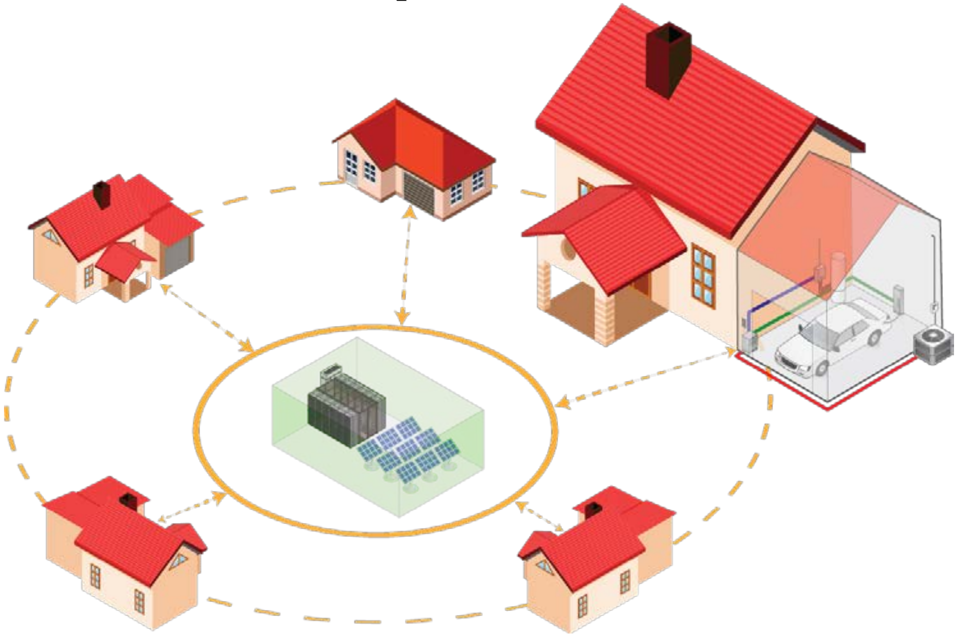
Transactive Whole Homes as Integrated Assets (Connected Neighborhoods)



Oak Ridge National Laboratory
Michael Starke, PhD
starkemr@ornl.gov

Project Summary

Timeline:

Start date: October 2016

Planned end date: December 2020

Key Milestones

- Develop VOLTTRON-based aggregator for 62 homes to evaluate microgrid-responsive functionality using cloud-based implementation of home instances of VOLTTRON platforms for Alabama Neighborhood, 6/1/2018.
- Deliver final report on the software framework for the VOLTTRON integration of IoT devices to perform reliable transactive control at-scale, 9/1/2018.

Budget:

Total Project $ to Date:

DOE: $1,800K

Cost Share: Confidential Southern Company

Total Project $: FY16 - Q1 FY21

DOE: $5,200K

Cost Share: Confidential Southern Company

Key Partners:

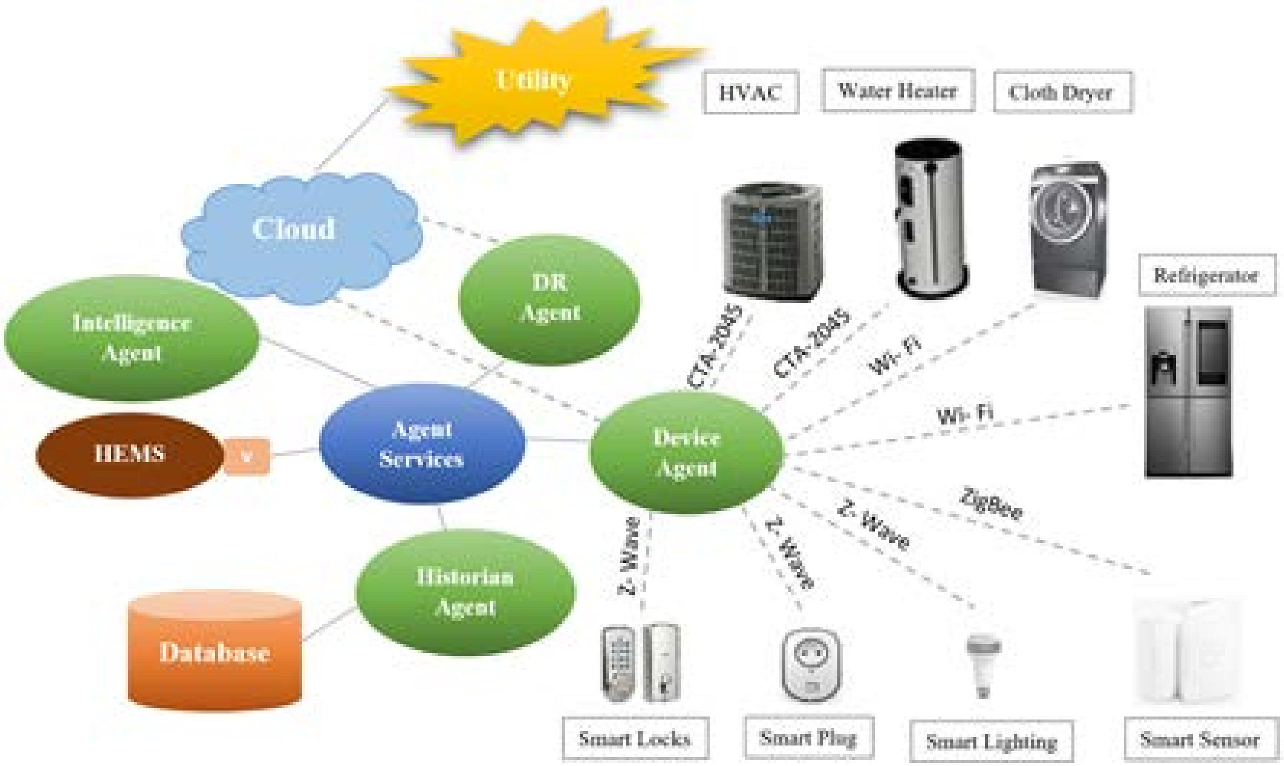
Southern Company	Southern Company
Alabama Power	Alabama Power
Georgia Power	Georgia Power
Rheem	Rheem
Carrier	Carrier

Project Outcome:

- This project will address needs for the Open-architecture control platforms for transactive energy ready buildings [DOE BTO MYPP Pages 98-99].
- The project will assess the impact that the VOLTTRON™ platform can have on the widescale building control and optimization.

Addressing Challenge

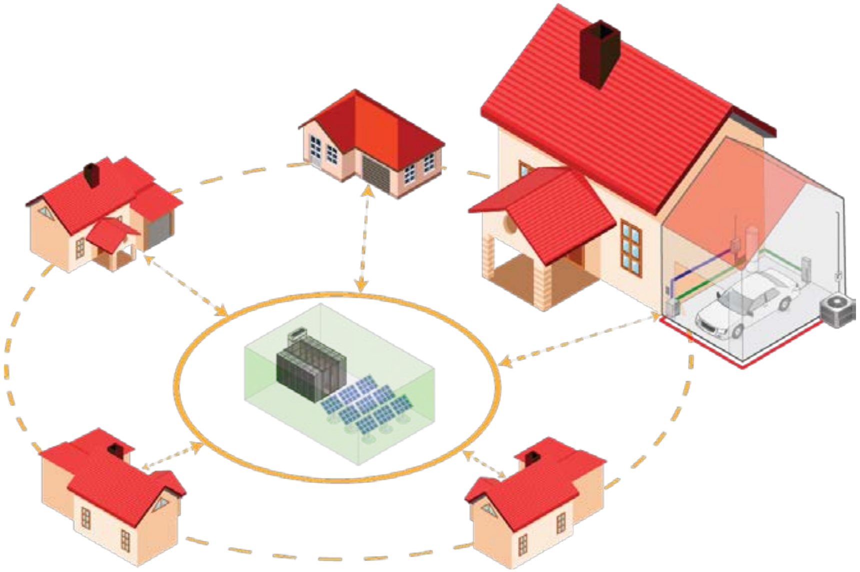
- Residential buildings have device level controls, but lack the utilization of these controls to support whole-view, building-level, energy efficiency and grid support.
- Grid support for residential load historically focused on load shedding by utility command and does not fully utilize the flexibility of these loads or support residential decision making.



Project Objective

- Develop two different open-architecture control platforms for transactive energy in residential buildings in neighborhoods.

Centralized Generation (Alabama Power)	Distributed Generation (Georgia Power)



Team

Southern Company: Utility provider, host of developed software, API developer

Oak Ridge National Laboratory: Transactive platform architect, API integrator, and optimizer

Alabama Power, Centralized

Rheem: Water heater and device API provider

Carrier: HVAC and device API provider

Georgia Power, Decentralized

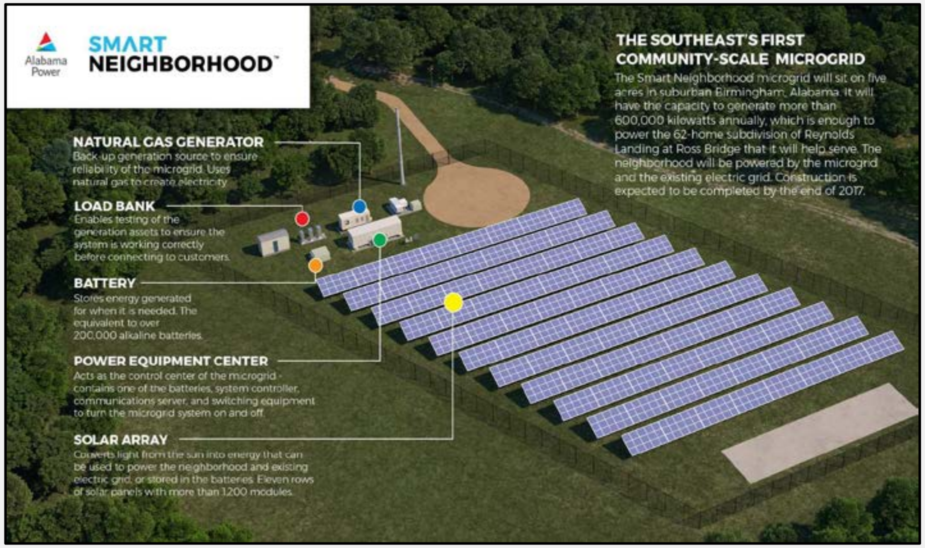
TBD: Water heater and HVAC device and API provider

TBD: Energy storage and PV device and API provider

TBD

Kickoff Meetings held in March, with more announcements to come.

Approach (Centralized Theme, Alabama Power)

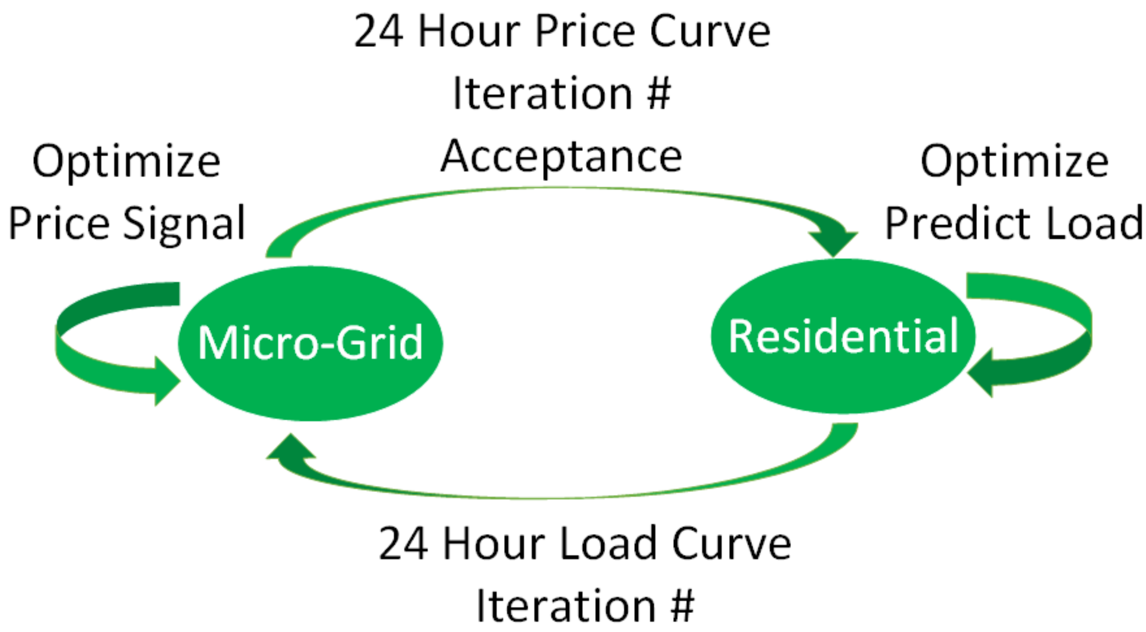


STATUS

- Neighborhood with 62 Planned homes.
- Neighborhood began construction October 2017 and is expected to be fully completed this month.
- Microgrid Hardware Installed and Operating:
  - <u>PV System</u>: 420kW
  - <u>Energy Storage System</u>: 250kW, 681kWh
  - <u>Generator</u>: 400kW
  - Microgrid Controller: ORNL Developed CSEISMIC Controller

Approach: Transactive Methodology

- Microgrid controller and VOLTTRON™ ‘negotiate/transact’ a load/price.
- Microgrid controller optimizes resources and creates 24-hour pricing offer.

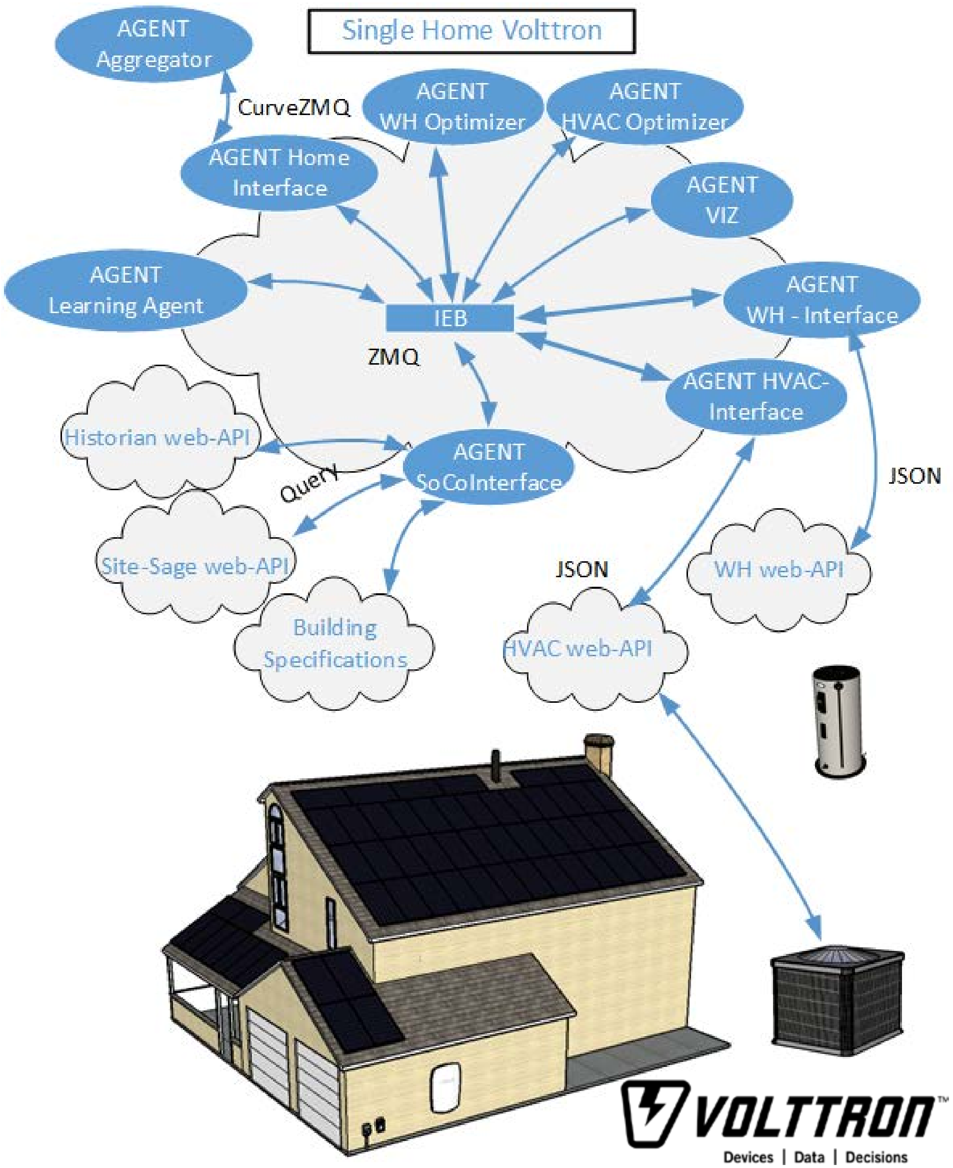


- VOLTTRON™ allocates price signals to resources (loads) which optimize and provide total load projection.
- This process iterates until Microgrid controller meets minimum convergence criteria.

Approach – Agent Framework

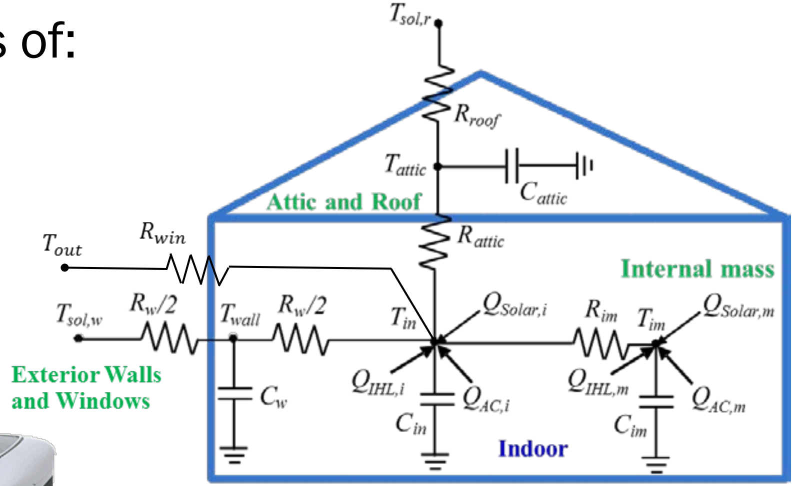
- Alabama Power: Agent-based framework to support autonomous integration and negotiation of load resources with a microgrid controller.

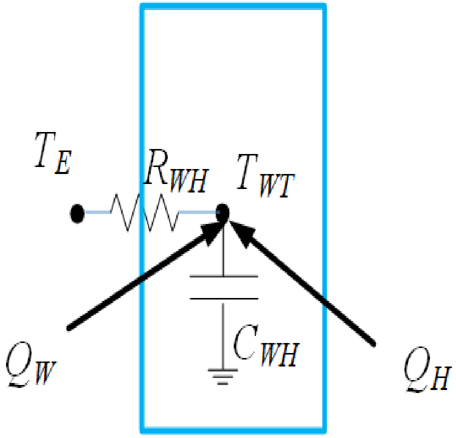
Agent	Purpose
Home Interface	Data Pass through and collector of optimization and electrical consumption projections for Aggregator agent.
HVAC Interface	Translates HVAC decisions and status to vendor API.
Water Heater Interface	Translates Water Heater decisions and status to vendor API.
HVAC Optimizer	Utilizes building specifications, forecasted weather data, building parameter data, price forecast, and HVAC status data to optimally schedule HVAC and provide expected electrical consumption.
Water Heater Optimizer	Utilizes predicted water consumption, price forecast, and Water Heater status data to optimally schedule Water Heater and provide expected electrical consumption.
SoCo Interface	Pulls data from Southern Company API which includes weather, building specifications, historical load measurements by circuit, device credentials, and historical data.
Learning	Utilizes data collected from SoCo stored data to perform predictions on hot water usage, internal heat loads, building parameters, etc.

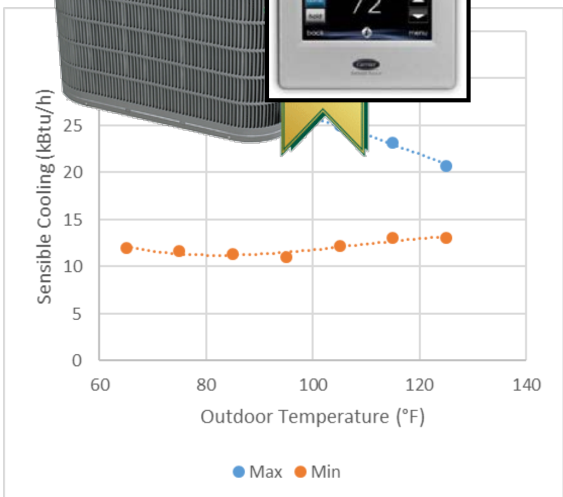


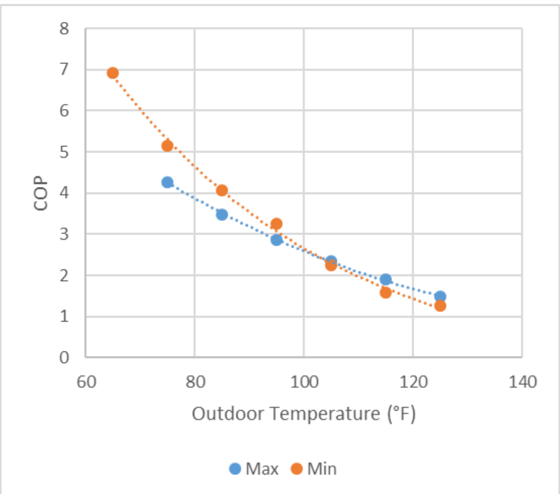
Approach – Optimization and Modeling

- Developed low cost computational models of:
  - Building envelope
  - HVAC performance
  - Water heater performance
  - Water heater model





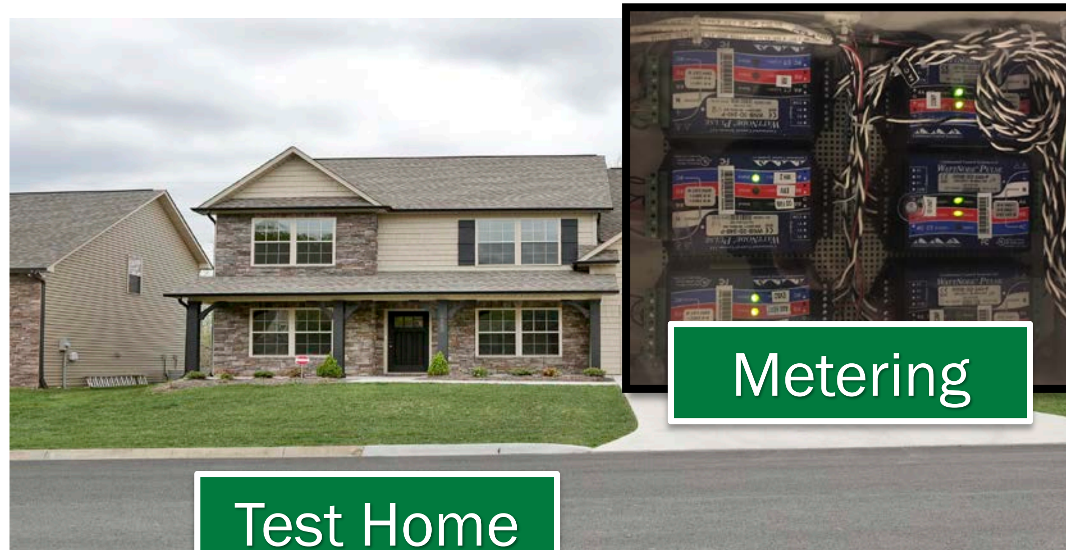




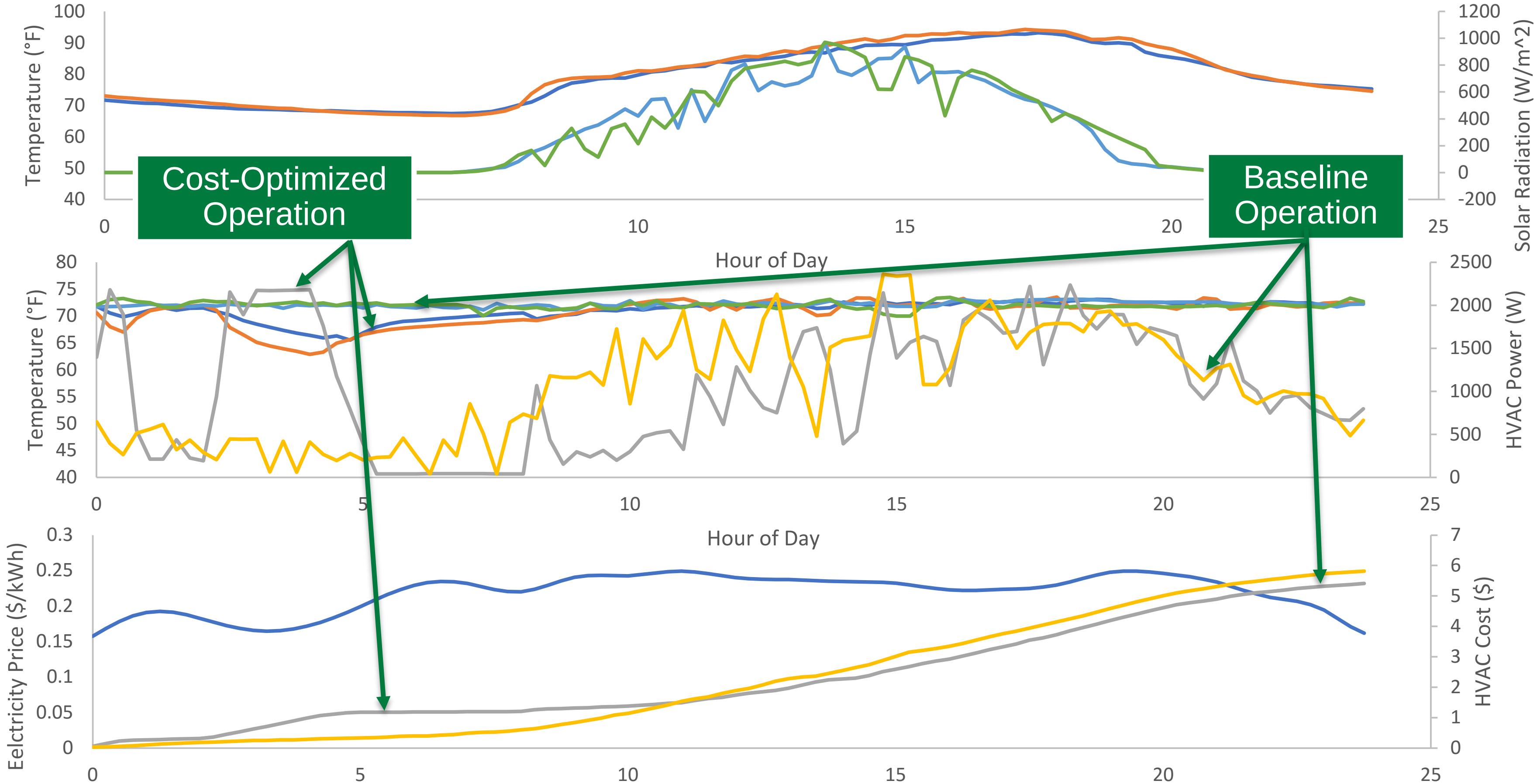
Approach – Validation on Hardware

Test Beds

- Yarnell Station actual home in a neighborhood.
- Yarnell has been retrofitted to mirror the connected neighborhood homes.
  - Carrier Greenspeed® home comfort system with an Infinity Touch thermostat
  - Rheem hybrid electric water heater
  - SiteSage
- Provides a baseline for establishing the optimization and control framework validation.
- Demonstration of tuned models for optimization and control.



Progress Continued (Price signal responsive)

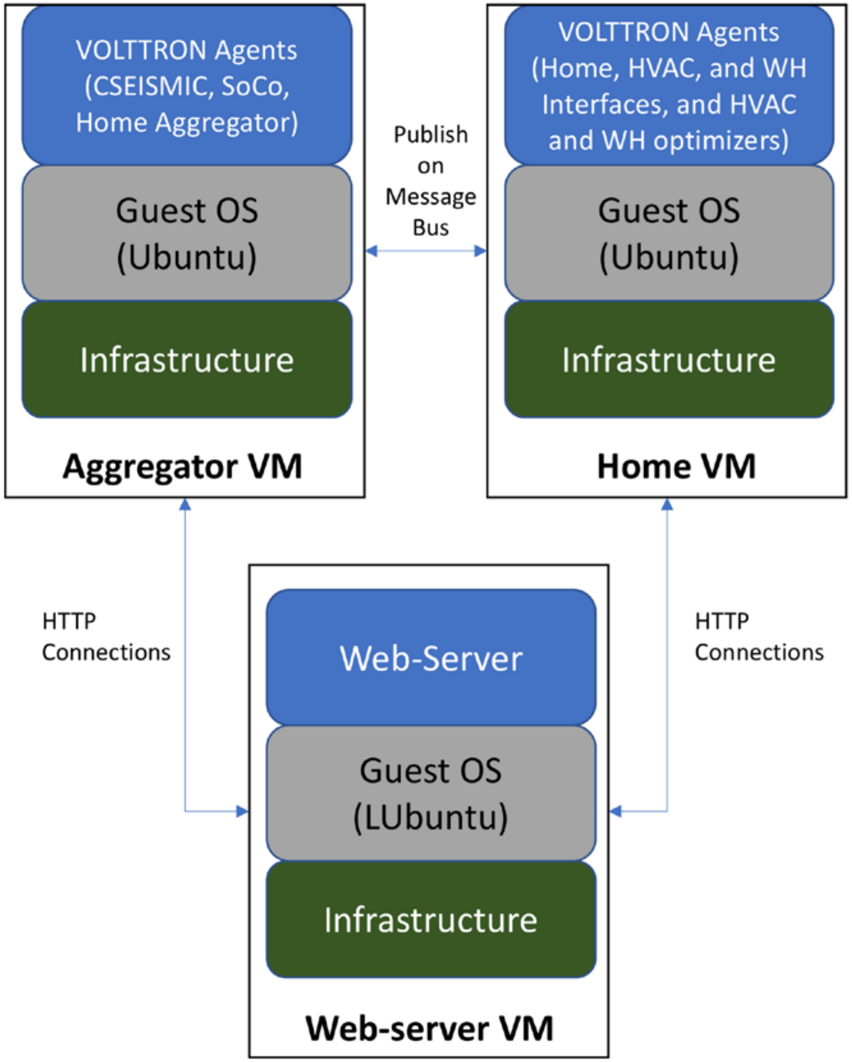


- Several weeks of running optimization (Summer 2017) at Yarnell.
- Data sorted to find closest matching weather examples.
- Price signal dynamic and opt.

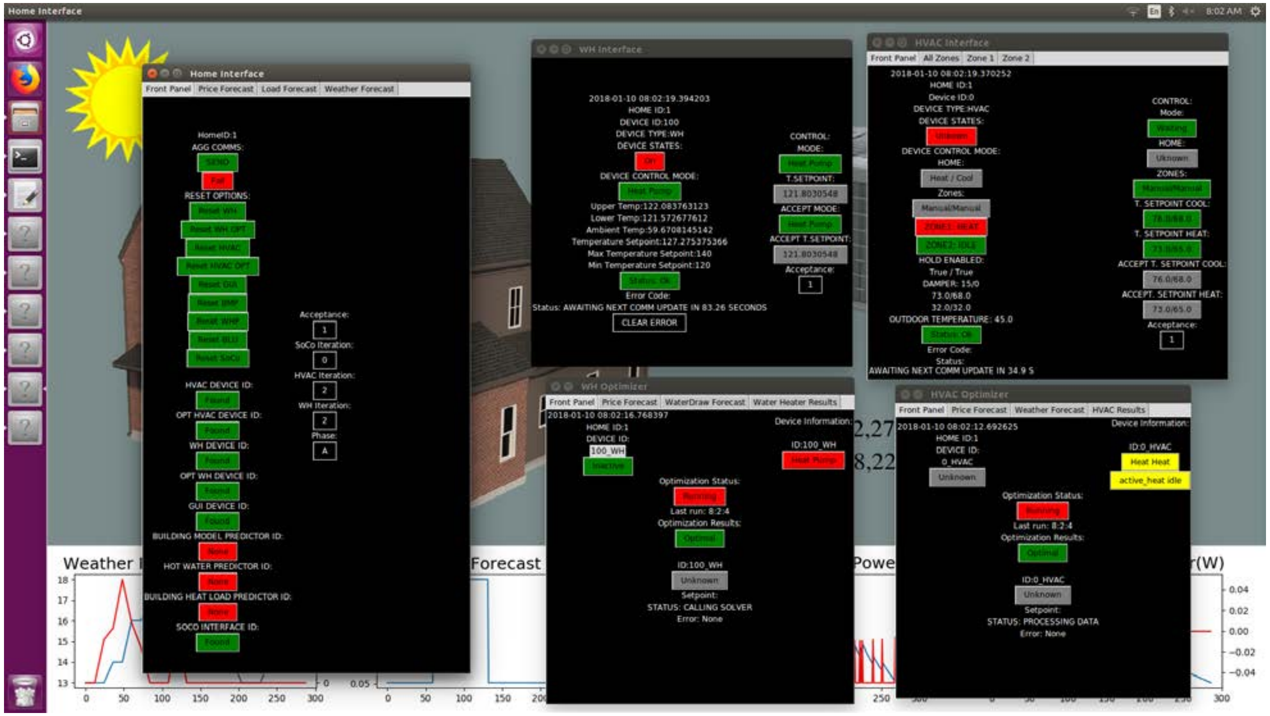
Approach - Validation on Software

Test Beds

- Computational validation testbed developed.
- Testing large scale implementation of the data architecture.
- Utilized to size computational requirements for deployment.
- Physical server with 128 cores and 128 GB of memory that be can allocated.
- One virtual machine per home connected to virtual communication interfaces that simulate device communications and utility interface.

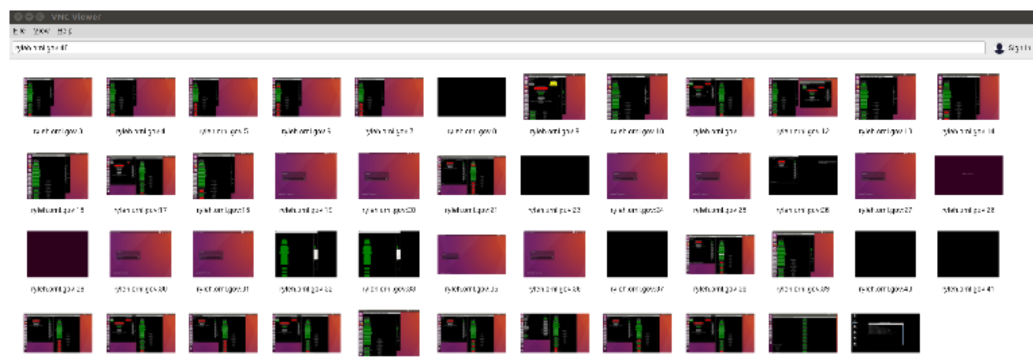


Progress Continued



- Device interfaces exist in gui and non-gui format.
- Agents displaying information and performing iterations for control and opt.

- On test-bed simulation test on 1, 8, 50 homes.
- Displayed 50+ virtual machines running and communicating.



51 Virtual Machines Simulating 50 Homes

Progress – Deployment in Progress

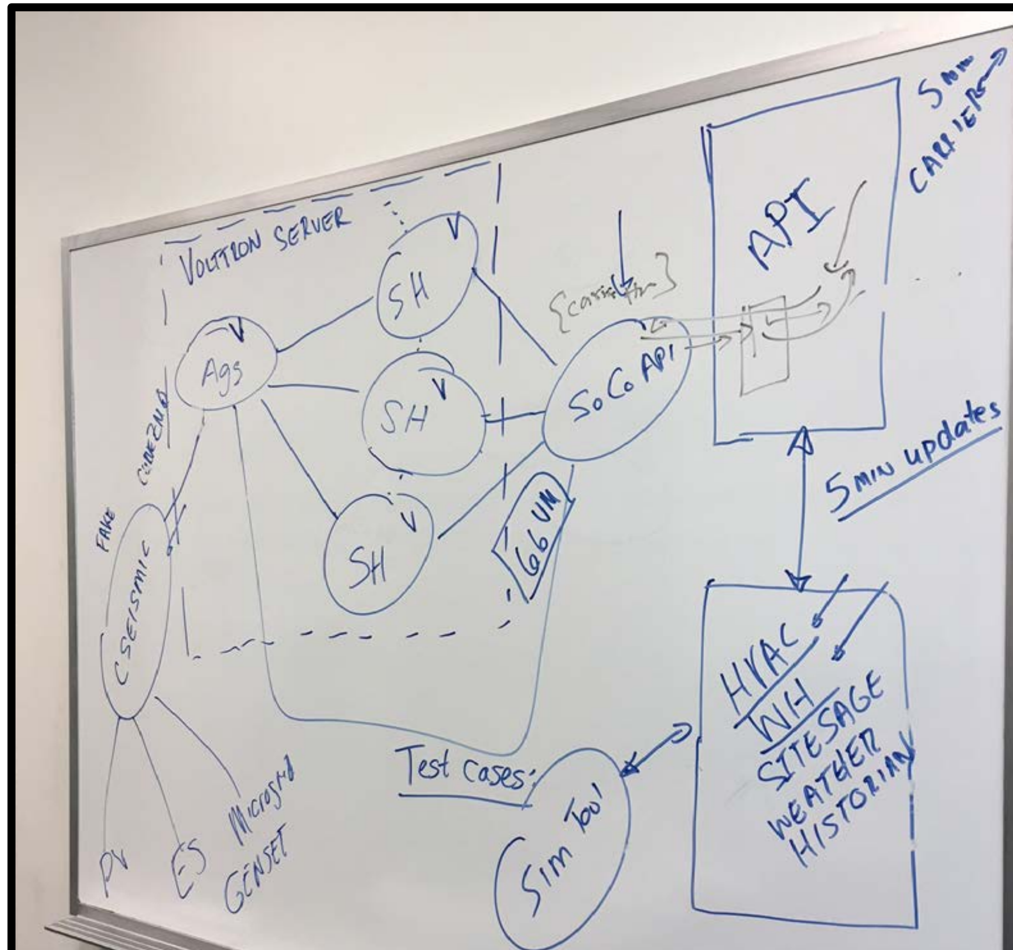
Advanced VOLTTRON™ Control Platform

Accomplishments:

- Developed agent framework to support device communications and controls.
- Developed optimization agents to support optimization of HVAC and load resources.
- Developed negotiation strategy with microgrid controller and communication means.
- Tested optimization and control approach at Yarnell research house.
- Tested agent framework at 50-home residential scale in simulation.
- Deployed agent framework on utility partner SoCo servers.
- Data collected for the last several months on occupied homes using agent framework.
- Draft ORNL report completed and submitted to DOE.
- 2 Journal Articles in "Draft" stage.

Stakeholder Engagement

- CRADA and NDA documents signed to access and develop API (Carrier, Rheem, Southern Company).
- Direct multi-call weekly discussions on API development with Southern Company – specific to architecture.
- Direct coordination on deployment of transactive platform, daily emails and phone calls.
- Discussions with vendors on API interfacing and communication needs.



Impact and Remaining Work

Target Market and Audience:

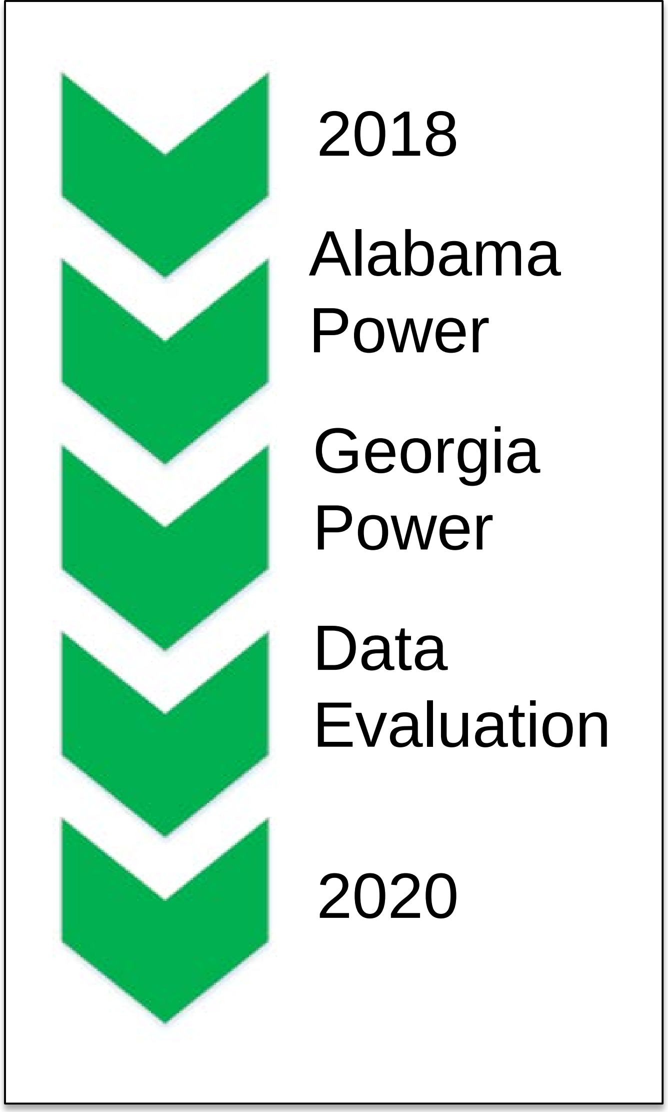
- Utilities looking to increase the *quantity and quality* of load resources.
- Device manufacturers looking to provide IoT solutions for integration in large scale utility projects.

Near Term:

- Begin the collaboration with Georgia Power project encompassing HVAC, water heaters, energy storage.
- Deploy final set of architecture including learning algorithms.

Long Term:

- Collect data and evaluate performance in Alabama Power deployment.
- Develop architecture and deploy agent based framework in coordination with Georgia Power.



Thank You

Oak Ridge National Laboratory
Michael Starke, PhD
starkemr@ornl.gov

REFERENCE SLIDES

Project Budget

Project Budget: Original project plan was $750K for FY16, followed by $1 million for FY17 and FY18.
Variances: FY16 actual funds received were $125K in July 2016. FY17 funds received were $75K was received in Oct 2016 and $1.
Cost to Date: $1,311K (71% of funds received); costs have been delayed to align with funds receipt and site construction progress
Additional Funding: Cost share contribution from Southern Company is confidential.

Budget History					
FY16– FY 2017 (past)		FY 2018 (current)		FY 2019 – Dec 2020 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$1,751	Confidential	$90K	Confidential	$1,900K	Confidential

Project Plan and Schedule

Describe the project plan including:

- Field deployment dates pushed back to align with construction schedule and homeowner move-in.
- Field assessment thru Jun 2020 includes sequence of use case tests as defined in the research plan.