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Adaptive Load Management:
Possible Implementation of Demand Response According to Well-Understood Value and Choice

Jhi-Young Joo and Marijallić

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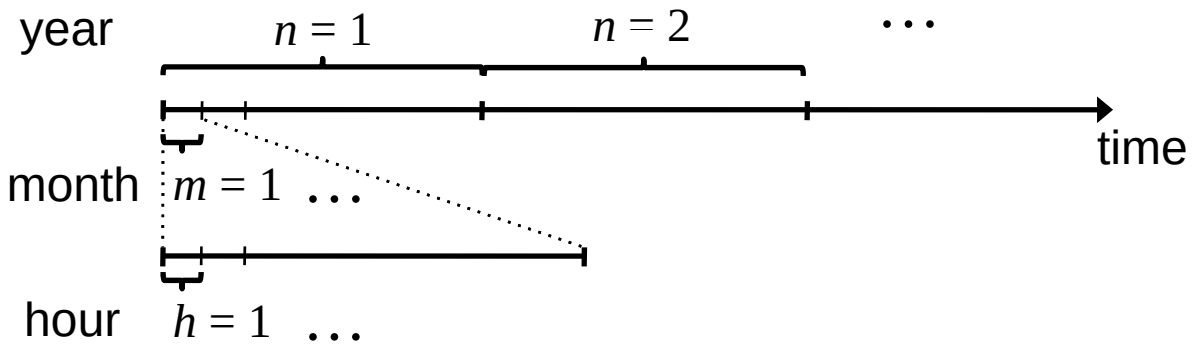
Background

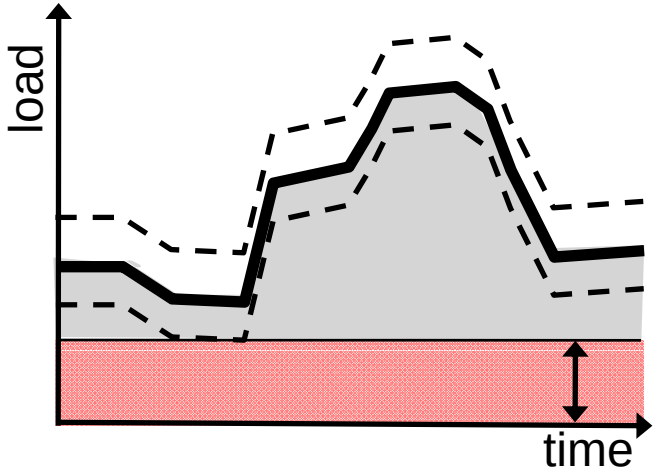
- **Problems** of price-responsive loads based on **baselines** [1]
  - Information asymmetry between end-users and operators
  - The value of the "baseline" changes over time
  - The availability and value of the supply also changesover time

- **Possible solution**
  - Schedule more "certain" supply and demand in a longer time scale
  - Schedule the difference when the information becomes more accurate and closer to the actual consumption
  - Customers define their own "baselines" and become responsible for them

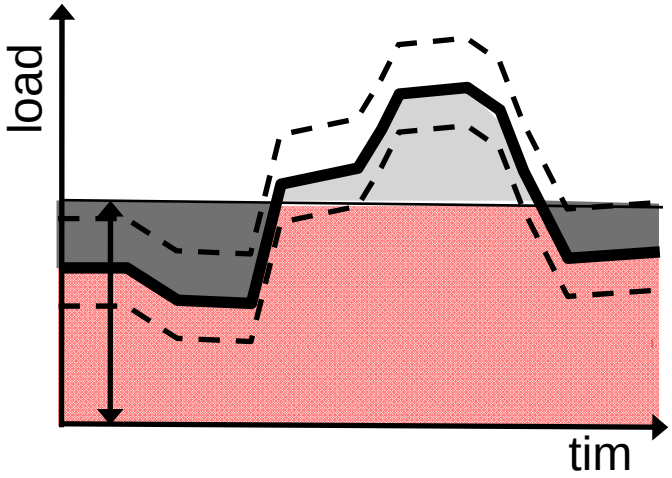
[1] Hung-po Chao, "Price-Responsive Demand for a Smart Grid World," The Electricity Journal, 2010, Vol.23, No.1

Overview of adaptive load management -- multi-temporal aspect





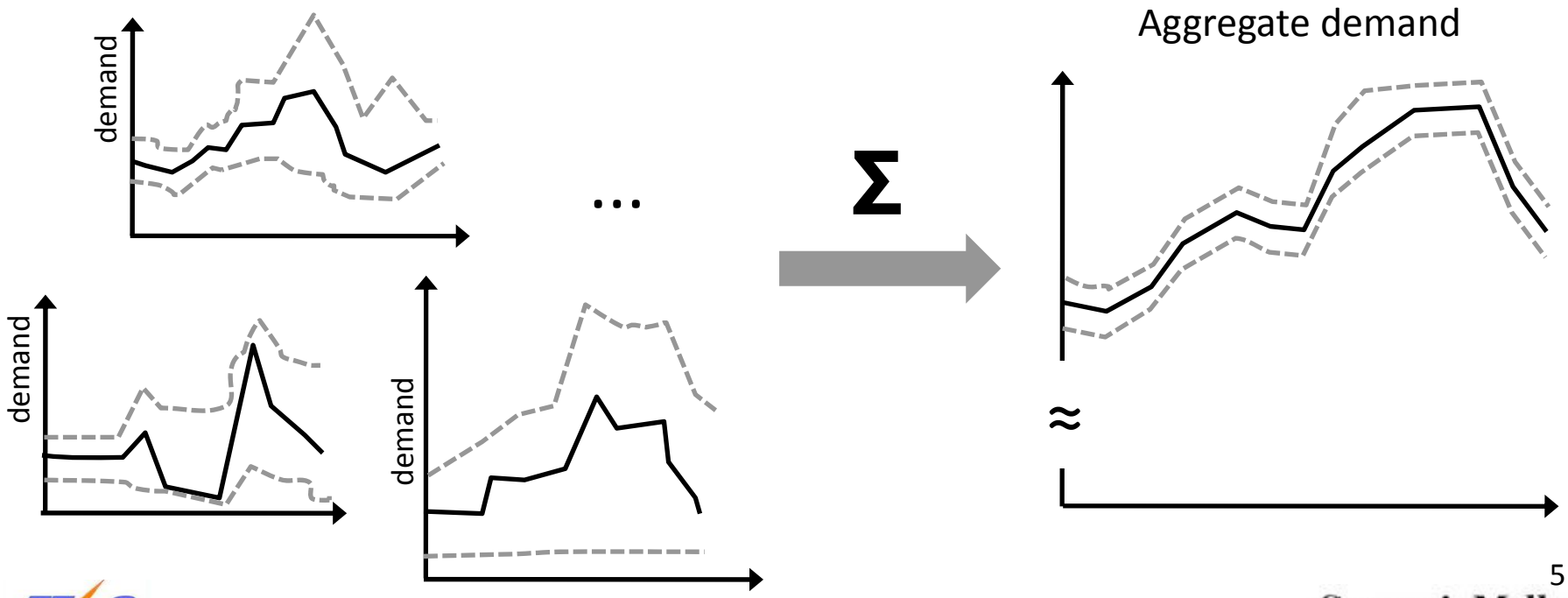
Risk prone LSE



Risk averse LSE

Overview of adaptive load management -- multi-layered aspect

- Why aggregation? Because small users
  - Are usually risk averse
  - Cannot participate in the market directly
  - Have higher uncertainty in demand quantity
    : aggregated demand curve more predictable



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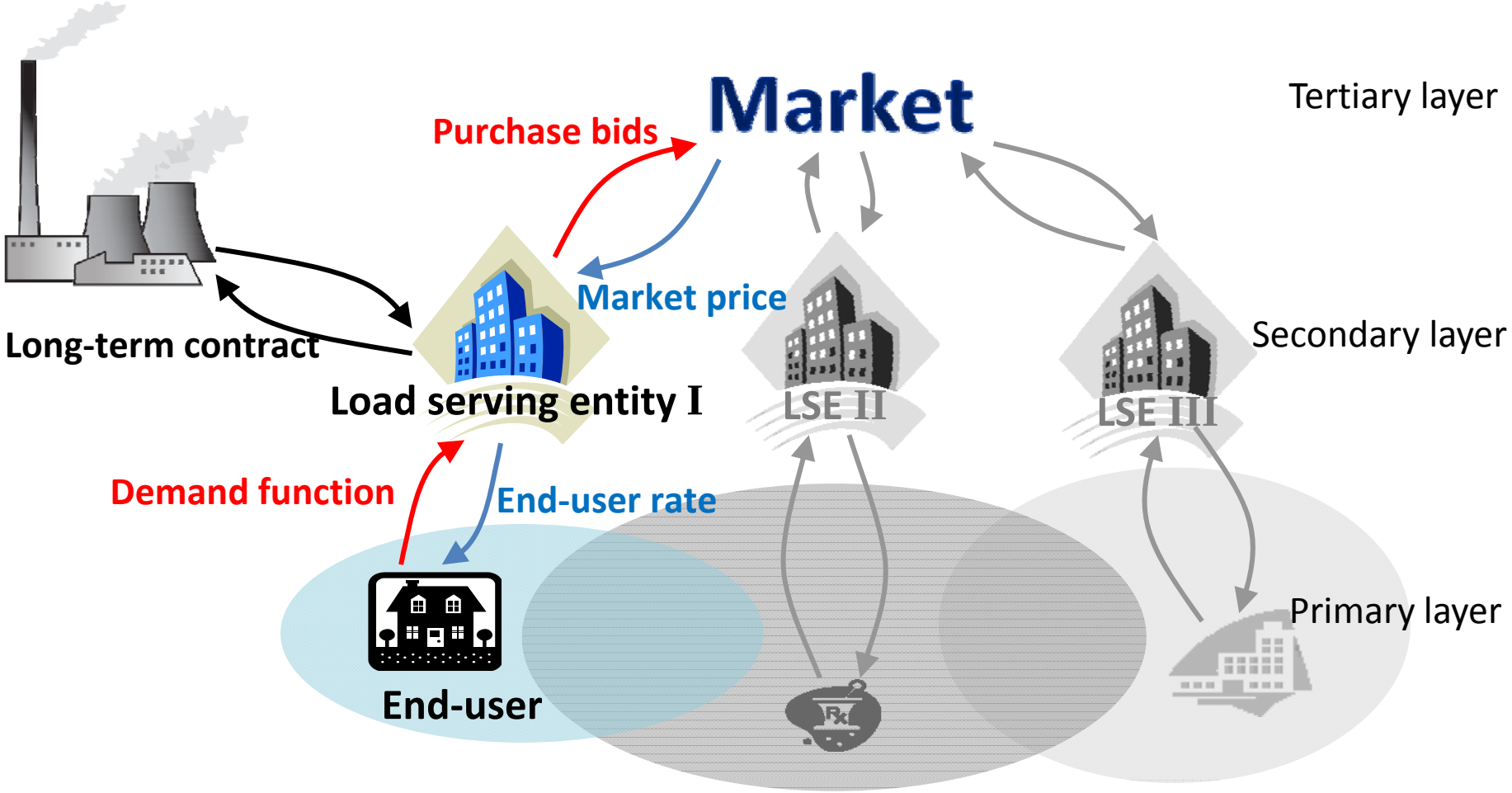
Overview of adaptive load management -- multi-layered and multi-temporal aspects



Power plant drawing by Catherine Collier, Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/imagelibrary/)

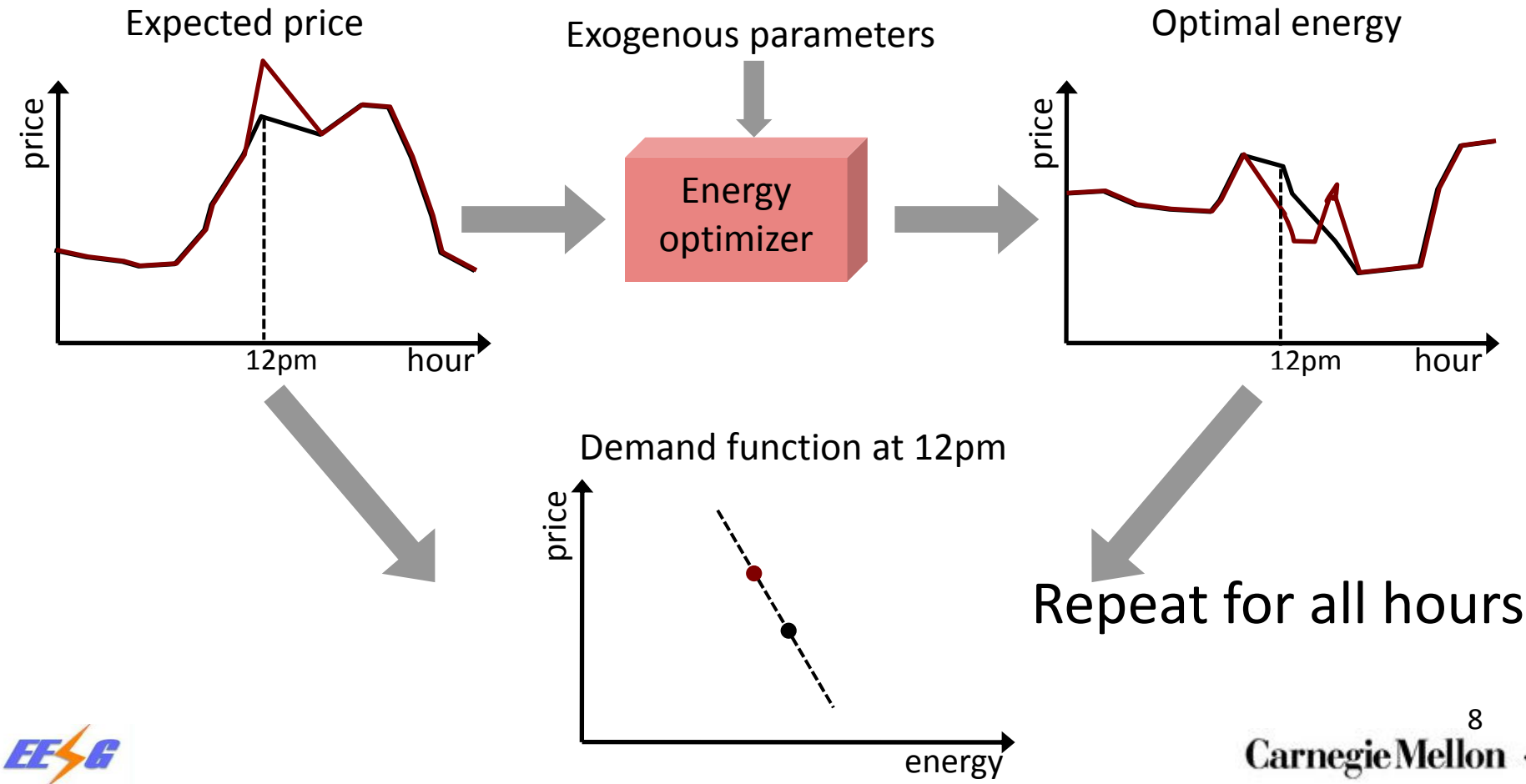
Values and choices of energy service

- Every user/customer has different values and needs for energy service

minimize (energy cost) + (utility) + (risk)
subject to (state dynamics)
(state, energy, cost constraints)

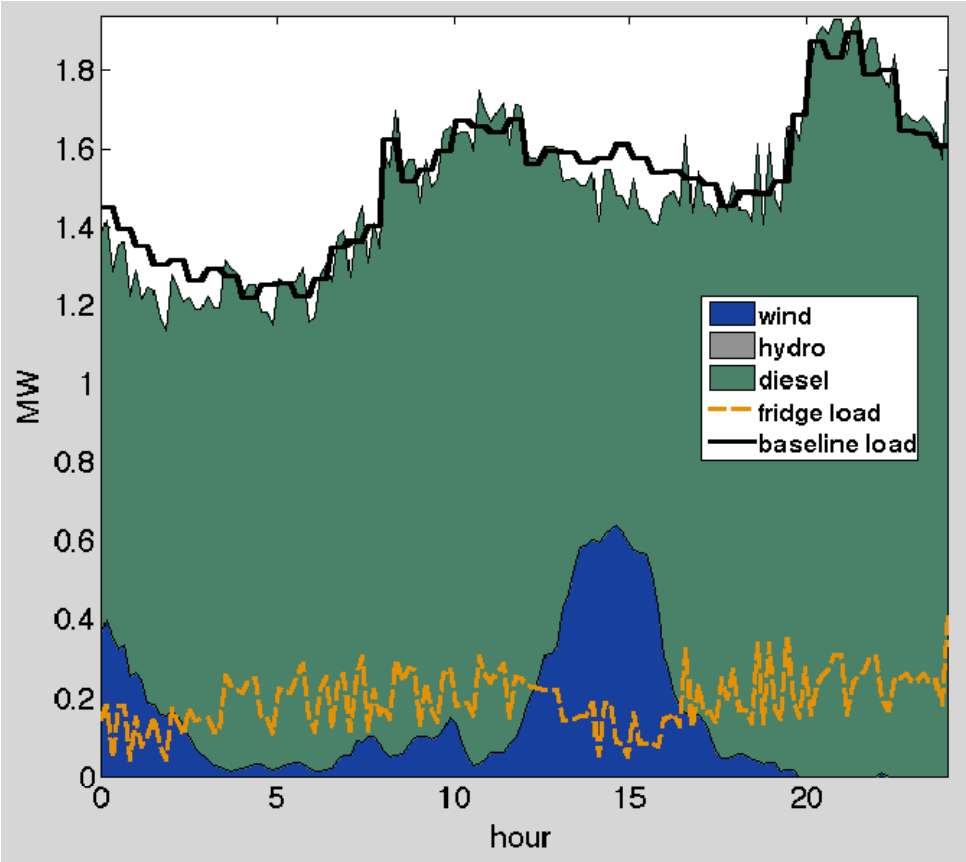
Balancing demand with the system

- One-shot optimization

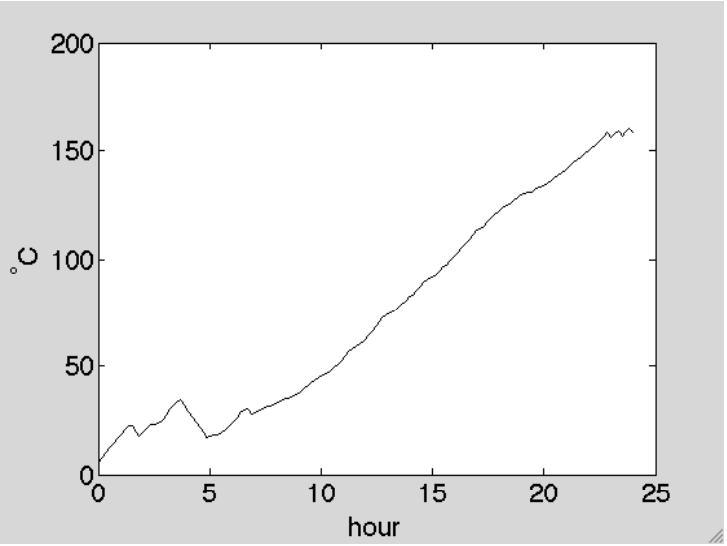


Examples of balancing with the system -- Island of Flores, Portugal

- One-shot optimization

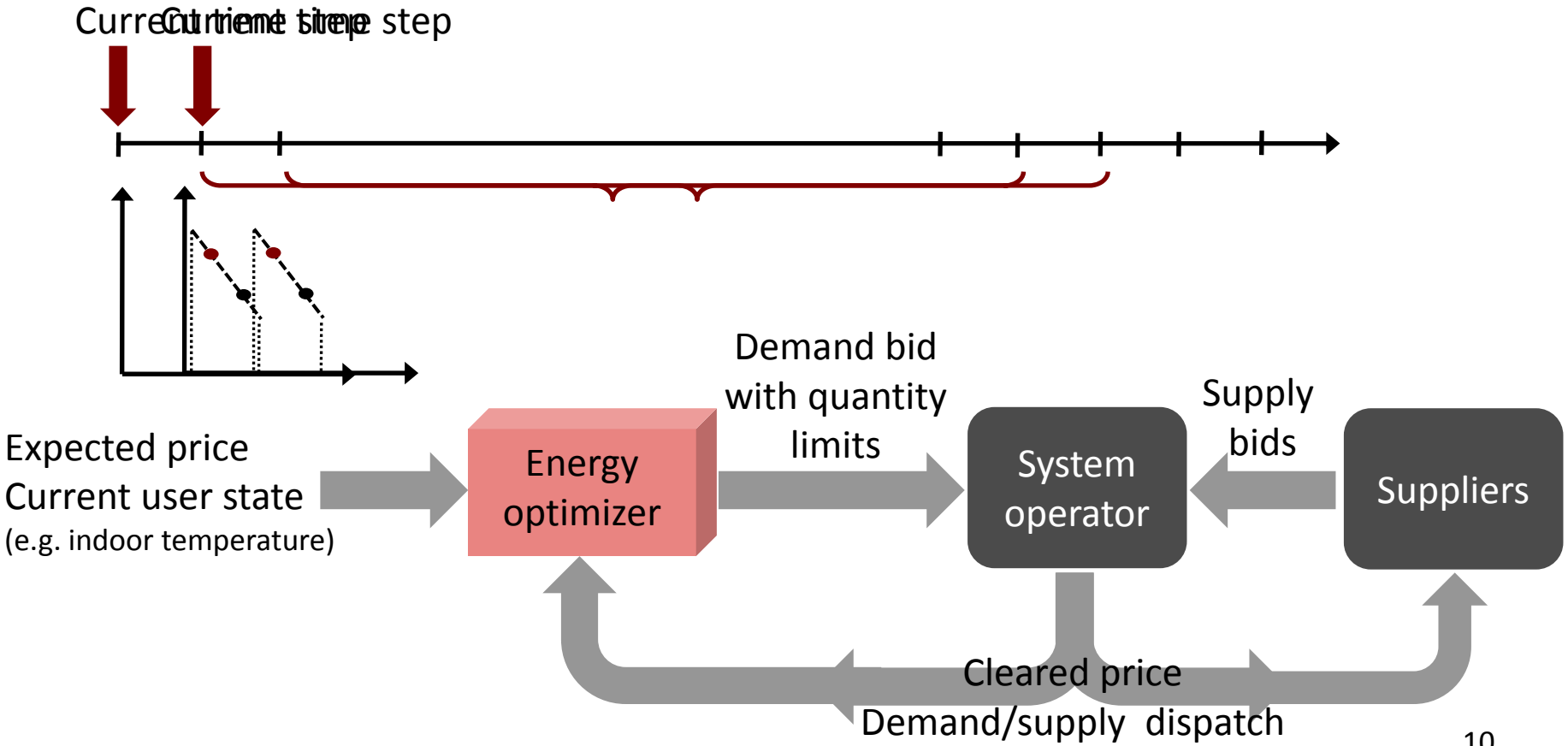


Internal temperature of the refrigerators



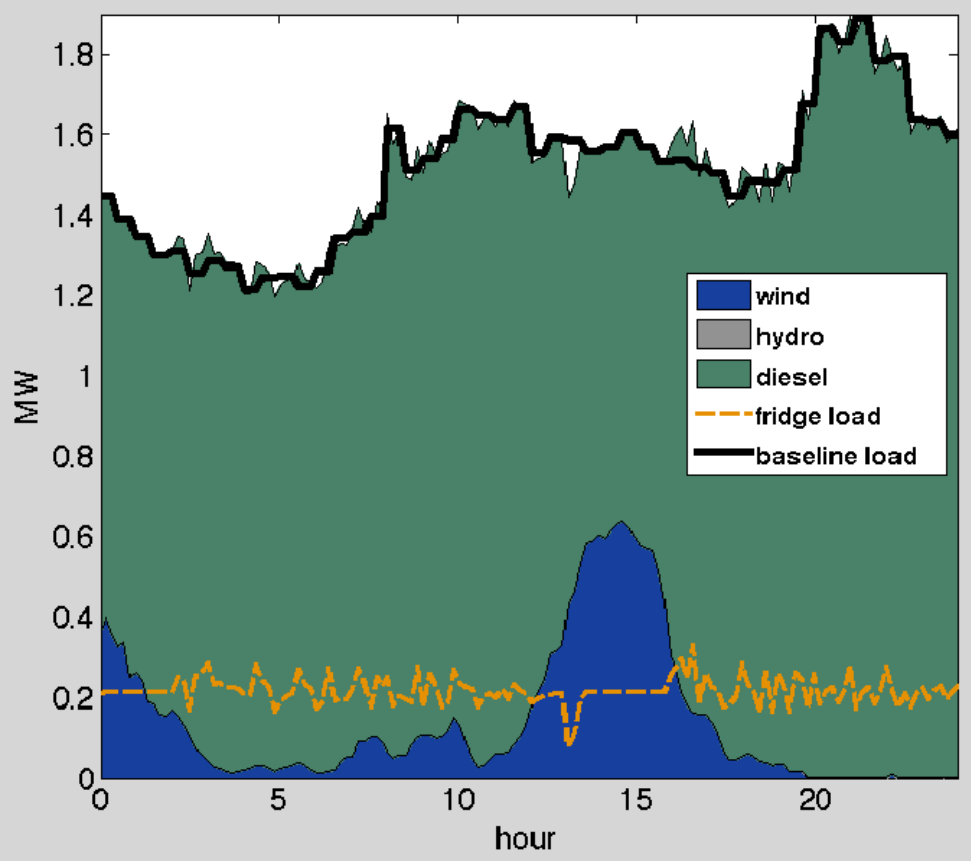
Balancing demand with the system

- Moving-horizon optimization



Examples of balancing with the system -- Island of Flores, Portugal

- Moving-horizon optimization



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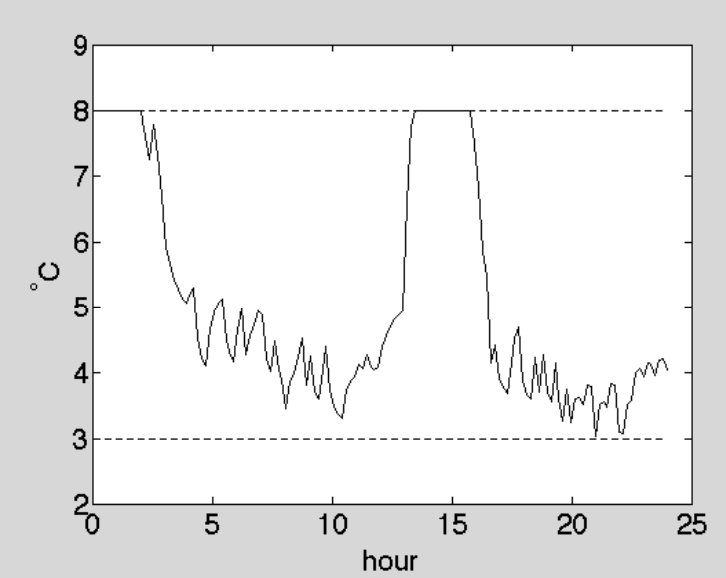

Conclusion

- **Multi-temporal and multi-layered optimization**
  - Multi-temporal aspect
    - Contracts based on the best forecast/information of the system and the users at different time steps
    - As the forecast and the information changes, additional contracts in a finer time step
    - Dependent on the risk aversion of the customer
  - Multi-layered aspect
    : reducing high uncertainty of small-users' demand through aggregation

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

Related publications and patents

- Chapters 8 and 9, “Engineering IT-Enabled Electricity Services; The Case Of Low-Cost Green Azores Islands”, Co-edited by M. Ilić and L. Xie, *to be published*
- J.-Y. Joo and M. Ilić, “Distributed Multi-Temporal Risk Management Approach To Designing Dynamic Pricing”, IEEE Power and Energy Society General Meeting, July 2012, *accepted*
- J.-Y. Joo and M. Ilić, Multi-Temporal Risk Minimization Of Adaptive Load Management In Electricity Spot Markets, *IEEE PES Innovative Smart Grid Technologies, Europe*, Dec 2011
- M. Ilić, J.-Y. Joo, L. Xie, M. Prica and N. Rotering, A Decision Making Framework and Simulator for Sustainable Electric Energy Systems, *IEEE Transactions on Sustainable Energy*, Jan 2011
- M. Ilić, L. Xie and J.-Y. Joo, Efficient Coordination of Wind Power and Price-Responsive Demand Part I: Theoretical Foundations, Part II: Case Studies, *IEEE Transactions on Power Systems*, *to appear*
- J.-Y. Joo and M.D. Ilić, Adaptive Load Management (ALM) in Electric Power Systems, *IEEE International Conference on Networking, Sensing and Control*, Apr 2010
- J.-Y. Joo and M.D. Ilić, A multi-layered adaptive load management system: information exchange between market participants for efficient and reliable energy use, *IEEE PES Transmission and Distribution Conference*, Apr 2010
- L. Xie, J.-Y. Joo and M.D. Ilić, Integration of intermittent resources with price-responsive loads, *41st North American Power Symposium*, Sep 2009