Effects of Home Energy Management Systems on Distribution Utilities and Feeders Under Various Market Structures

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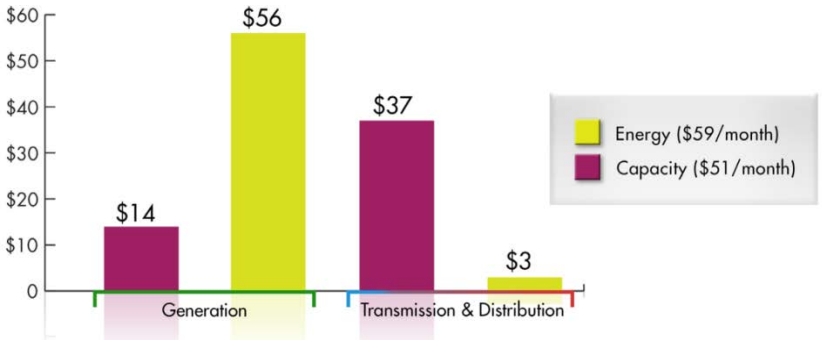
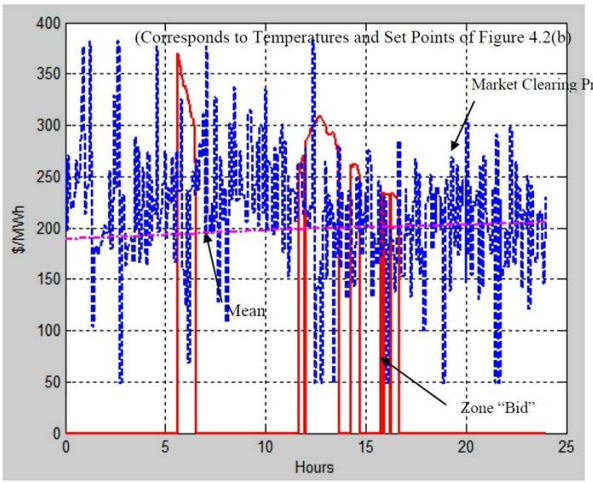
Retail Tariffs are Evolving

- Net metering is unsustainable at high penetrations of distributed generation
- Ramp rates are increasing
- Transactive pricing results in volatility
- Customers need incentives to schedule



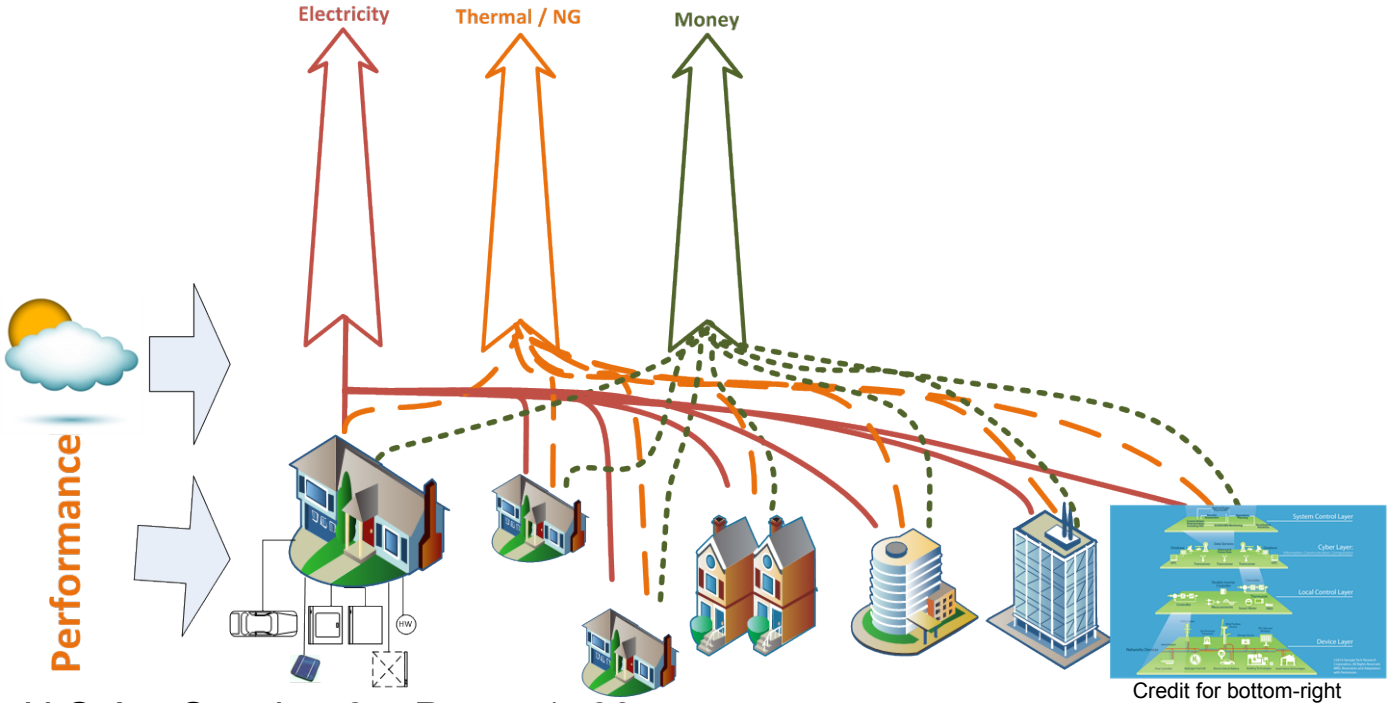
Credit: EPRI "The Integrated Grid: Realizing the Full Value of Central and Distributed Energy Resources" (October 2007)



Credit: D. Hammerstrom, et al "Pacific Northwest GridWise Testbed Demonstration Projects Part I. Olympic Peninsula Project" (October 2007)

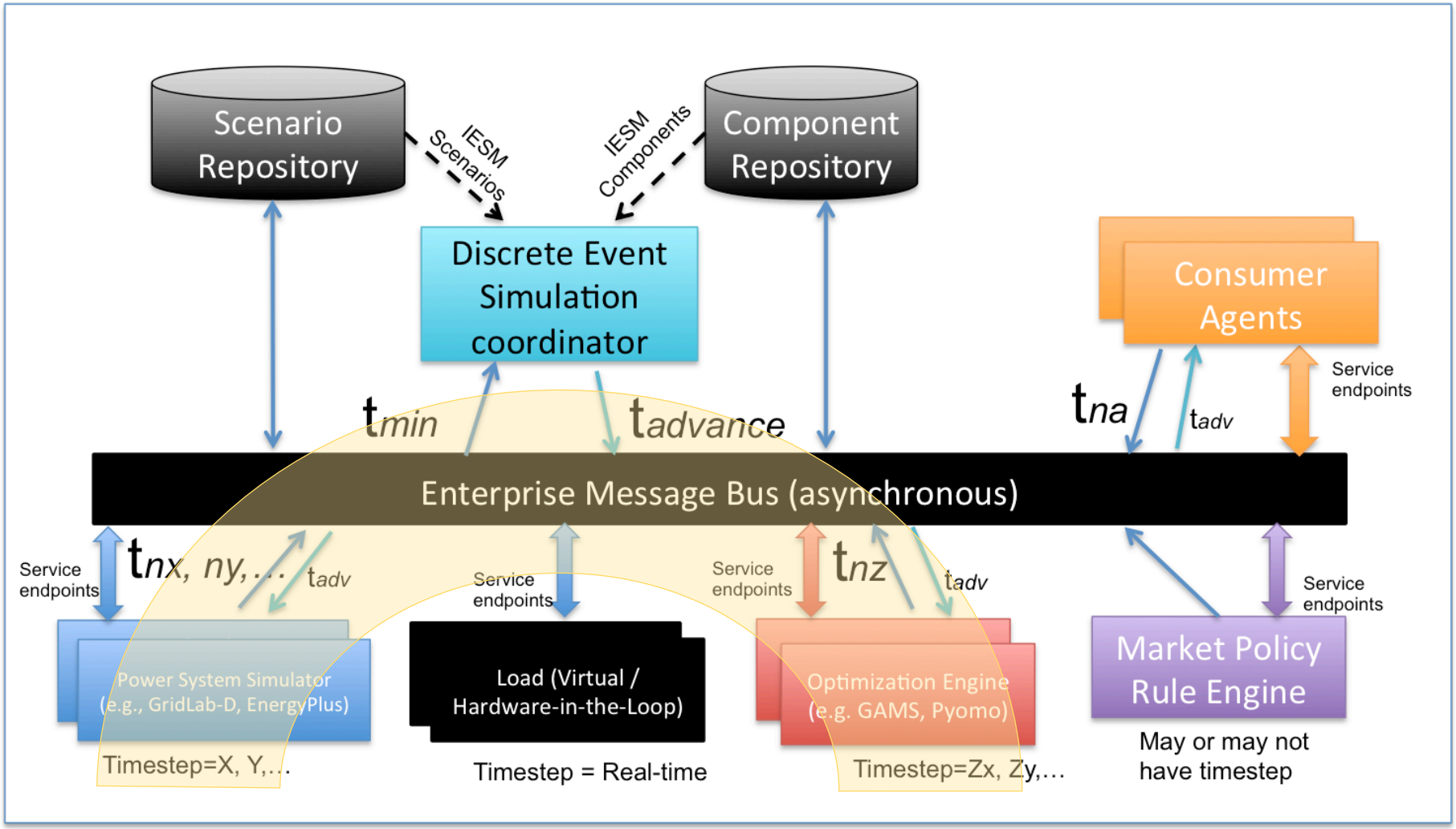
Integrated Energy System Model (IESM)

- Simulation tool
- Physics-based performance of technologies and buildings
- Multiple retail markets and tariff structures
- Provide market layer input to market-to-device HIL testing



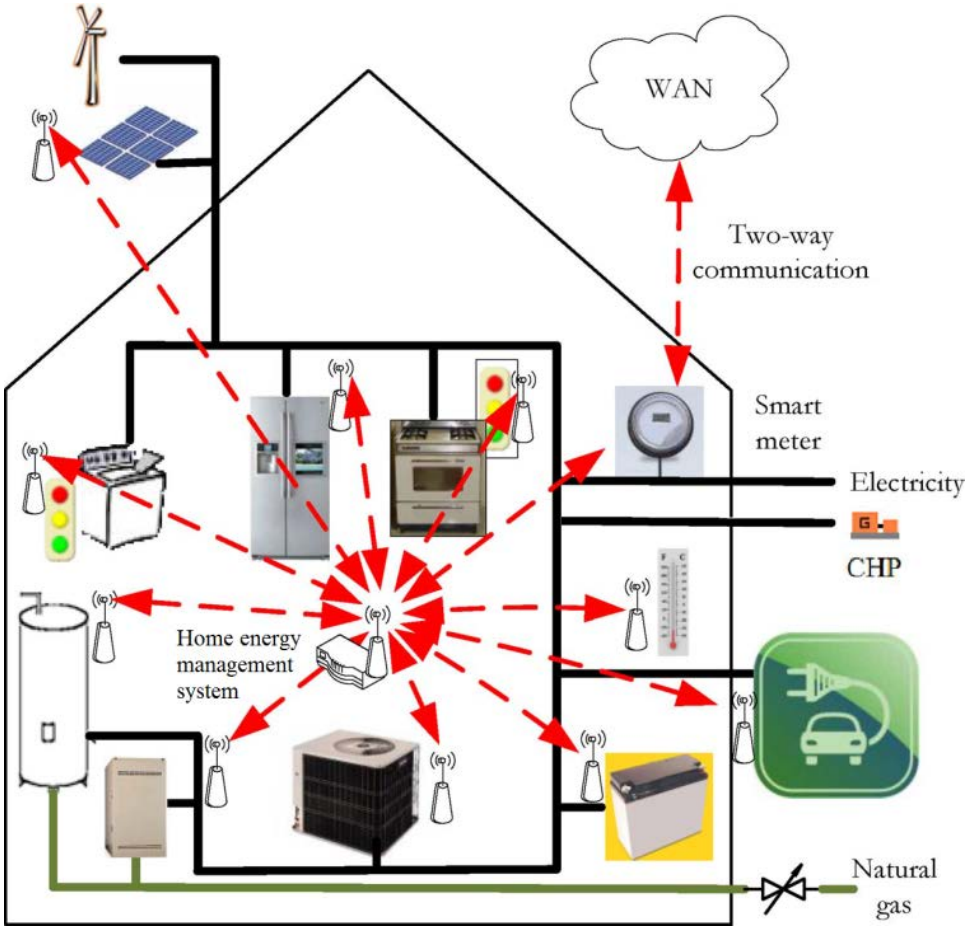
Credit for bottom-right figure: Georgia Institute of Technology

IESM is a Co-Simulation Tool

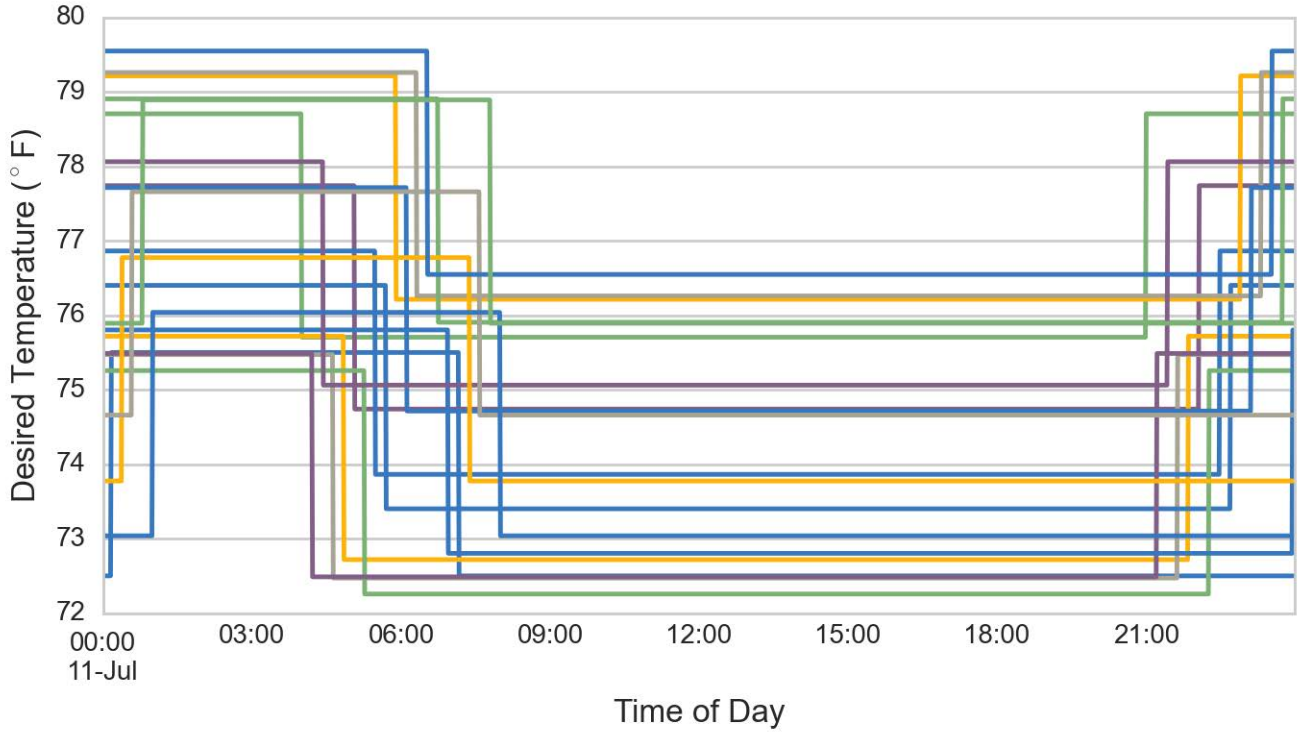


Home Energy Management System (HEMS)

- Minimizing cost for air conditioning
- Using predicted weather conditions and energy prices
- Setpoint kept at or below desired temperature
- Can be 5°F (2.8°C) below the desired temperature

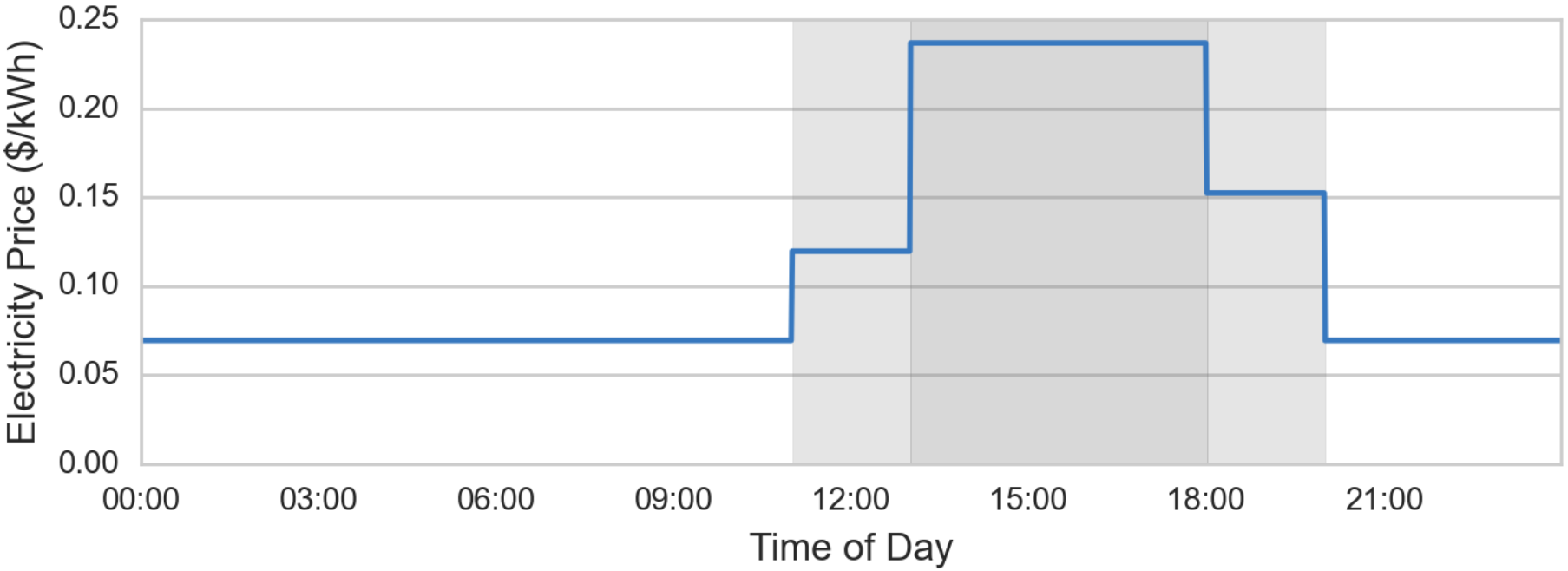


20 Identical Houses with Varied Schedules



- Daytime temperatures: 72-77°F (22.2-25.0°C)
- Start time: 4:00 and 8:00 AM
- Nightime mode after 16 hours – temperature increased by 3°F (1.7°C)

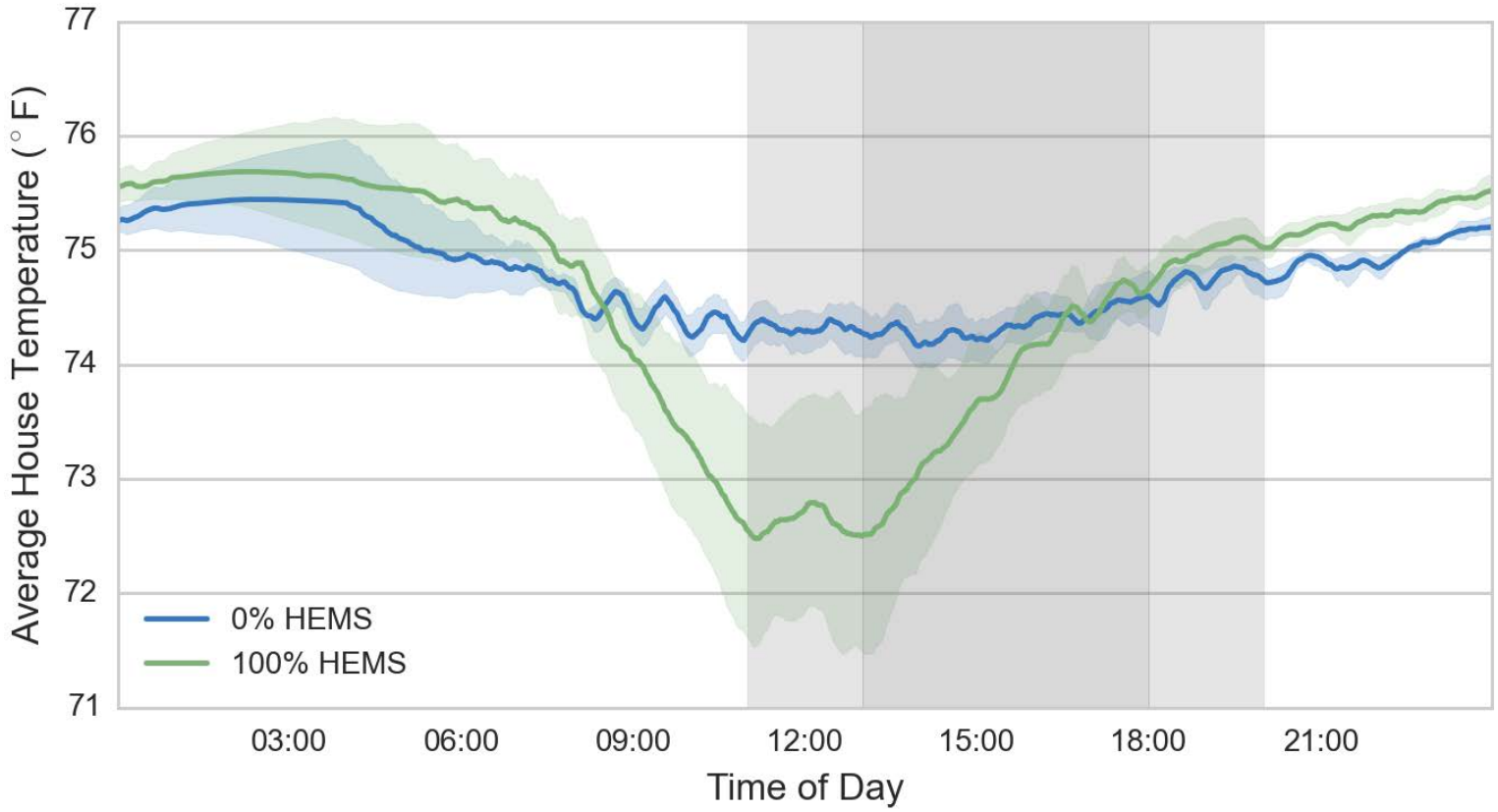
Time of Use (TOU) Pricing



- TOU pricing from Duke Energy*
- Mid-day price peaks with shoulders

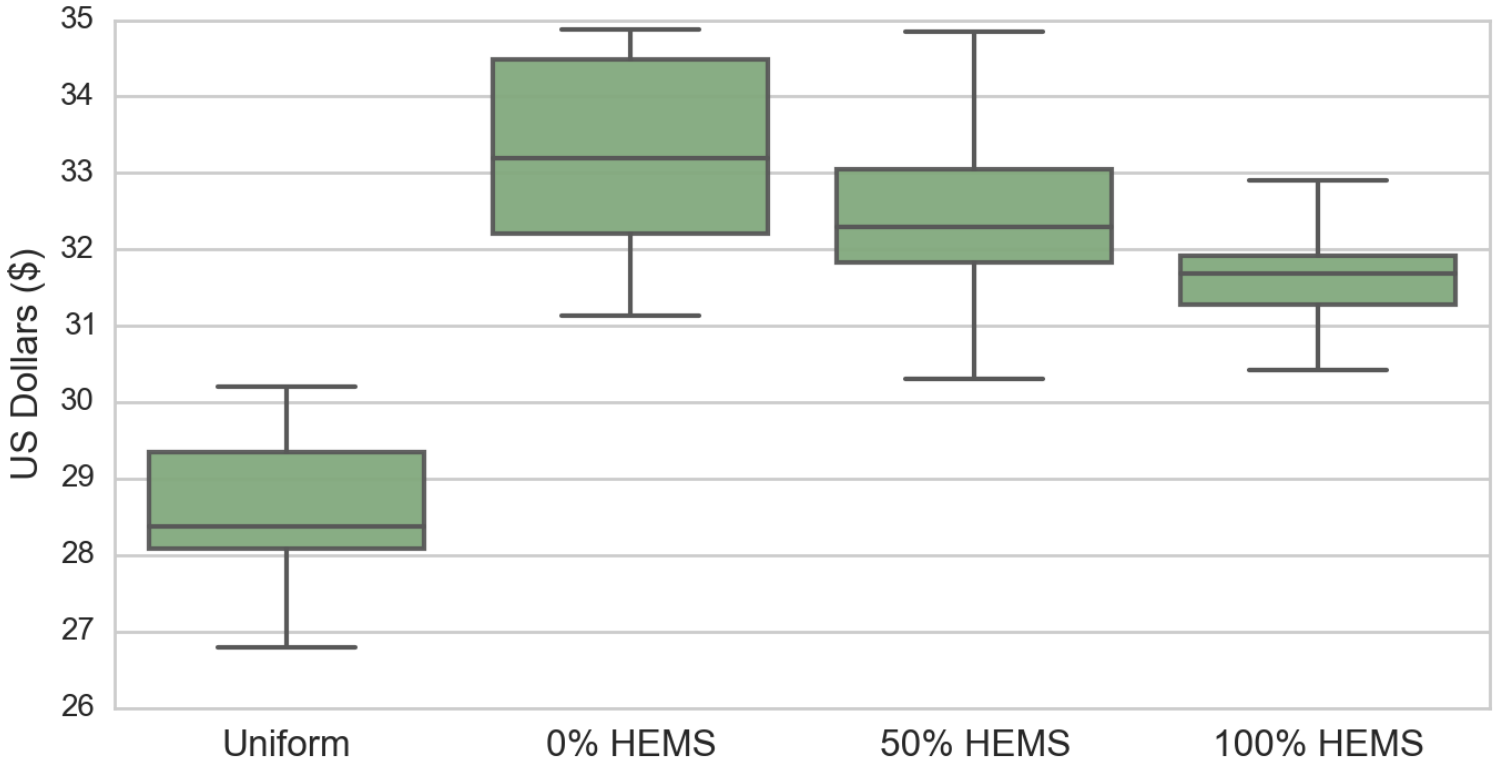
* Residential Service Time-of-Use Schedule R-TOU-31

HEMS Minimizes Cost by Precooling Houses



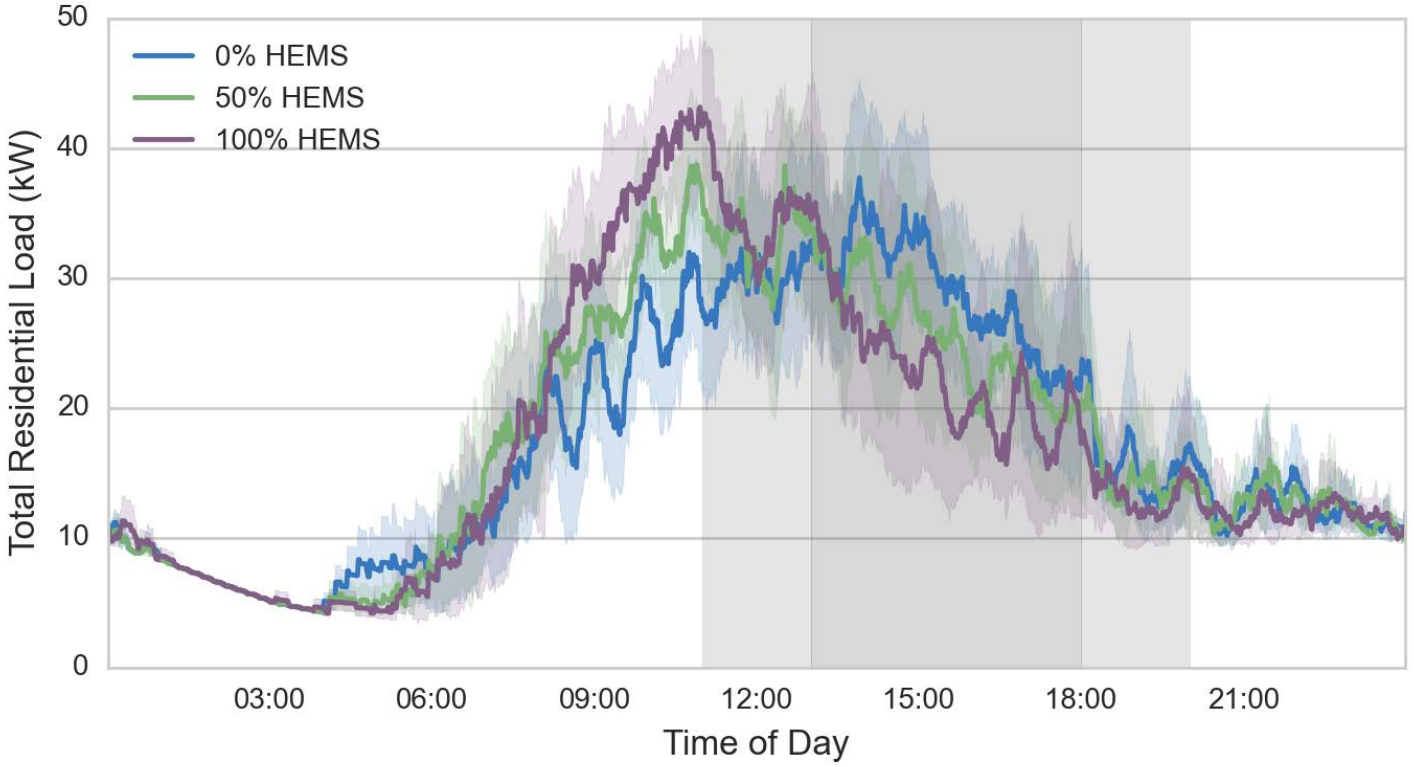
- Precool by about 2°F (1.1°C) before peak pricing

Average Residence Saves 5% on Electric Bill



- Estimated energy bills for July 7-17, 2012
- Two market structures and three HEMS penetrations
- Bills under uniform rate are higher during other seasons

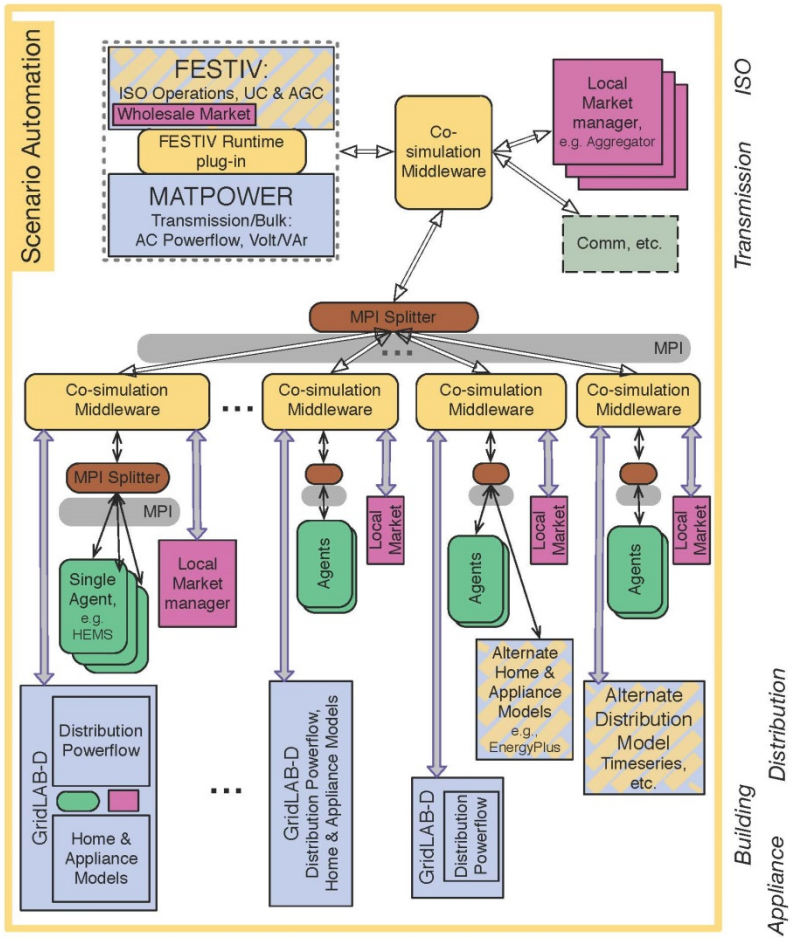
But Loads are Shifted Earlier



- Increased peak load
- Potentially increasing infrastructure requirements
- Potentially decreasing the transformer lifetimes

Next Steps and Future Work

- Larger feeders with many homes
- Rooftop photovoltaic solar
- HEMS with cost-comfort tradeoffs
- Additional controllable loads (water heating and electric vehicles)
- Hardware-in-the-loop testing
- Integration with bulk power system models



Conclusions

- HEMS and controllable loads can be beneficial
- But markets / tariffs need to evolve and supporting equipment is necessary
- Potential unintended consequence of TOU rates are identified and quantified
- Larger systems should be analyzed to better understand issues and opportunities
- HIL testing is underway to verify performance

Acknowledgement

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