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TRANSACTIVE CONTROL OF COMMERCIAL BUILDING HVAC

MULTI-AGENT VOLTTRON APPLICATION

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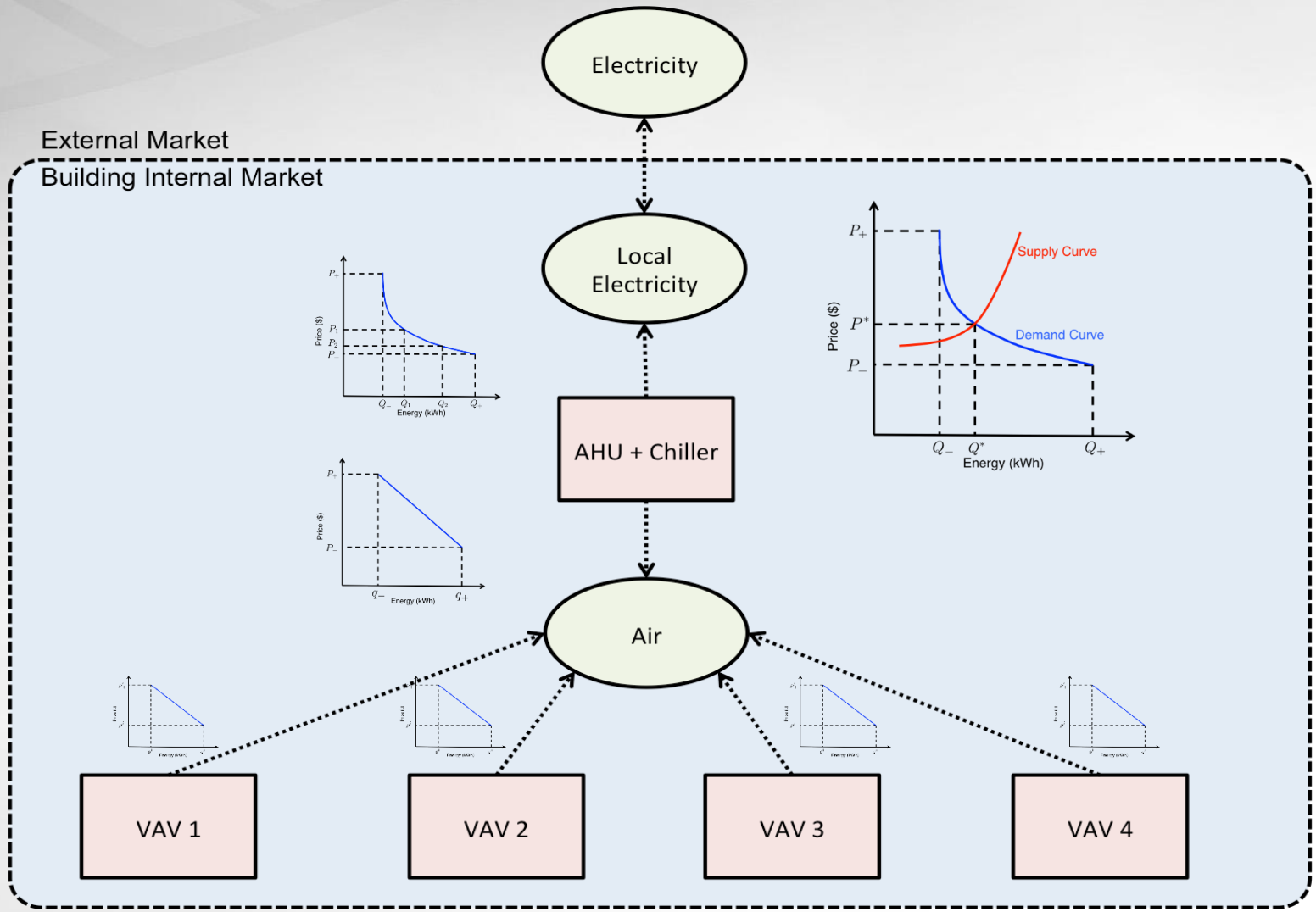
Application Description

- Application controls HVAC system via zone cooling set points to provide electric demand flexibility
- 23+ agents representing different components of the building
  - Additional agents for validating controls in whole building simulation package
- Uses dual-auction market mechanism to negotiate amount of cool air delivered to each building zone
  - Distributed decision making, distributed control
- Zones ‘buy’ cool air from air handler
  - Zones adjust cooling set points depending on settled market price
- Scalable to multiple zones, multiple air handlers, multiple buildings, …

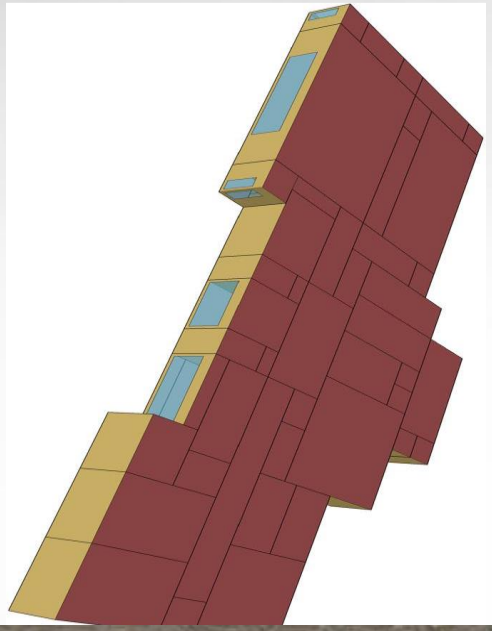
Transactive Market Concept



Building Testbed

- New office/lab building at PNNL
- “Living lab” for control experiments
- Occupancy sensors in all zones
- 2 Multi-zone AHUs with VAV, 3 single zone packaged units
- Chilled water from central plant
- VOLTTRON agent installed (March) and monitoring BAS

Experiments control AHU-001 and the 17 VAVs served



Agents

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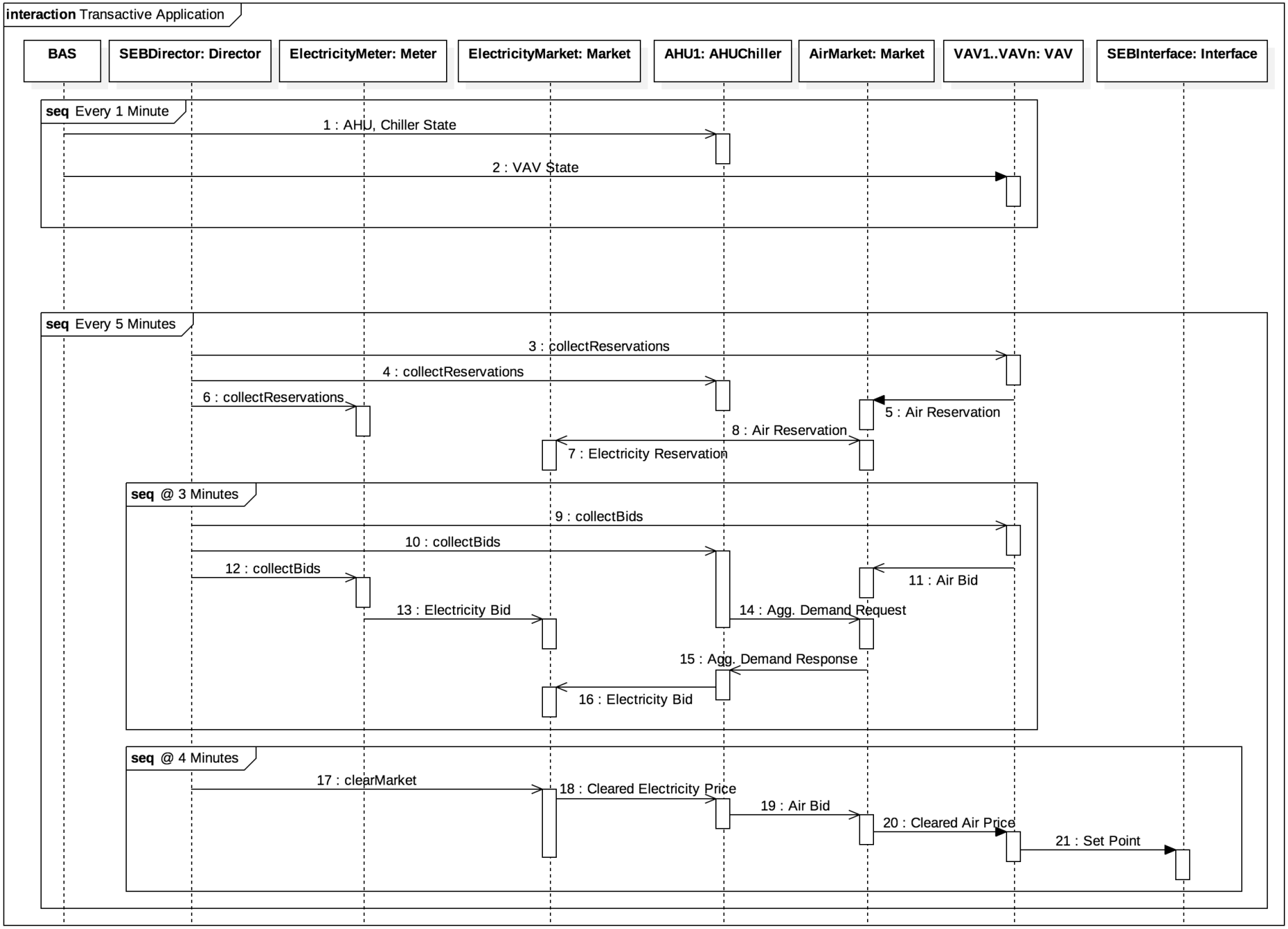
'Physical' Agents

- Thermostat Agent (17)
  - Represents a single thermal zone and VAV
  - Estimates cooling load, bids for cool air
- AHUChiller Agent (1)
  - Combines AHU (Fan) and Chiller Models
  - Estimates HVAV energy, sells air to zones
- Meter Agent (1)
  - Represents connection to electric utility
  - Provides price curve and/or demand limit

'Virtual' Agents

- Market Agent (2)
  - Collects bids and clears market
- Interface Agent (1)
  - Translates application output to building specific points and logic
- Director Agent (1-3)
  - Provides synchronization for market bidding and clearing
- EnergyPlus Agent (1)
  - Interface to EnergyPlus for validating control algorithm
  - Virtual "hardware in the loop"


interaction Transactive Application
BAS
SEBDirector: Director
ElectricityMeter: Meter
ElectricityMarket: Market
AHU1: AHUChiller
AirMarket: Market
VAV1..VAVn: VAV
SEBInterface: Interface
seq Every 1 Minute
1 : AHU, Chiller State
2 : VAV State
seq Every 5 Minutes
3 : collectReservations
4 : collectReservations
6 : collectReservations
5 : Air Reservation
8 : Air Reservation
7 : Electricity Reservation
seq @ 3 Minutes
9 : collectBids
10 : collectBids
12 : collectBids
11 : Air Bid
13 : Electricity Bid
14 : Agg. Demand Request
15 : Agg. Demand Response
16 : Electricity Bid
seq @ 4 Minutes
17 : clearMarket
18 : Cleared Electricity Price
19 : Air Bid
20 : Cleared Air Price
21 : Set Point

DEMO

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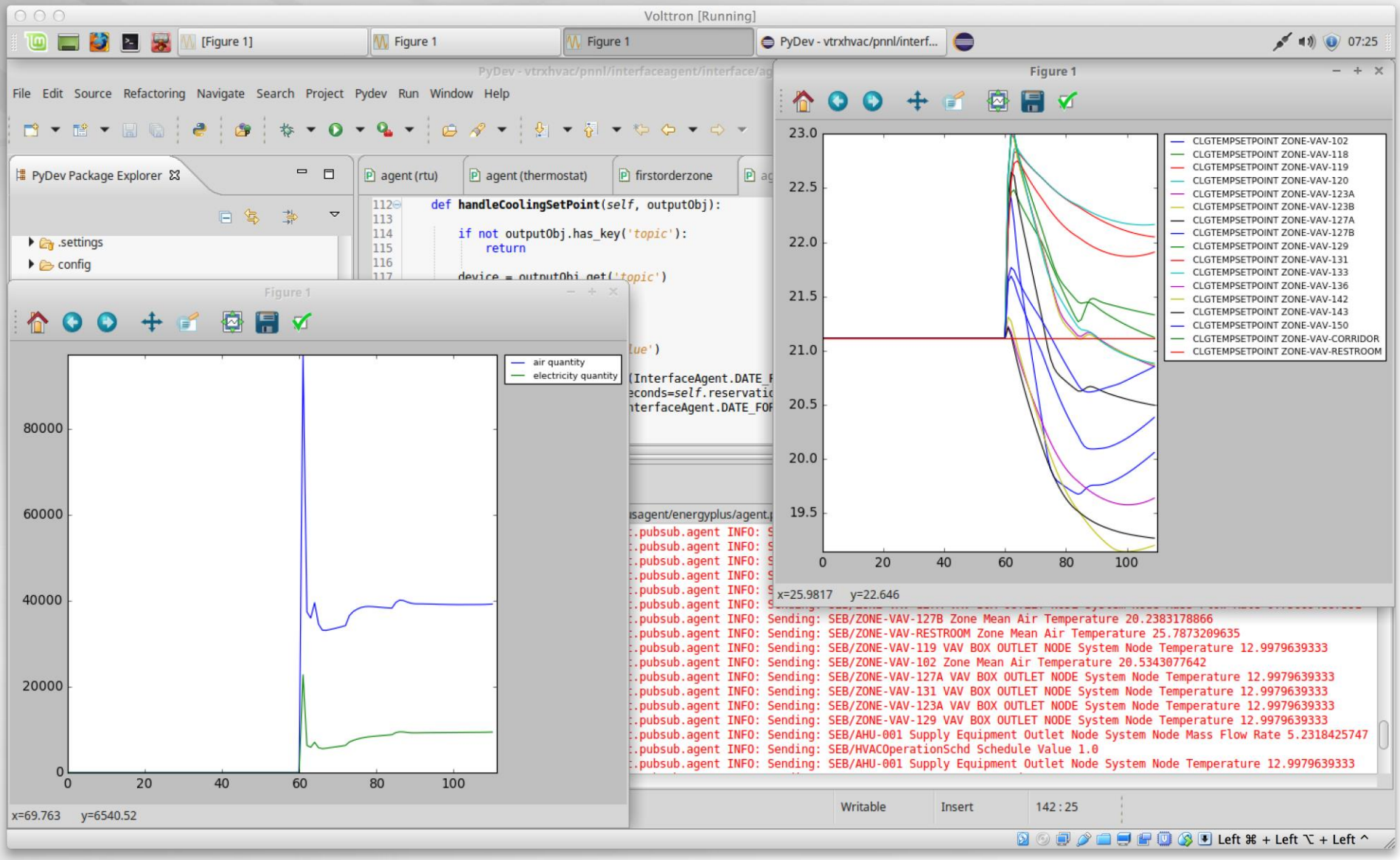
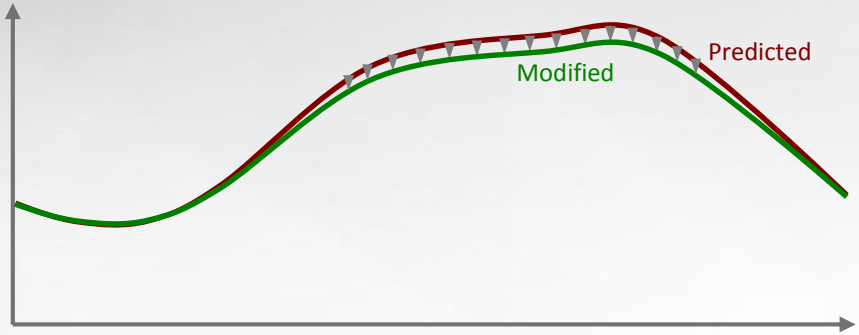


Control Experiments

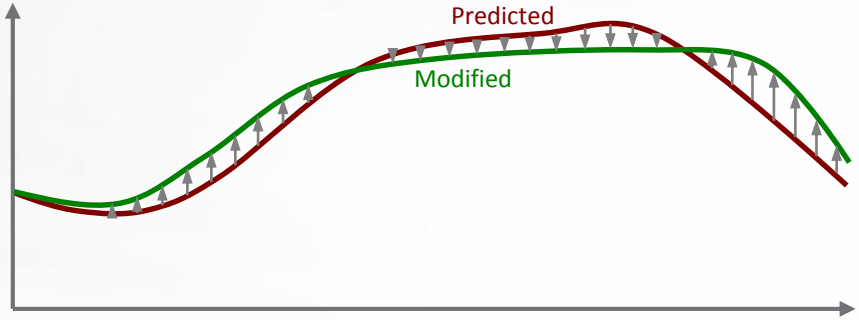
Energy Efficiency

Experiment will test methods for coordinating the operation of HVAC equipment to improve efficiency, e.g. by optimally loading, or adjusting reset schedules



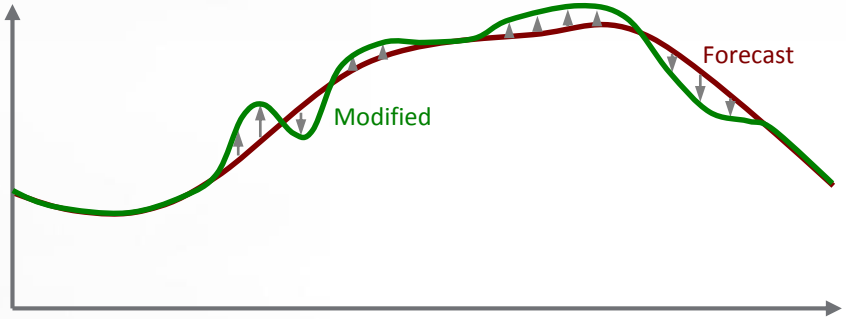
Demand Reduction

Experiment will test ability of market system to meet a desired demand reduction target

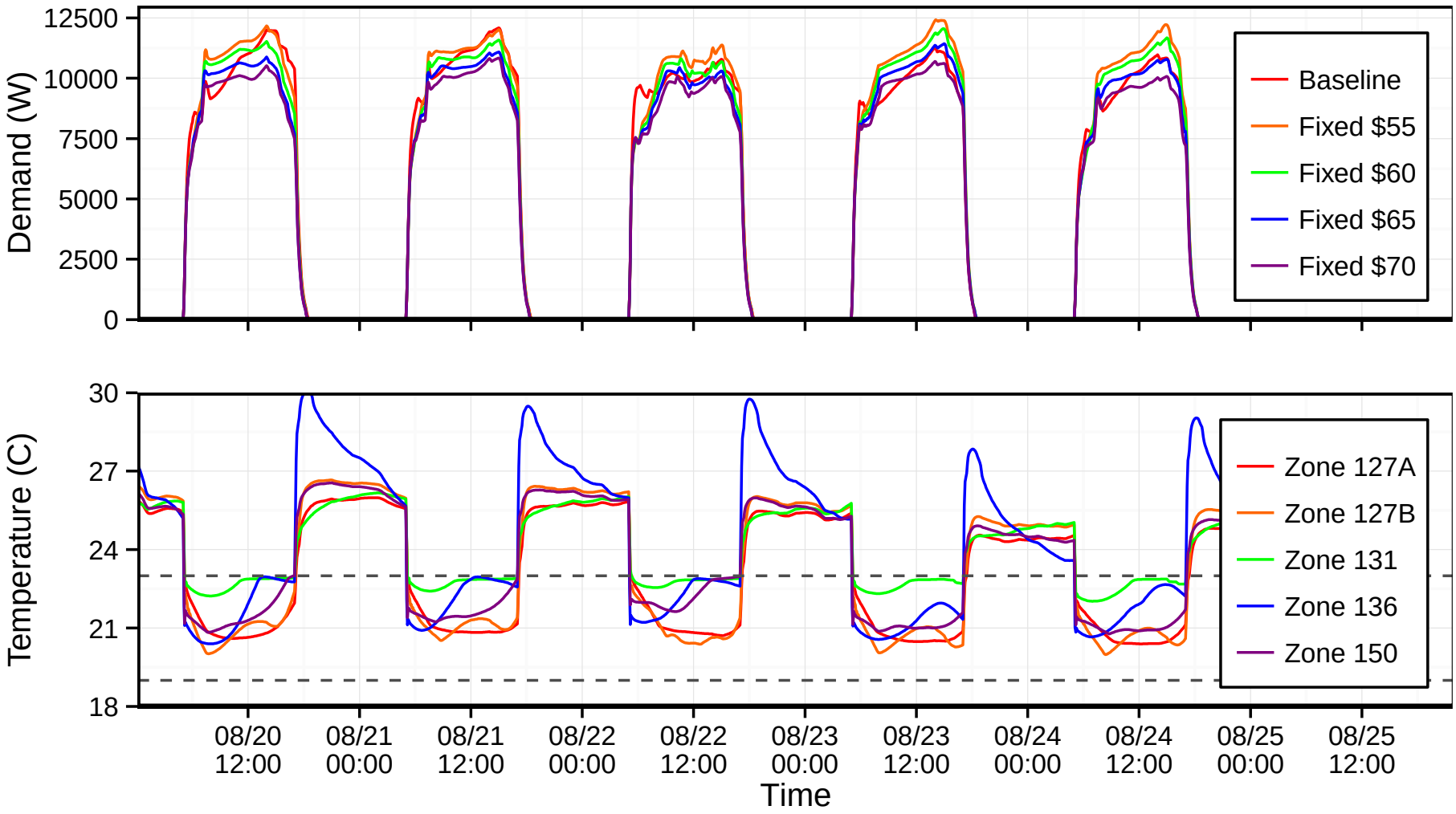


Dynamic Incentive

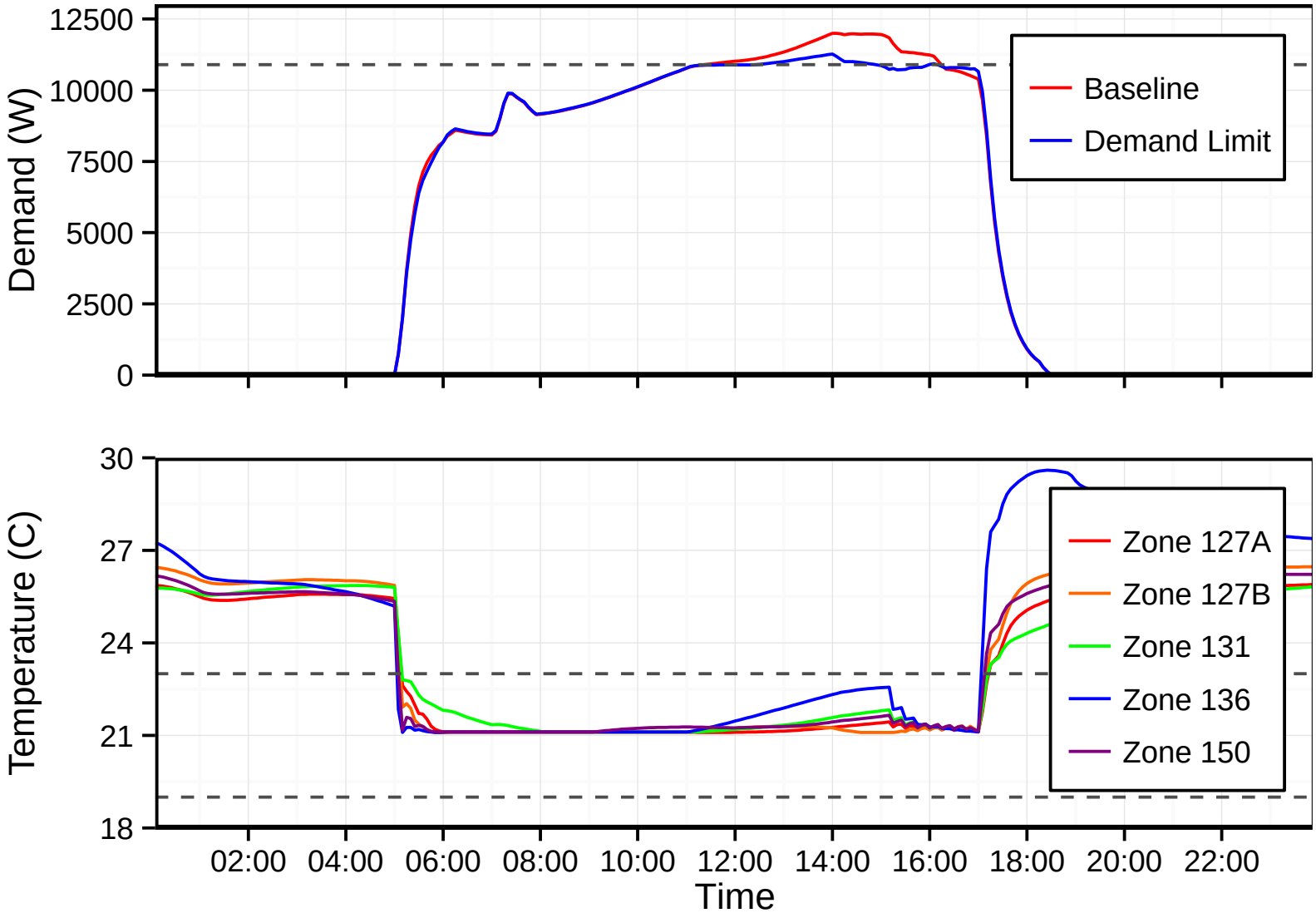
Experiment will test ability of building to respond to both up and down requests based on dynamic incentive signal



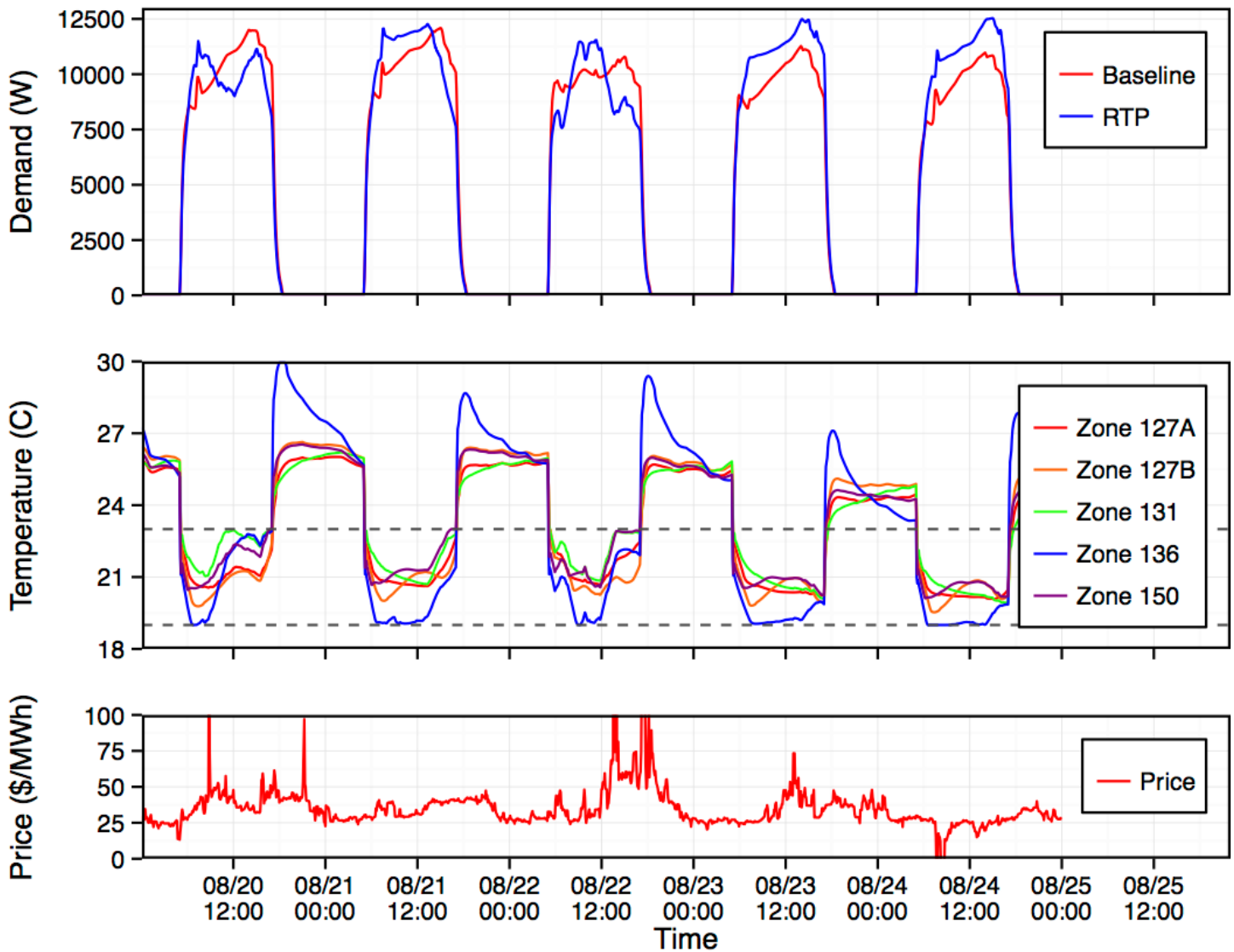
Simulation Studies – Fixed



Simulation Studies – Demand Limit



Simulation Studies – Dynamic Incentive



Physical Demonstration

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- Zone and equipment models tuned using data from BAS
- VOLTTRON implementation complete
  - Market and zone/equipment agents have been migrated to VOLTTRON
  - Building data streams integrated into real-time market clearing
- Initial testing of market algorithms underway
  - Agents actively listening to building and calculating new set points
- Experiments will be conducted throughout summer
  - Scaling experiments to additional equipment, buildings on PNNL Campus
  - Foundation for Clean Energy and Transactive Campus project