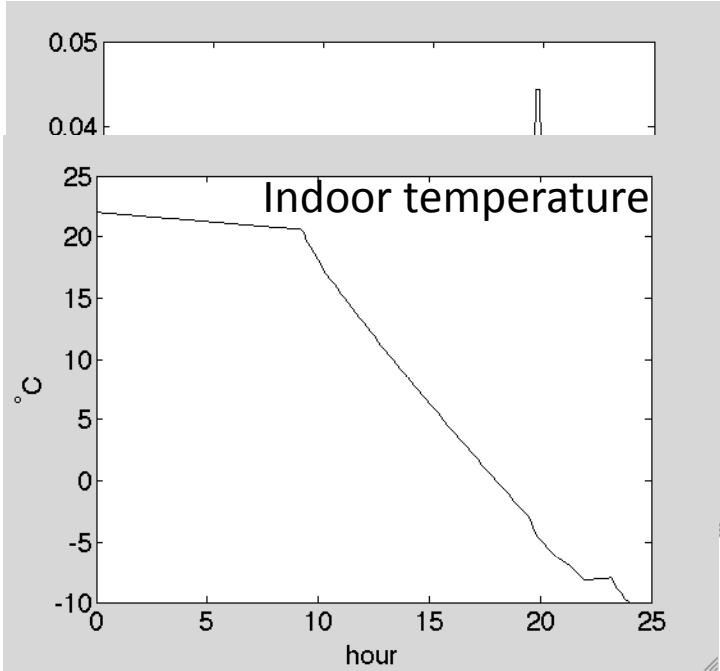


Numerical examples: São Miguel

❖ Air-conditioning load
: Day-Ahead Scheduling (July 16, 2008)

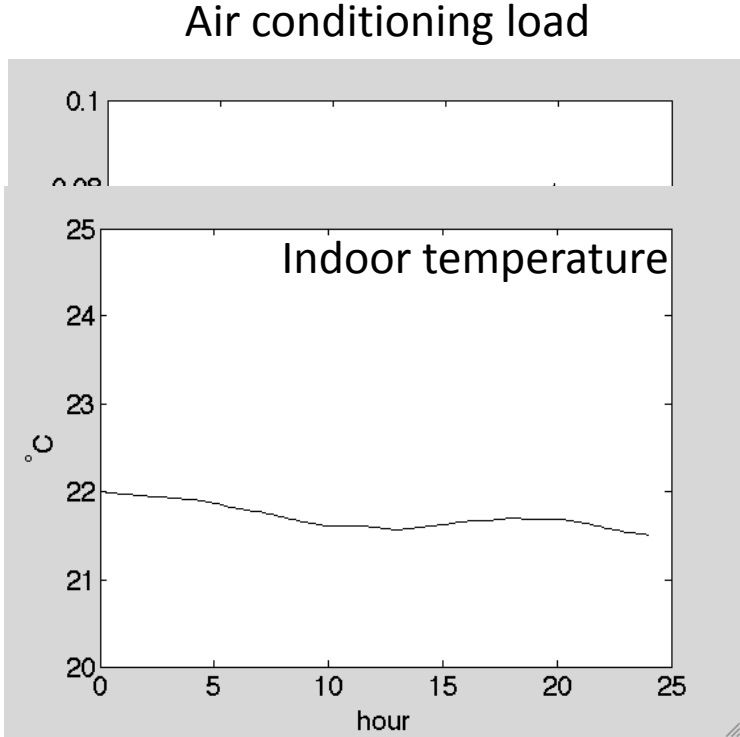
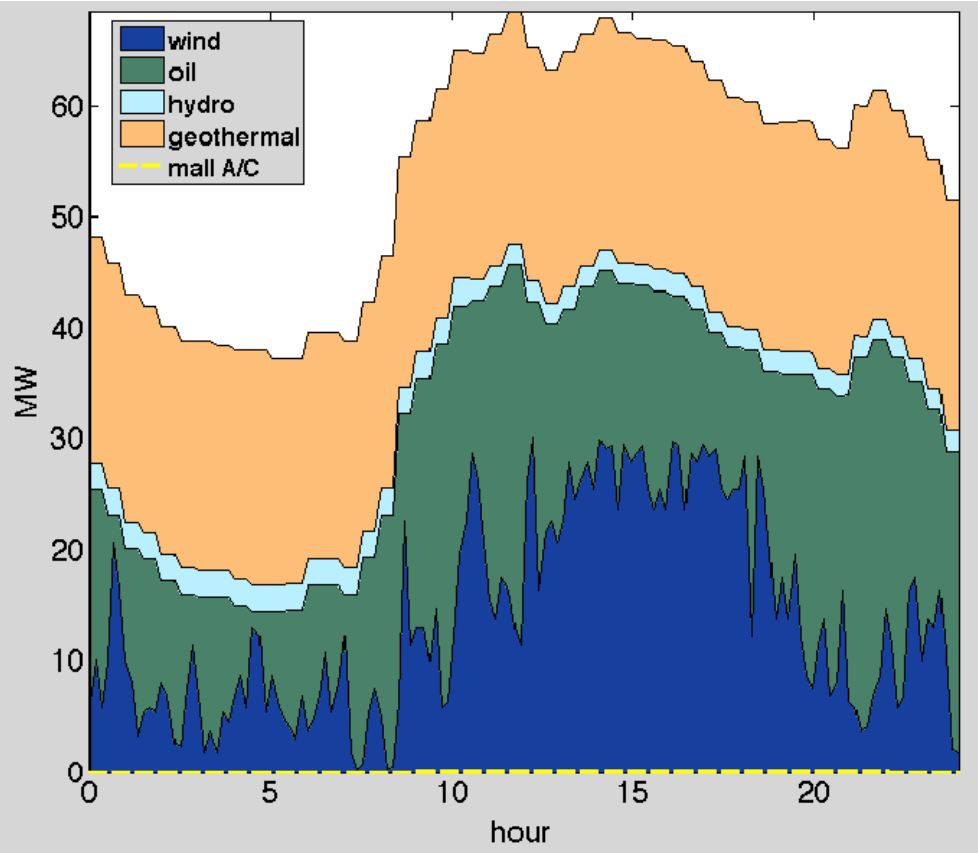


Air conditioning load



Numerical examples: São Miguel

❖ Air-conditioning load
: **Real-Time Adjustment**(July 16, 2008)



Concluding remarks

❖ Different technology for different types of loads

- Day-ahead scheduling and real-time adjustment requires different technology
- Physical characteristics of the loads, scheduling flexibility, cost/benefit, and other restrictions

❖ **Information exchange at the right time** between demand entities and system operator is crucial for a **physically implementable** demand response scheme.