Connected Neighborhood

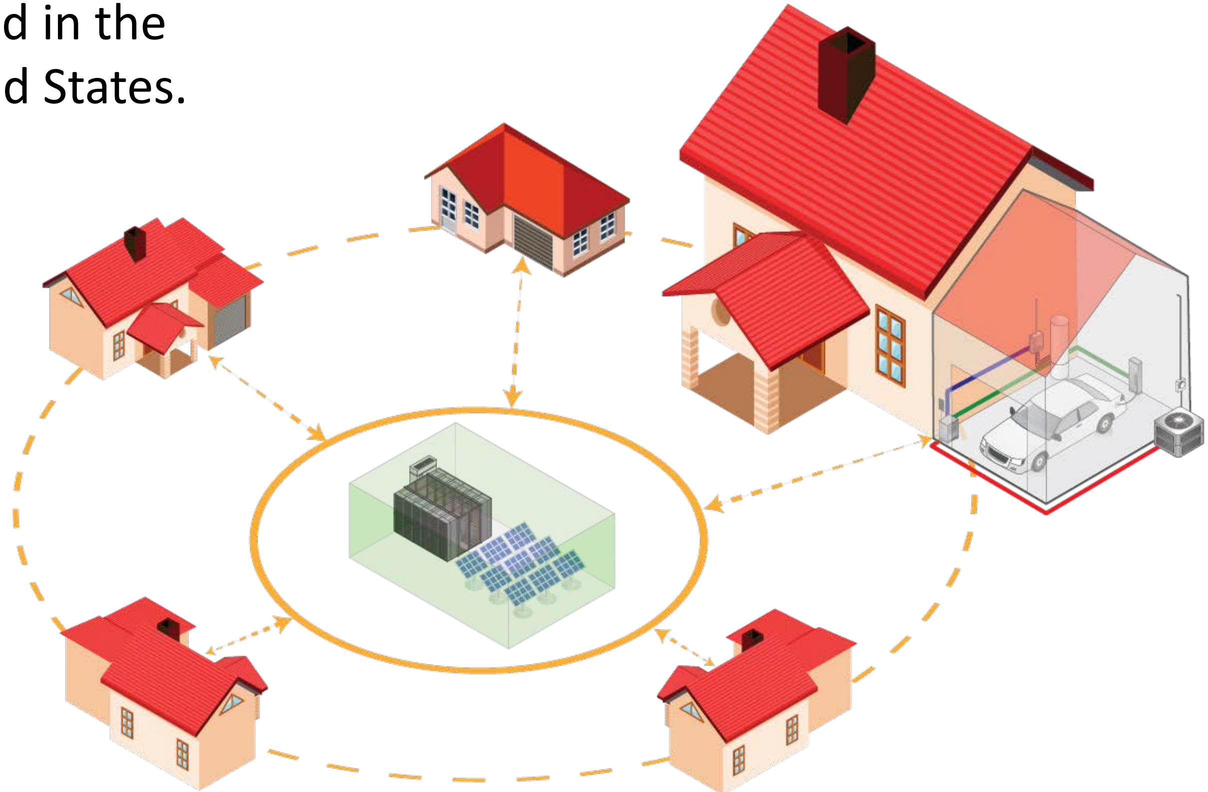
2017 Building Technologies Office Peer Review

First-of-its-kind, **transactive** residential microgrid in the Southeastern United States.

Southern Company

Alabama Power

Georgia Power



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Project Summary

Timeline:
Start date: March 2016
Planned end date: December 2020

Key Milestones

1. Draft reference guide for control architecture in connected neighborhood detailing use cases, load management techniques, and deployment specification (12/31/2017)
2. Draft deployment specification document in collaboration with Southern Company on the connected neighborhood in Alabama (9/30/2017)

Budget:

Total Project $ to Date:

- DOE: $470,000
- Cost Share: $233,812 (FY17)

Total Project $:

- DOE: $2,000,000
- Cost Share: $378,865

Key Partners:

Southern Company
Alabama Power
Georgia Power
Carrier
Rheem

Project Outcome:

Using VOLTTRON™, demonstrate a neighborhood-level, buildings-to-grid integration strategy that demonstrates grid integration, scalable distributed control and residential transactive controls for end-use energy management.

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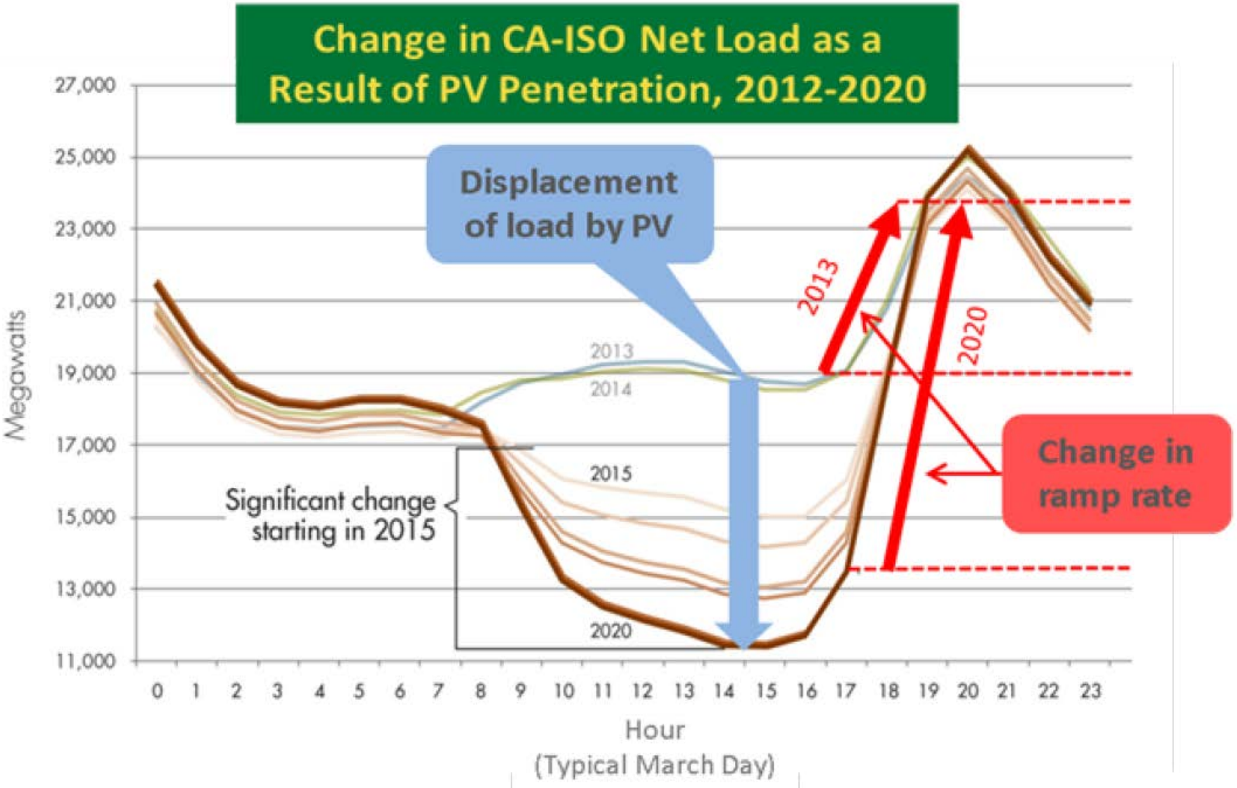
Purpose and Objectives

Problem Statement:

The **21st century** demands a modern, flexible grid capable of delivering reliable, affordable, and clean electricity. Additionally, the rapid and continued adoption of renewable resources results in a power grid that is more **intermittent**, **distributed**, and **uncontrollable**. This shift requires operating strategies that take full advantage of all available resources, which includes energy utilization within the building.



However, the magnitude that **building characteristics**, **equipment**, and **appliances** can be leveraged in a **transactive energy** ecosystem to benefit the building owner and the grid has not been shown. **Demonstrated** benefits are needed.

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Purpose and Objectives

With **Southern Company**, deploy two transactive **microgrid** approaches to distributed power generation and storage with **building level energy management** through **VOLTTRON**-based **transactive controls.**

- One neighborhood (~60 new homes) will aggregate renewable generation and distributed energy storage at the neighborhood level through **community scale** storage, solar photovoltaic (PV), and emergency distributed generation. (**Alabama Power**)
- Second neighborhood (~50 homes) will utilize a fully distributed approach with rooftop solar PV and home energy storage. Project start will be in Q3 2017. (**Georgia Power**)

Q1 FY16 — Southern Company

Q1 FY17 — Alabama Power

Q3 FY17 — Georgia Power

Purpose and Objectives

Target Market: Residences and electricity providers nationwide.

- **113.6 million residences**[1]
- **3,306 electricity providers**[2]
- **4.388 Quads of Electricity**[1]

Impact of Project:

- Neighborhood-level transactive energy and controls integration strategy that demonstrates grid integration, scalable distributed control and end-use energy management.
- VOLTTRON-based, building-level control of HVAC and water heating to deliver virtual storage capacity to offset electrical storage requirements.
- **Near-term Outcomes** – New VOLTTRON™ agents for HVAC, water heating and system self-discovery implemented in homes.
- **Intermediate Outcomes** – Assess the transactive control at 2 neighborhoods.
- **Long-term Outcomes** – large scale implementation by utility.

[1] DOE RECS 2009

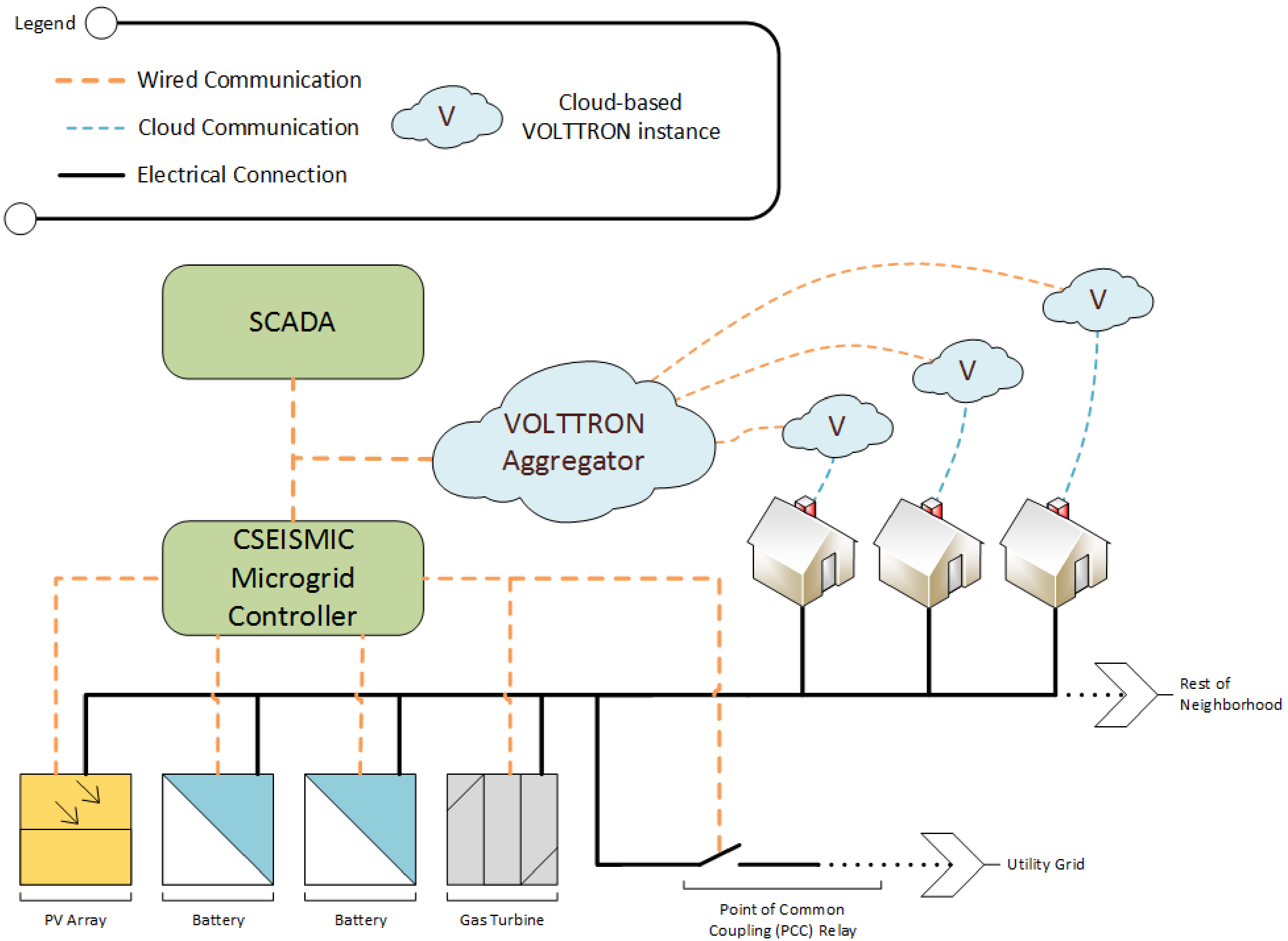
[2]American Public Power Association 2015-2016 Annual Directory

Approach – Utility Use Cases to Explore

- **Prioritize cost:** The goal of generation management will be to reduce cost to “pool” participants. The goal of demand management is to reduce cost to the individual customers and utility.
  - Based on weather, solar irradiance, and load forecasts coupled with time of use pricing, the neighborhood master controller will optimize battery storage, generation, and “virtual storage” to minimize overall system cost.

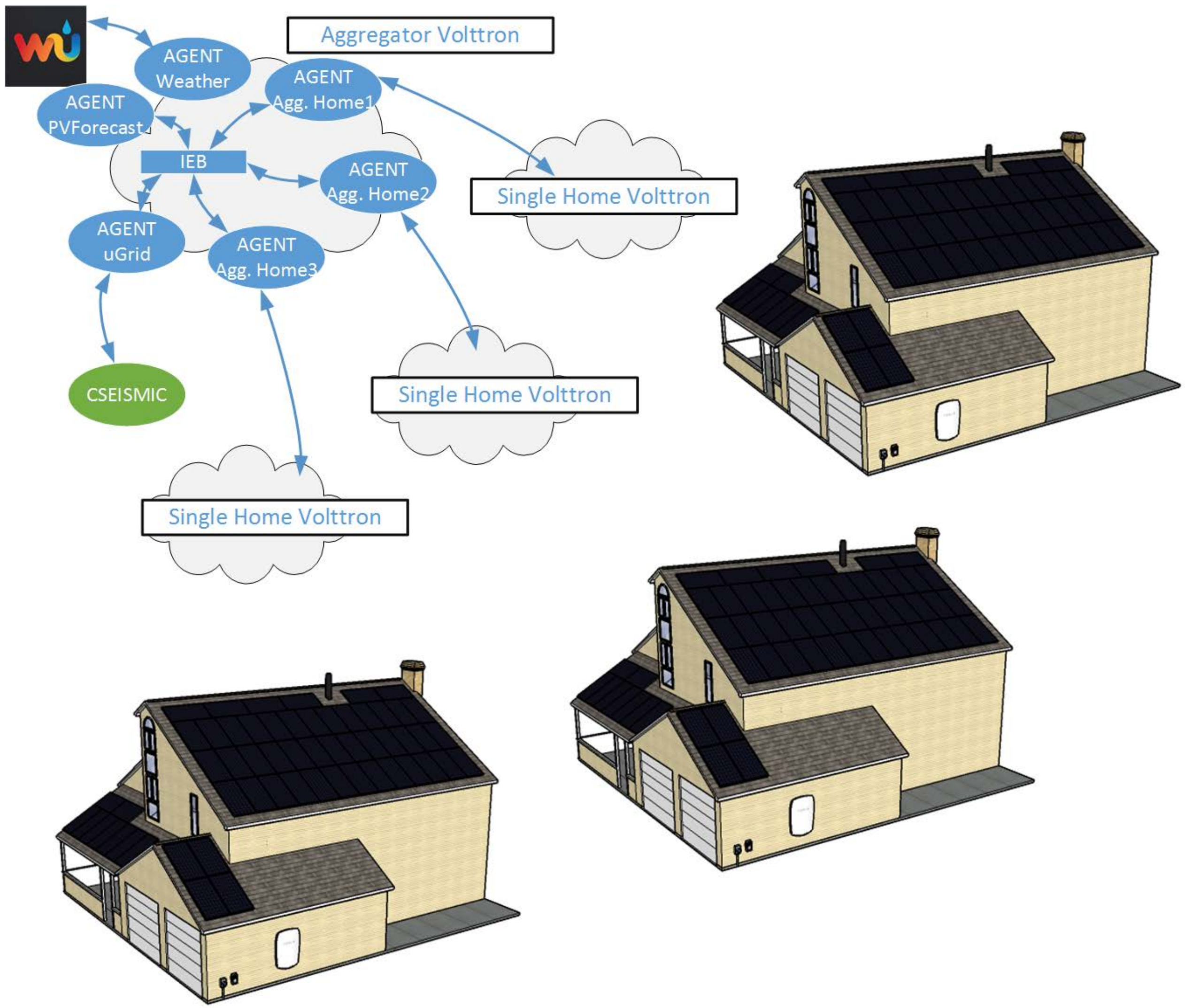
- **Prioritize reliability:** The goal is to demonstrate improved reliability for all customers served in the microgrid.
  - Loads would be cycled to provide a level/flat and continuous aggregate load (to help the generator and reduce the battery’s PV smoothing requirements).

Approach – Neighborhood Architecture



Approach – VOLTTRON™ Framework

- Each home within the community will have a single VOLTTRON™ instance.
- The communication to Microgrid Controller will go through an aggregation VOLTTRON™ instance that compiles data and transacts with Microgrid.



IEB - Information exchange bus

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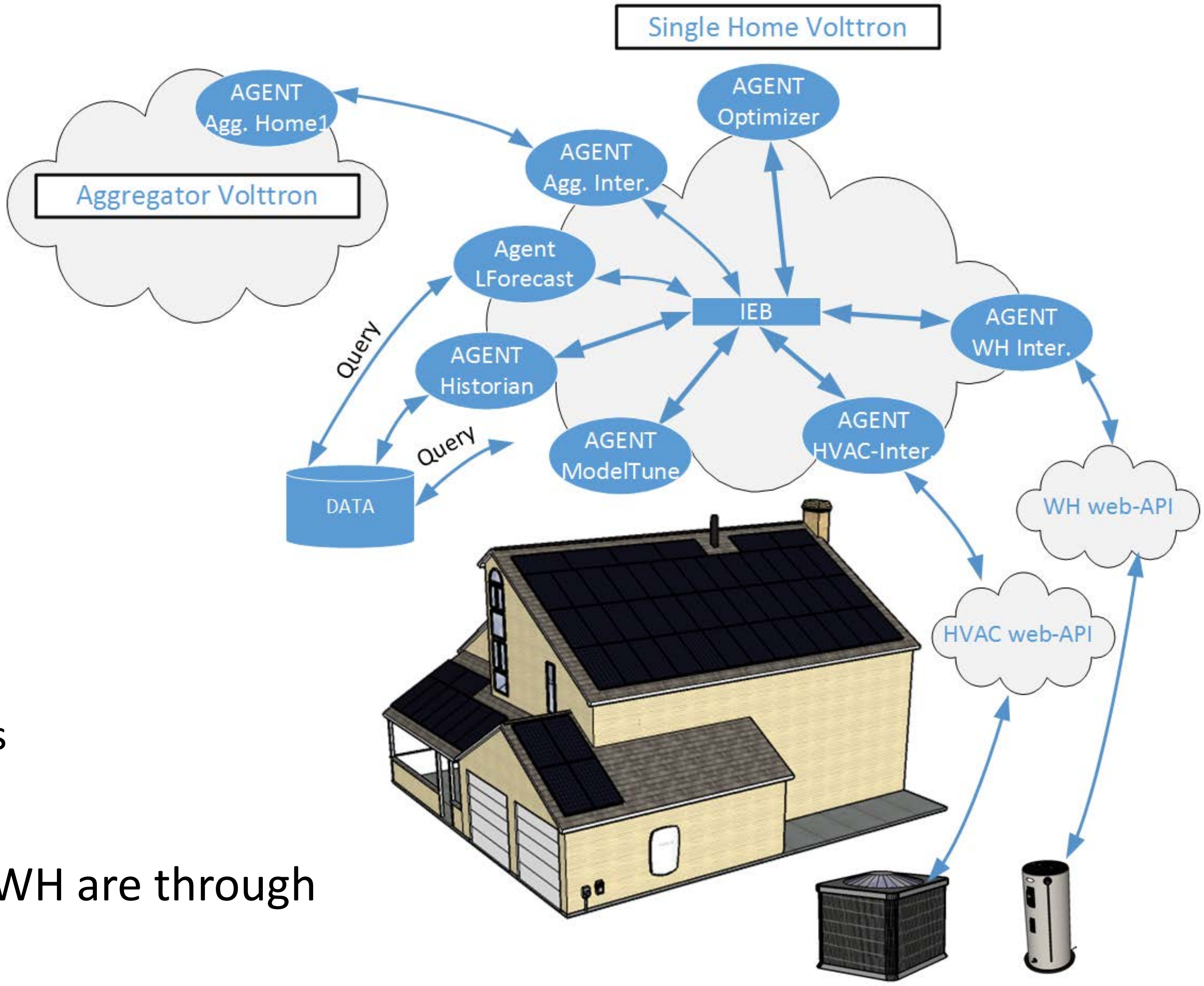
Approach – VOLTTRON® Home Instance

- Each home VOLTTRON™ instance will support a number of different agents:
  - Optimizer
  - HVAC Interface
  - WH Interface
  - Learning Algorithms
  - Historians
  - Forecasting Algorithms
- Interfaces to HVAC and WH are through vendor provided API.



Approach

Key Issues:

- Integration of multiple disciplines, organizations, and desired outcomes in one project.
- Communication and optimization of multiple types of DERs and vendor devices down to the home level.
- How to dispatch individual home loads based on a microgrid controller's evaluation of resource availability and cost.
- How to do all of this - *within the limits of the customer's comfort preferences, while maximizing the economic benefit to the customer.*

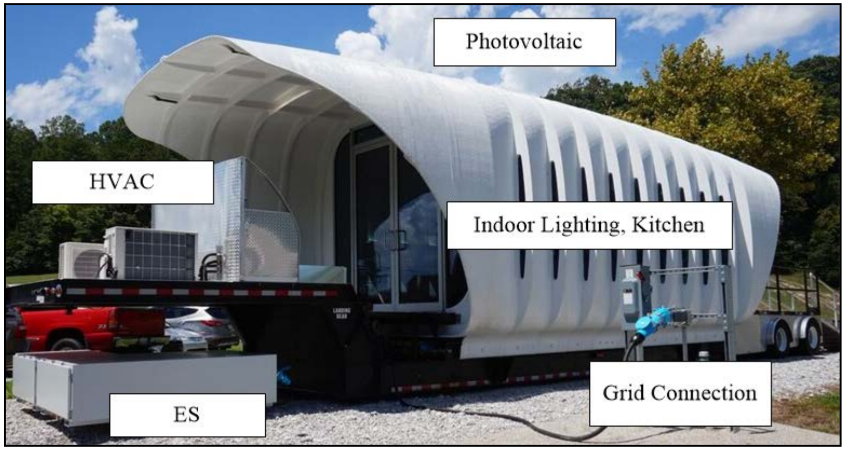
Distinctive Characteristics:

- **First-of-its-kind** residential microgrid deployment in the Southeastern US.
- Uses **transactive controls** to monitor and control home appliance loads.
- Addresses centralized (utility-owned) DER as well as customer-owned DER (e.g. roof mounted solar and home battery systems).

Progress and Accomplishments

Accomplishments:

- Defined home characteristics (construction, HVAC and WH appliances)
- Developed a self-discovery agent for VOLTTRON™ (will facilitate the automatic addition of new appliances as the neighborhoods are built).
- Established computing requirements for the home VOLTTRON™ systems and a neighborhood aggregator VOLTTRON™ instance based on a cloud computing arrangement.
- Drafted the initial reference guide, which will be edited as the project progresses.
- Demonstrated communication and control functionality on AMIE with VOLTTRON™ agents.
- Retrofitted a lab research home to serve as a local evaluation platform.
- Executed NDAs with Carrier and Rheem.
- Demonstrated connectivity and functionality with Rheem API.
- Final stages of executing a CRADA with Southern Company Services.



Progress and Accomplishments

Market Impact:

- Teamed with two major manufacturers of HVAC and water heating equipment for deployment of their equipment at the two neighborhoods.

Lessons Learned:

- Available Home Energy Management Systems are based on proprietary software. Securing agreements for access to that software and/or APIs can be time-consuming and costly.

Project Integration and Collaboration

Project Integration:

- The project team collaborates through weekly conference calls and frequent on-site meetings at ORNL and the Southern Company laboratory. The project team also has regular conference calls with appliance manufacturers and has met at the manufacturer's facilities.
- Project significantly leverages other GMLC and transactive controls research projects, for example, Virtual Storage, Connected Home, etc.

Partners, Subcontractors, and Collaborators: Primary project partners are Southern Company, and subsidiaries Alabama Power, Georgia Power and PowerSecure (turnkey DER provider). Additional partners include Carrier (HVAC manufacturer) and Rheem (water heater manufacturer). Both industry partners have allowed the Lab access to their API for appliance monitoring and control.

Southern Company

Alabama Power

Georgia Power

Next Steps and Future Plans

Next Steps and Future Plans:

- Laboratory testing of the VOLTTRON™ app at an unoccupied research house.
- Laboratory testing of communication between VOLTTRON™ at the home and a microgrid controller (demonstrating integration with DER).
- Field deployment at the first connected neighborhood in Alabama.

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REFERENCE SLIDES

Project Budget

Project Budget: Original project plan included $750K for 2016, followed by $1 million for the following two years.
Variances: FY16 funds actual funds received were $125K, of which $25K was received in July and $100K was received in July 2016. Original FY17 request was $1 million, of which $75K was received in October 2016.
Cost to Date: Costs to date are $216K. Effort and equipment expenses are delayed to align with timing of funds receipt.

Budget History					
FY 2016 (past)		FY 2017 (current)		FY 2018 – FY 2020 Q1 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$125K*	$	$133K*	$	$ 2 Million	$

*** Indicates funds received (not FY budget request).**

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Project Plan and Schedule

Project Schedule												
Project Start: March 2016	Completed Work											
Projected End: December 2020	Active Task (in progress work)											
	◆ Milestone/Deliverable (Originally Planned)											
	◆ Milestone/Deliverable (Actual)											
	FY2016				FY2017				FY2018			
Task	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
Past Work												
Q4 FY16 Milestone: Complete Literature Review				◆								
Q4 Milestone: Establish Use Cases				◆								
Q4 Milestone: Establish Features				◆								
Q4 Milestone: Draft reference guide				◆								
Current/Future Work												
Q2 Milestone: Develop VOLTRON Apps					◆	◆						
Q2 Milestone: Initial App Testing (Lab)						◆						
Q3 Milestone: Final App Testing (Lab)							◆					