Connected Neighborhoods

Altus Neighborhood, Photo Courtesy: Georgia Power

Reynolds Landing Neighborhood, Photo Courtesy: Alabama Power

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Project Summary

Timeline:

Start date: Oct 2018

Planned end date: June 2023

FY21 Key Milestones

1. Complete GA software deployment; Dec 31 2020
2. Execute Use Cases; June 30 2021

Budget:

Total Project $ to Date:

- DOE: $3.4M
- Cost Share: Confidential (Southern Company)

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Key Partners:

Southern Company (CRADA)	
Alabama Power	Georgia Power
Carrier	Lennox
Rheem	AO Smith
SiteSage	LG Chem
	ecobee
	Skycentrics

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 quantify and demonstrate the impact that grid-interactive controls at residential and neighborhood level.

Team

ORNL

Heather Buckberry, Principal Investigator – Lead project team, analyze results, write publications/present results
Michael Starke, Home Optimization Lead – Develop Objective Functions for Device and Home Optimization
Helia Zandi, Home Optimization Developer – Develop Equipment Models/Controls and Machine Learning
Jeff Munk, Equipment Lead – Develop HVAC and WH optimization models
Chris Winstead, System Architect – Develop Cloud Deployment, Integrate Optimization Code, Dashboard Architect
Teja Kuruganti, Subprogram Manager – System integration, controls, and data analytics

Southern Company

Justin Hill, Principal Investigator – Lead SoCo R&D, engineering and IT teams
Chase Cortner, Research Engineer - Interface with AL and GA neighborhood homeowners
Vincent Williams, Georgia Power Site Representative – Interface with GA Homeowners
Greg Sewell, SoCo RES Lead – Lead IT Development Team for SoCo RES (Residential Energy Service)
Che McNichols, System Architect SoCo RES
Eric Baker, Developer SoCo RES

Challenge

Problem Definition:

Buildings account for **35% of CO2 emissions** and almost **40% of the United States' energy use.** The Grid-Interactive Efficient Buildings Roadmap by the US Department of Energy's (DOE's) Building Technologies Office (BTO) notes that implementing grid-interactive efficient building (GEB) technology has the potential to **reduce CO2 emissions by 80 million tons/year**—roughly equivalent to 17 million cars.

Challenges to realizing a portion of this technical potential, in the residential market, include

- How to interface with a variety of unique manufacturer interfaces
- Forecast home level and equipment loads using simplified models
- How to effect home device level control to support aggregated load shapes for the neighborhood.

Altus Neighborhood, Photos Courtesy: Georgia Power

Approach - Overview

- Utilize home device's native IoT functionality and manufacturer APIs as source for actionable data and to serve as a control "lever" to effect shift and shape loads at the home and neighborhood scale.

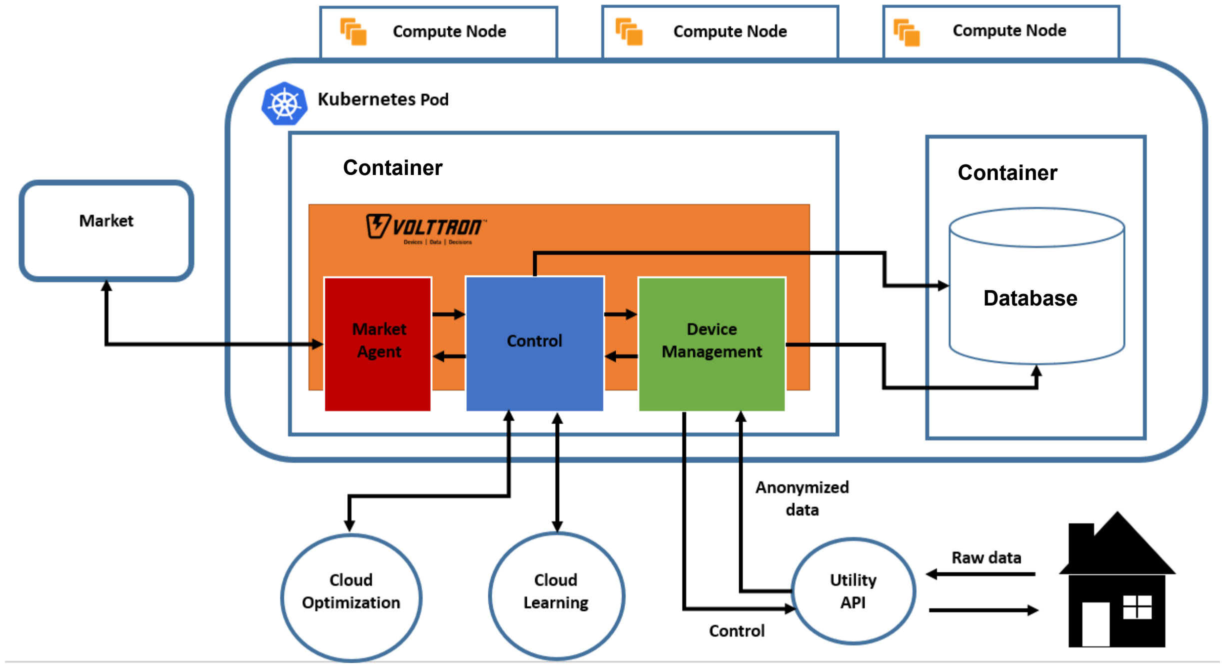
- Deploy using commercial cloud computing for our platform, continuously obtaining load and utility price information, computing the home loads and solutions, then adjusting device setpoints within the bounds of customer setpoint preferences.

- Demonstrate distributed energy resources (DERs) and Demand Flexibility use cases optimizing cost, reliability, and environmental impact with real-time utility-to-customer interaction

Reynolds Landing Idea Home, Photo Courtesy: Alabama Power

Altus Neighborhood, Photos Courtesy: Georgia Power

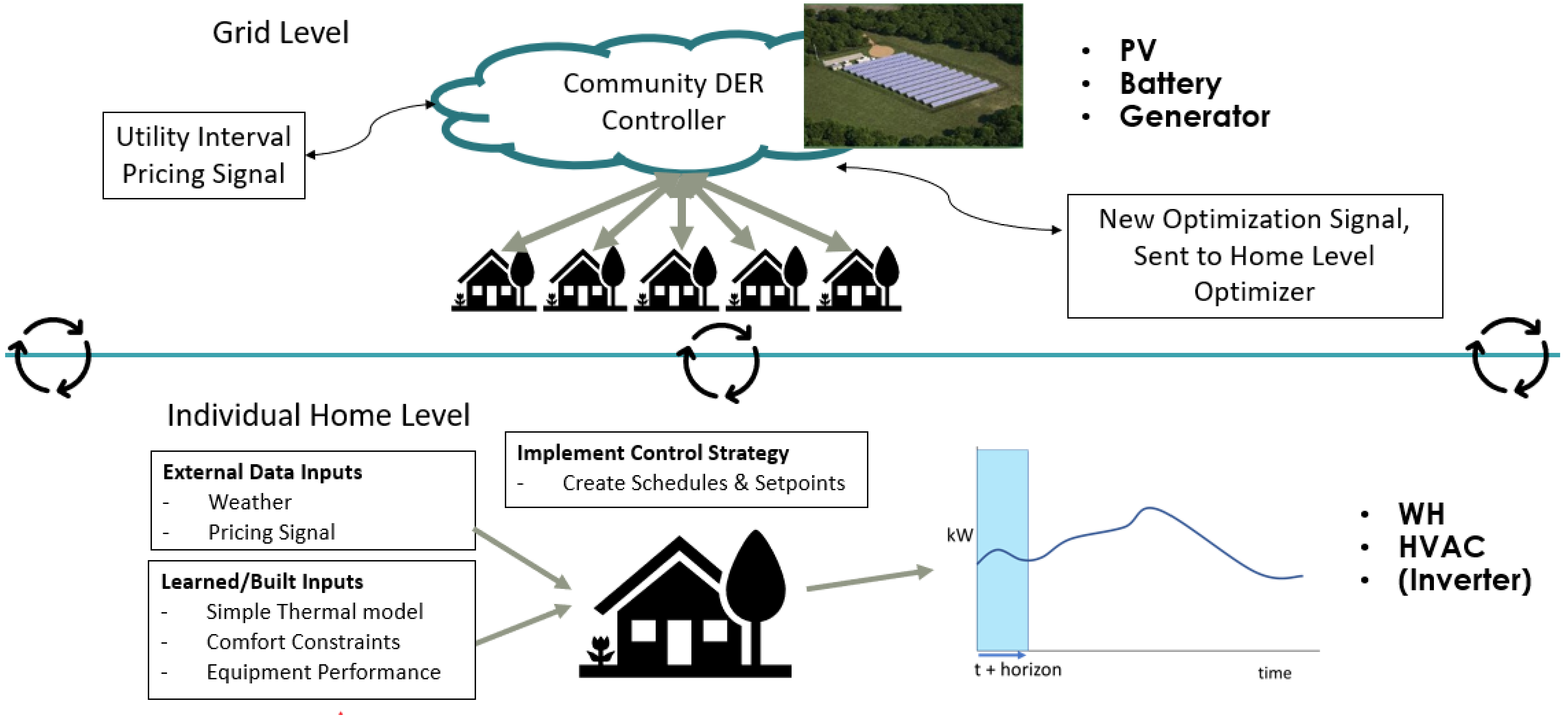
Approach – Software Architecture



ORNL Oak Leaf Architecture (Altus Neighborhood)

- An integrated system interacting with vendor API, SoCo API, computing in the cloud using an agent-based framework
- Cloud-based services to:
  - Host our Oak Leaf optimization
  - Pull load status, weather and utility price information
  - Push device setpoints
  - Dashboard performance
  - Access data lakes used for long term storage
- Enable utilization of different data sources in near real-time
  - Device measured data
  - Weather forecasting
  - Predicted behavior
- Utilizes learning and predictions to assess future operations

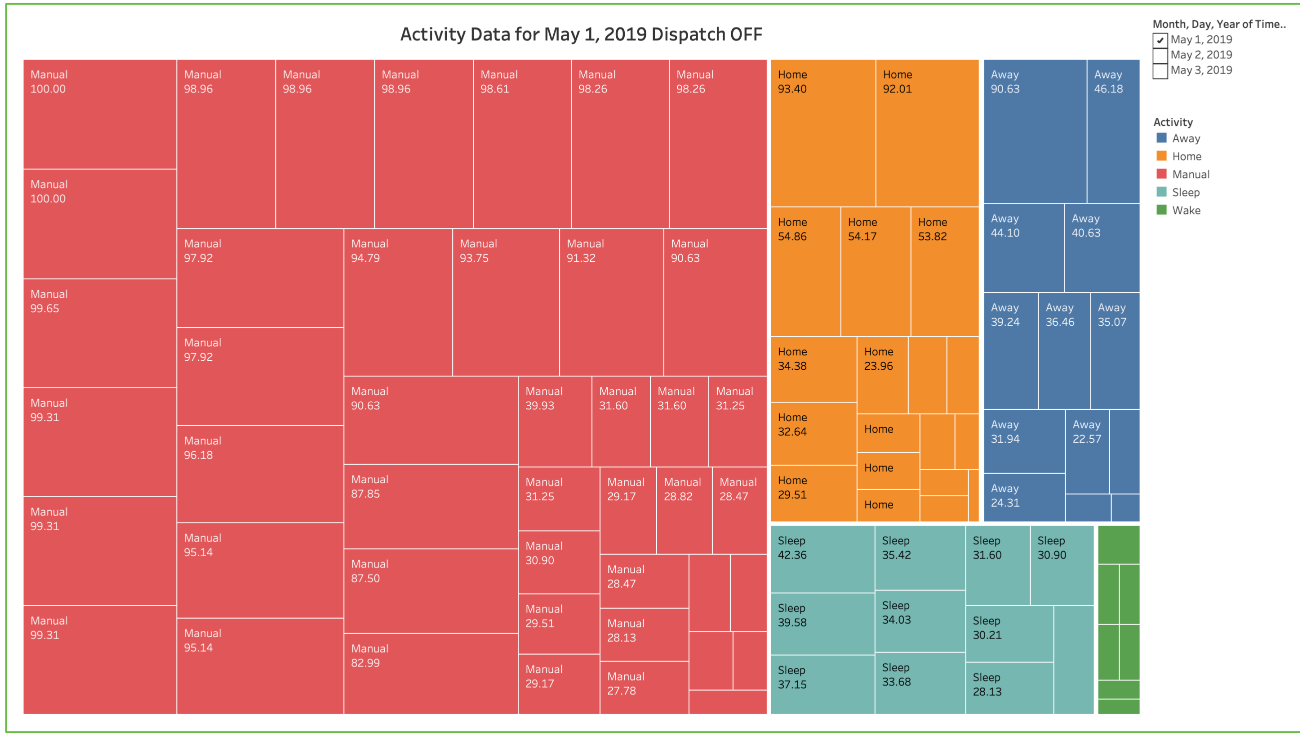
Approach – Modeling & Optimization



Microgrid rendering, Courtesy: Alabama Power

Approach – Barriers & Mitigation

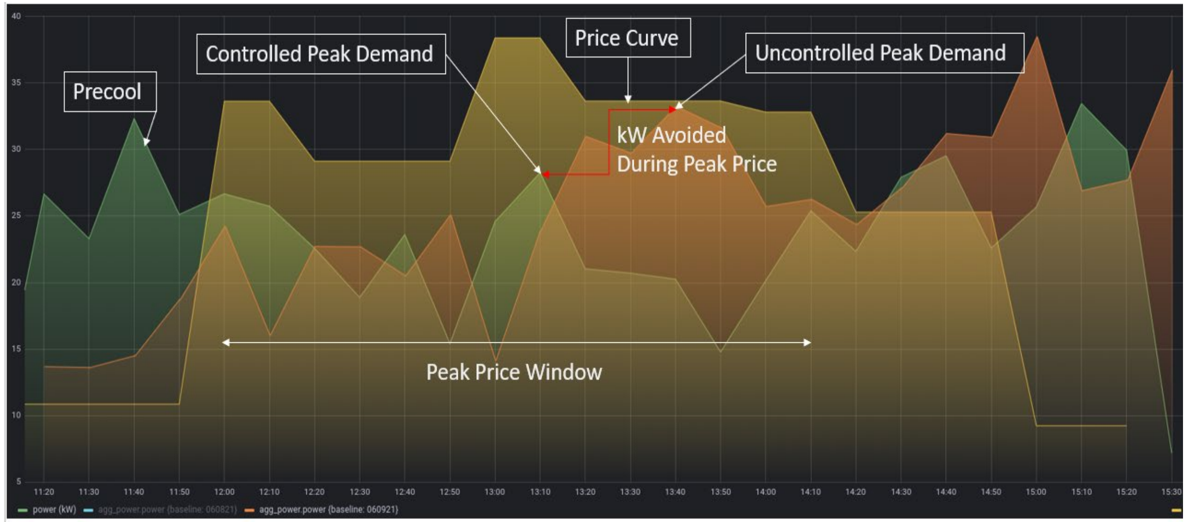
- Barriers, technical challenges, and project risks:
  - Lack of standardized APIs and data framework
  - Homeowner acceptance/use of programmable devices
  - Limits on homeowner acceptance of setpoint reset
  - Limited control inputs for certain types of device
- Mitigation strategies:
  - Work closely with manufacturers to understand their APIs
  - Use a utility developed system to disaggregate personal information, parse data and standardize input fields
  - Utility staff meet with homeowners to help setup their systems
  - Build in methods to help detect homeowner changes and temporarily pause Oak Leaf changes to their systems



Impact

ORNL's Oak Leaf optimization and dispatch system shaped and shifted loads by changing HVAC, water heater, and(for the Altus neighborhood) inverter set points ahead of real-time price increases forecast by the utility.

- Alabama
  - HVAC peak power demand reductions of 15% were observed in summer operation
  - water heater demand was reduced 43% in winter operation.
- Georgia
  - HVAC peak power demand reductions of 12% were observed in summer operation



Reynolds Landing 2019

44% less energy consumed than baseline neighborhood

7,167 kWh saved annually per home on an equivalent square foot basis

$931 saved annually per home on an equivalent square foot basis

5.6 tons of CO_2 generation annually avoided per home

Altus 2020

42% less energy purchased annually compared with baseline neighborhood on sq ft basis

20% energy savings (excluding PV generation) compared to baseline neighborhood on sq ft basis

Homes averaged 873 kWh sold back to Georgia Power annually

In winter, 30% lower maximum hourly kW demand than baseline

In summer, 62% lower maximum hourly kW demand than baseline

9.3 tons of CO_2 generation annually avoided per home

Progress

- Overall the project is in the mid to late phase.
  - AL - deployment and assessment completed in March 2021.
  - GA - deployment began in spring 2021, use case testing/data collection and data analysis ongoing through Dec 2022
- Accomplishments:
  - Successfully integrated with APIs for multiple equipment types and from different manufacturers
  - Developed unique simplified device and home models to forecast and then optimize device and home loads
  - Developed a grid-interactive approach to optimize and control select home loads in conjunction with microgrid and utility price forecasts
- Budget – have expended planned FY21 funding, new funding for added scope
- Schedule – was extended to align with site construction progress (some COVID delays)and added scope
- Key technical and validation highlights
  - HVAC and WH, as grid-interactive loads, can provide significant demand response (load shift/shed)
  - Homeowners desire a means to opt out of optimized control on occasion
  - WHs provide more, and longer duration, load shaping than HVAC – but at a different time and season
  - HVAC results can be limited by homeowner sensitivity to temperature changes
- Why does this matter? By seamlessly integrating controllable loads with the grid, we can demonstrate cost savings for homeowners as well as demand response and load shape to the utility.

Stakeholder Engagement

- **Ongoing, close collaboration between CRADA Partners ORNL and Southern Company**
  - ORNL and SoCo Research meet weekly
  - Full project team (ORNL, SoCo Research & SoCo IT) meets biweekly
  - Jointly developed use cases
  - Developed the project schedule for development of Oak Leaf and SoCo RES
  - Develop and maintain the deployment (and use case) schedules
- **Homeowner Connection**
  - Southern Company, Alabama Power and Georgia Power are the POCs for homeowners
  - Monthly focus groups and surveys
  - Respond directly to homeowner requests
- **Equipment Manufacturer Connection**
  - NDAs established
  - Both SoCo and ORNL work with the equipment (HVAC, WH, Inverter) manufacturers to interface with their APIs
  - ORNL provides manufacturers feedback on APIs and controls

Remaining Project Work

Continue GA use case testing (for summer and winter) through Dec 2022 to include:

- Economic Comparison
- Solar Self Consumption
- Shape Load
- Microgrid controller integration
- Real Time of Use (RTU) price signal
- Situational Awareness – pre-charge battery
- Islanding

Develop final project CRADA report - June 2023

Submit software copyright – June 2023

Investigate opportunities for third party integrators to use Oak Leaf software

Ultimate Success: Oak Leaf optimization forms the basis for integrators and utilities to implement at scale

Thank you

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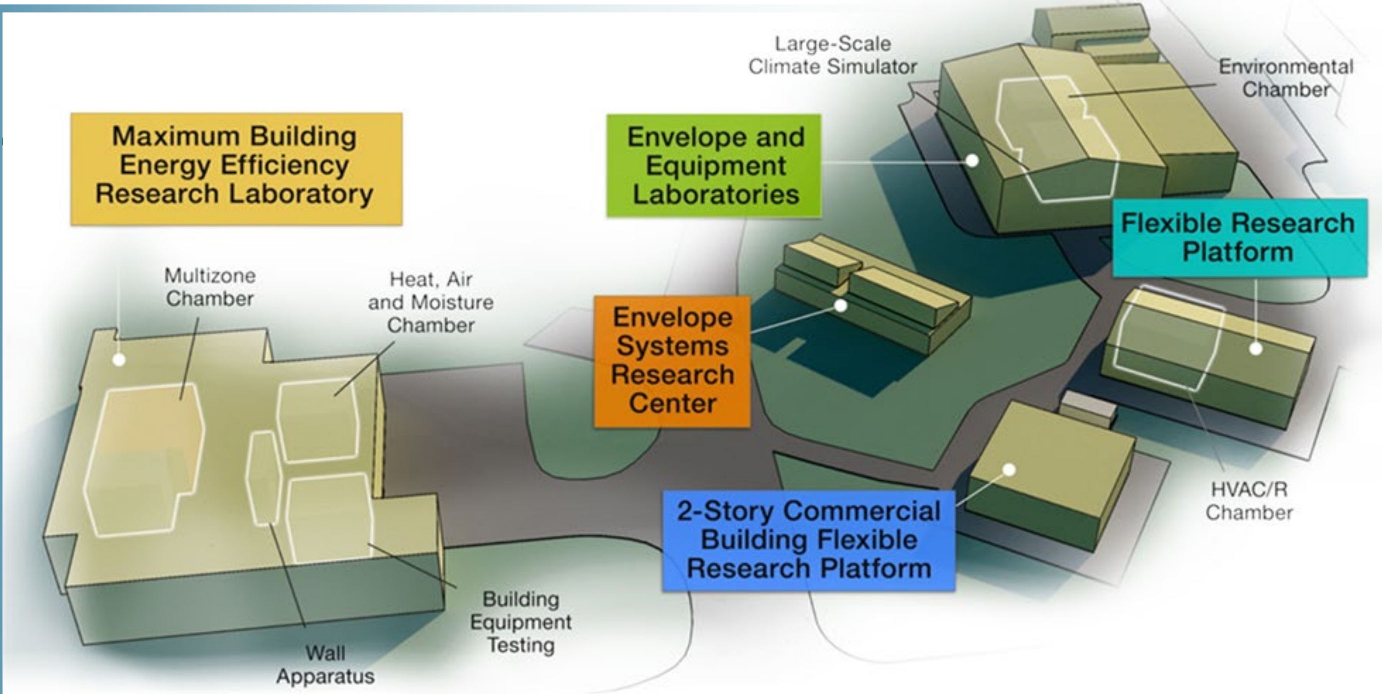

ORNL's Building Technologies Research and Integration Center (BTRIC) has supported DOE BTO since 1993. BTRIC is comprised of 50,000+ ft^2 of lab facilities conducting RD&D to support the DOE mission to equitably transition America to a carbon pollution-free electricity sector by 2035 and carbon free economy by 2050.

Scientific and Economic Results

238 publications in FY20
125 industry partners
27 university partners
10 R&D 100 awards
42 active CRADAs

BTRIC is a DOE-Designated National User Facility

REFERENCE SLIDES

Project Budget

Project Budget: original plan lab call L048-1533 $3.4M (FY19-FY21 as follows: $1.5M, $1.5M, $400K)
Variances: Additional funds added under separate project for added scope and extended duration
Cost to Date: 100% of original funding
Additional Funding: Additional scope has been funded for $427K in FY21/22 for added tasks

Budget History					
FY19 – FY 2020 (past)		FY 2021 (current)		FY 2022 – June 2023 (planned request)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$3M	Confidential	$400K	Confidential	*$427K*	Confidential

Project Plan and Schedule

Describe the project plan including:

- Lab call L048-1533 start date Oct 1, 2018 & Original Project planned completion date 12/31/20
- Schedule extended to align with site construction by neighborhood developer
- Additional tasks added during following years
- GA neighborhood available for testing thru Dec 2022, final reporting the following 2 quarters

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)
Past Work									
FY19 Q1 Milestone: AL heating season use case qtr report	◆								
FY19 Q2 Milestone: AL software architecture qtr report		◆							
FY19 Q3 Milestone: Deploy AL cooling season use case qtr report			◆						
FY19 Q4 Milestone: Annual Report				◆					
FY20 Q1 Milestone: Source-load optimization AL					◆				
FY20 Q2 Milestone: Adaptive load shaping AL						◆			
FY20 Q3 Milestone: market validation workshop & report (extended to Q4 due to COVID delays)								◆	
FY20 Q4 Milestone: Annual Report								◆	
FY21 Q1 Milestone: Initial Software Deployment (GA)									◆
FY21 Q2 Milestone: Execute heating use cases									
FY21 Q3 Milestone: Execute cooling use cases									
Current/Future Work									