Smart Neighborhoods

Reynolds Landing, Birmingham, AL
Altus, Atlanta, GA

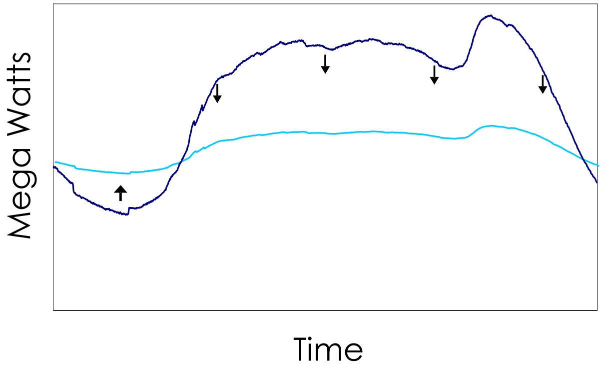
ORNL: Chris Winstead, Helia Zandi, **Teja Kuruganti**

Southern Company: Justin Hill, **Phil Markham**

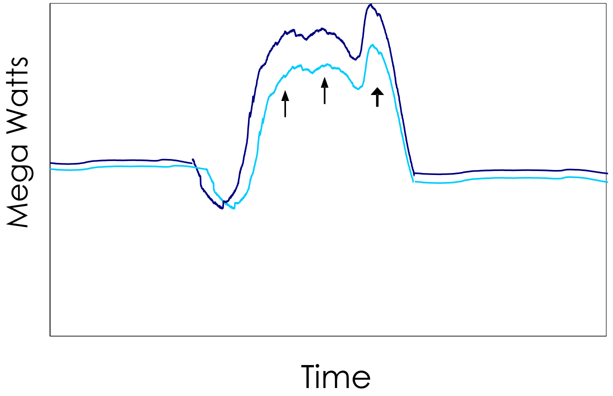
Motivation - Opportunity space

Facilities or large critical loads require microgrids to cost-effectively meet continuity of operations and resilience requirements	Existing electric grid lack methods for managing on-site generation low voltage (building), medium voltage (distribution), and high voltage (transmission) systems	Buildings have the potential to reduce their consumption by 20%-30% through advanced sensors and controls	Significant advantages in co-optimizing microgrid generation & neighborhood-scale consumption/residential loads	Significant need in scalable control and automation techniques for improving resilience and situational awareness

Source: Southern Company



Reduce Energy Intensity and Increase Energy Efficiency



Increase Load Flexibility and Improve Grid Resiliency

5.5 million commercial, 118 million residential, projected to be 80% of load growth through 2040

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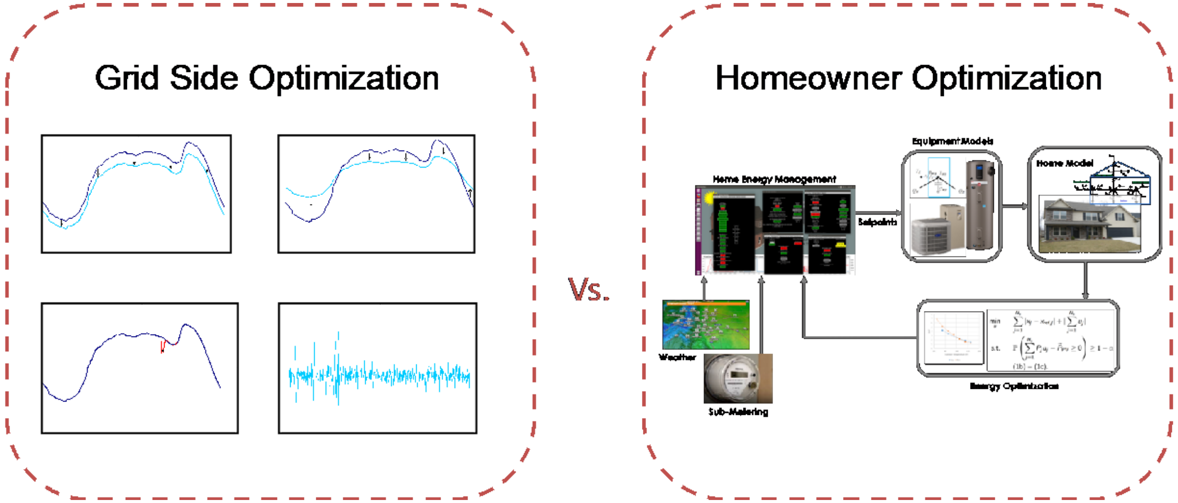
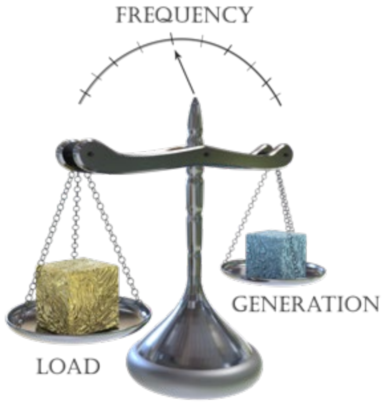
Understanding homes and enabling them as grid assets

It is a balancing act to effectively manage resource efficiency and homeowner comfort

- **Changing philosophy on what supplies our generation**
  - Generation is moving from centralized plants to distributed
  - Integrating resources and coordinating resources is becoming more important (interoperability is a challenge)
  - Increased renewable generation
- **Increasing need for resilience of electrical system**
  - Establishing and utilizing residential building flexibility to support the grid.
  - Ensuring that customer privacy is maintained while supporting grid needs.
  - Improving system resiliency under threats of systems outages.





Southern Company Smart Neighborhood Initiatives

Understanding tomorrow's home today

Two first-of-a-kind smart home communities at the intersection of energy efficiency, distributed energy resources & buildings-to-grid integration and the traditional utility model

Georgia Power Smart Neighborhood™

- 46 townhomes
- Atlanta, Georgia
- Homeowner owned solar + storage
- Grid integration of solar, storage, HVAC, water heating & EV charging

Alabama Power SMART NEIGHBORHOOD®

- 62 single-family homes
- Birmingham, Alabama
- Utility owned, grid-connected microgrid
  - → 330 kW solar
  - → 680 kWh storage
  - → 400 kW NG generator
- Grid integration of microgrid, water heating & HVAC

Major Research Partners

Electric Power Research Institute and U.S. Department of Energy's Oak Ridge National Laboratory

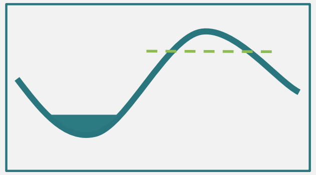
Key Vendor Partners

LG Chem, Delta, Carrier, ecobee, Rheem, SkyCentrics, Flair, Vivint, Pulte Homes, Signature Homes

Key Results

Homes are 30-40% more efficient
EV makes up 15-20% of total usage
Successful microgrid islanding
New business opportunities deployed

Driving New Internal Efficiencies – Utility Benefits



High Performance Homes

Changing Load Shapes

Tighter envelope

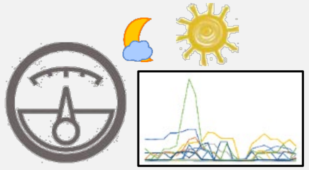
Advanced Building Energy Systems

Managing Behind-the-Meter Assets

Energy Use Optimization

Buildings as a resource

Create load shapes

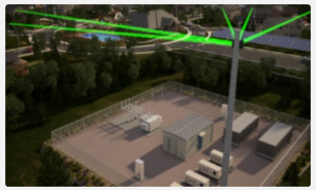


Identifying Revenue & Rate Design Impacts

Informed Load Forecasting

New building codes & standards

How to price energy in IoT future



Understanding Renewable Energy Grid Integration

Help meet 2050 Low-to-No Carbon Goal

New infrastructure needs

Balance grid & customer benefits

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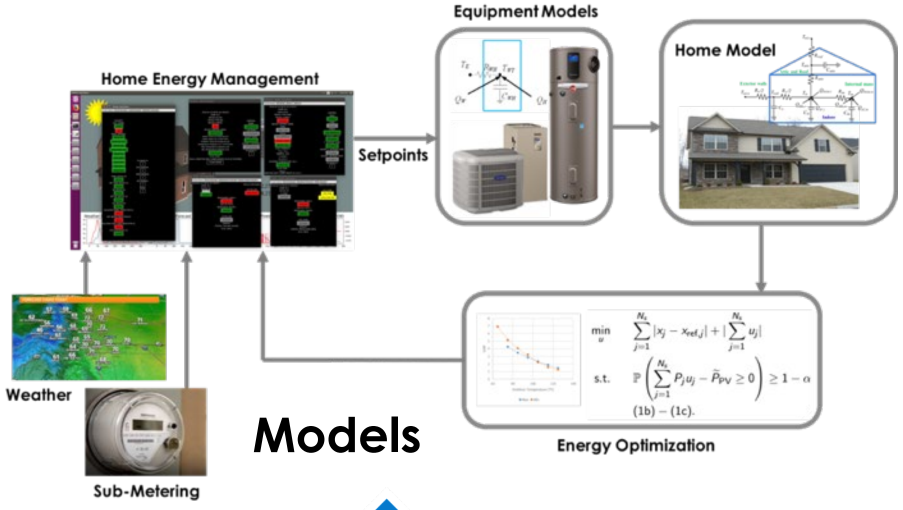
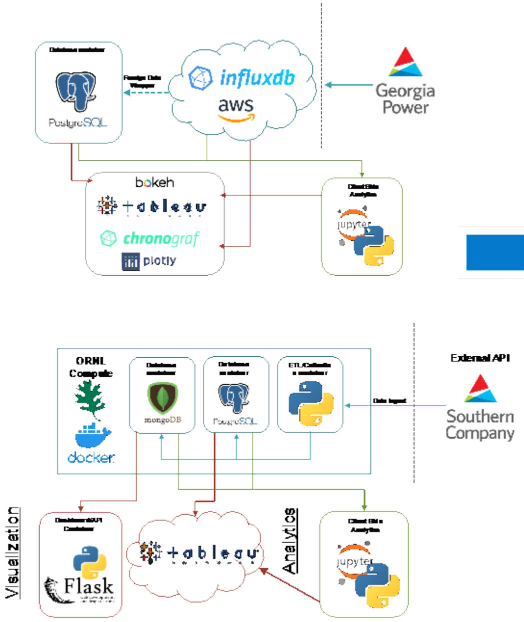
Grid Interactive Energy Efficient Buildings

It is a balancing act to effectively manage resource efficiency and Grid Reliability

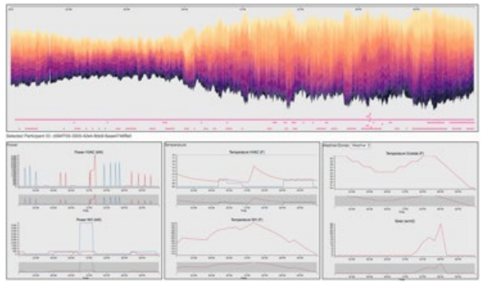


Models

Data

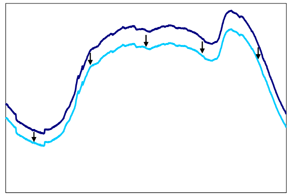


Analytics

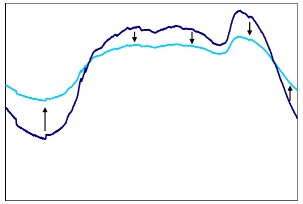


Situational Awareness

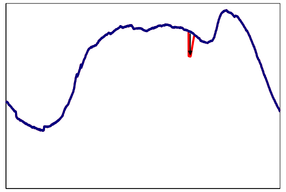
Field - Sensors and Controls



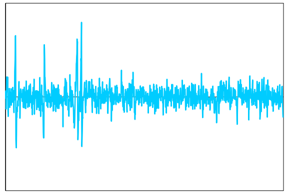
Energy Efficiency



Adaptive Load Shape



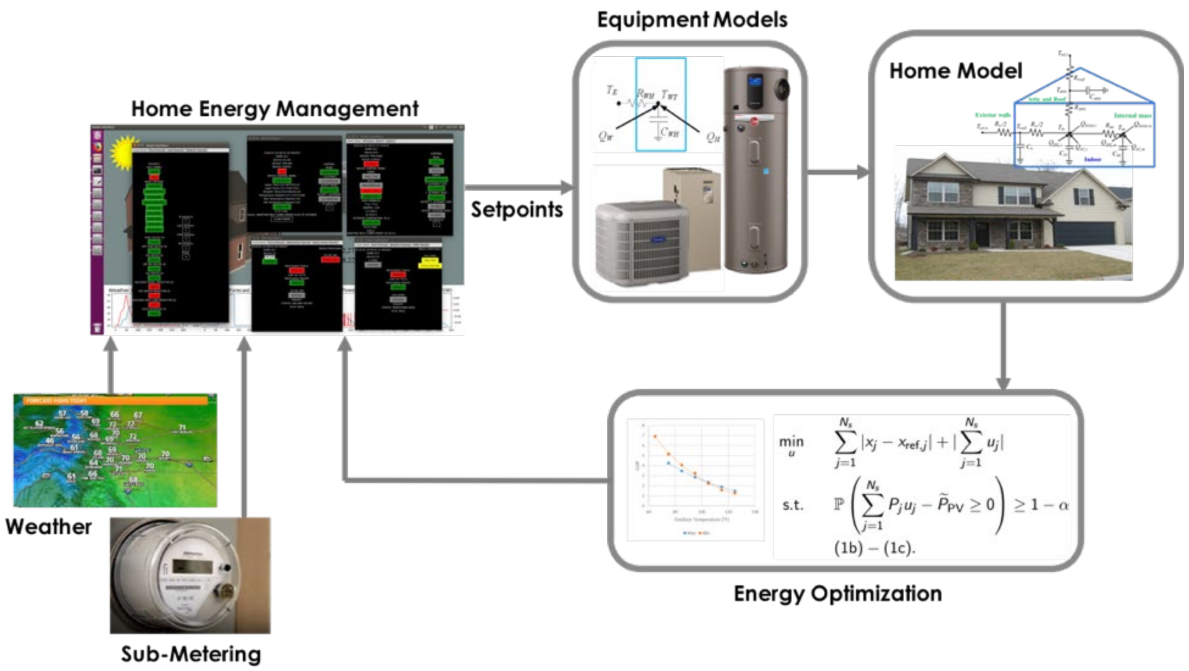
Reliability response



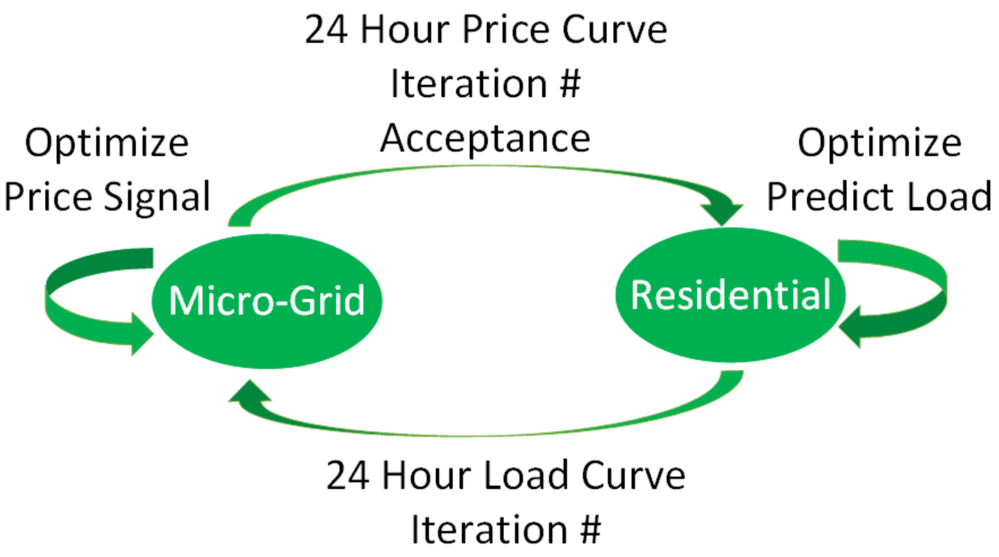
Regulation response

Neighborhood performing two-levels of optimization

Residential-Level Optimization



Neighborhood-Microgrid Optimization



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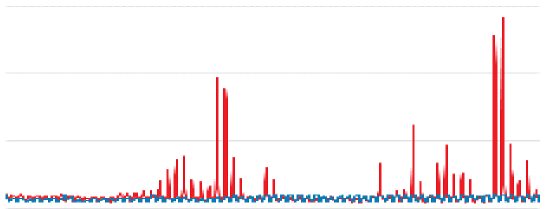
Control and Optimization at-scale

Quantify Grid Service Capability

Determine the additional value of continuous optimization vs. event driven DR

Ability to predict Homeowner Comfort/Convenience/Productivity

Forecasting Day-Ahead Cost is like predicting the weather



Planning tools use average data, which removes value

Device Capabilities enabled in APIs

Phased Testing Approach

Laboratory

- Simulation-based Testing
- Software as Deployed

ORNL Yarnell Station

- Unoccupied Research Home in West Knoxville
- Development Testing

Southern Company Idea Home

- Southern Company Development Environment
- Unoccupied Research Home at Reynold's Landing
- User Acceptance Testing (UAT) Phase

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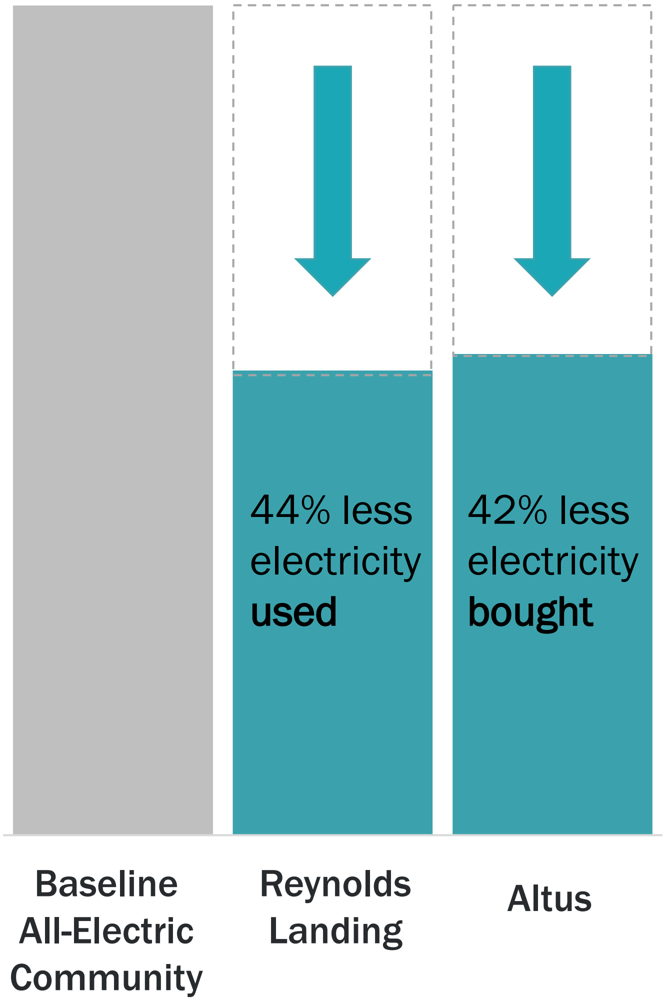
Results from DOE's First Connected Communities

Reynolds Landing *(Hoover, AL)*

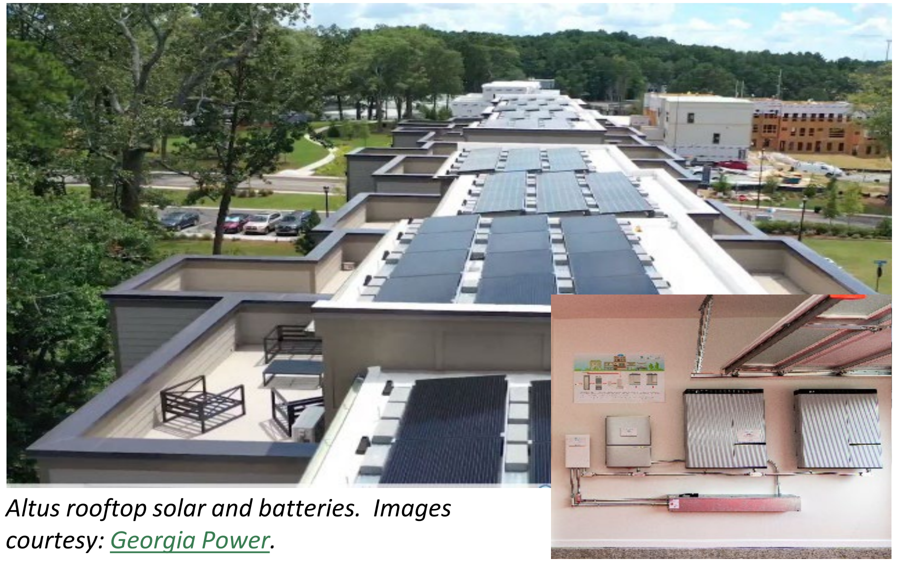
Alabama Power Smart Neighborhood® Idea Home. Image courtesy: Alabama Power.

- ✓ **7,167 kWh annual savings** per home on an equivalent sq. ft. basis
- ✓ **$931 annual savings** per home on an equivalent square foot basis
- ✓ **5.6 tons of CO_2 avoided per home**

Average Home Energy Use



Altus at the Quarter *(Atlanta, GA)*



Altus rooftop solar and batteries. Images courtesy: Georgia Power.

- ✓ **Homes sold an average 873 kWh** back to Georgia Power annually
- ✓ **In winter, 30% lower max hourly kW demand** than baseline
- ✓ **In summer, 62% lower max hourly kW demand** than baseline
- ✓ **9.3 tons of CO_2 avoided per home**

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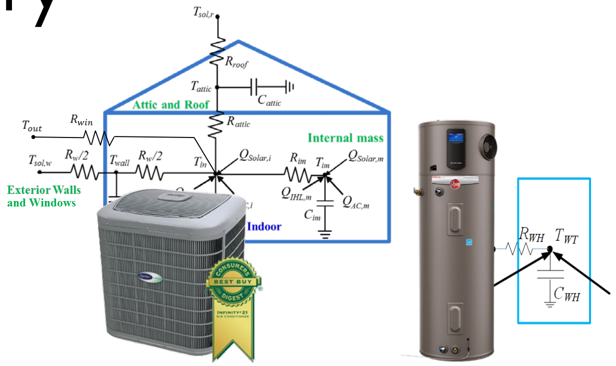
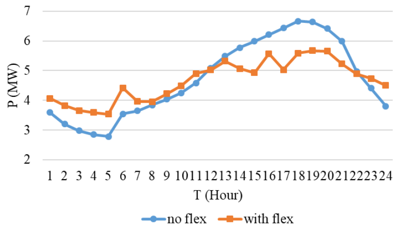
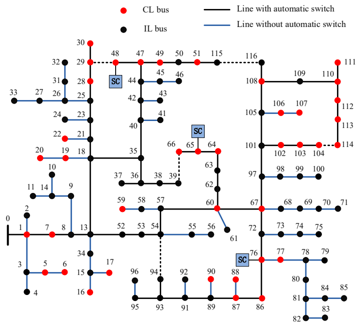
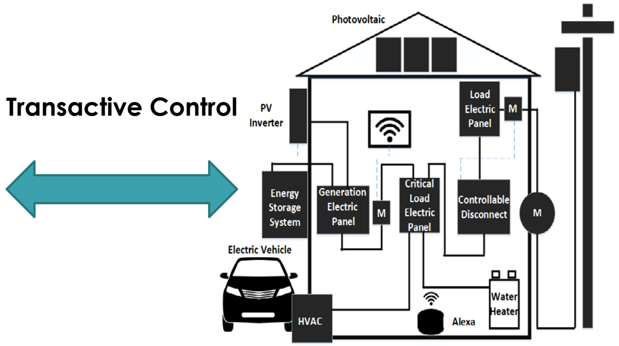
Key Advances to Address Scalability

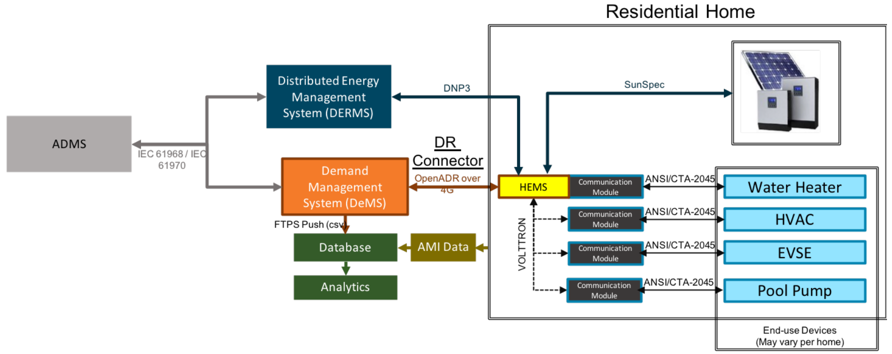
- **System Integration** – Overlay Architectures
  - Diverse set of requirements in these two domains
  - Integration – System of systems
- **Models - Online learning-driven models**
  - Characterize devices based on available sensor data
  - Forecast energy-use based on disturbances and constraints
- **Controls** - Grid-interactive Building Controls
  - Utilize open communication standards
  - Optimize resources for demand reduction and grid support











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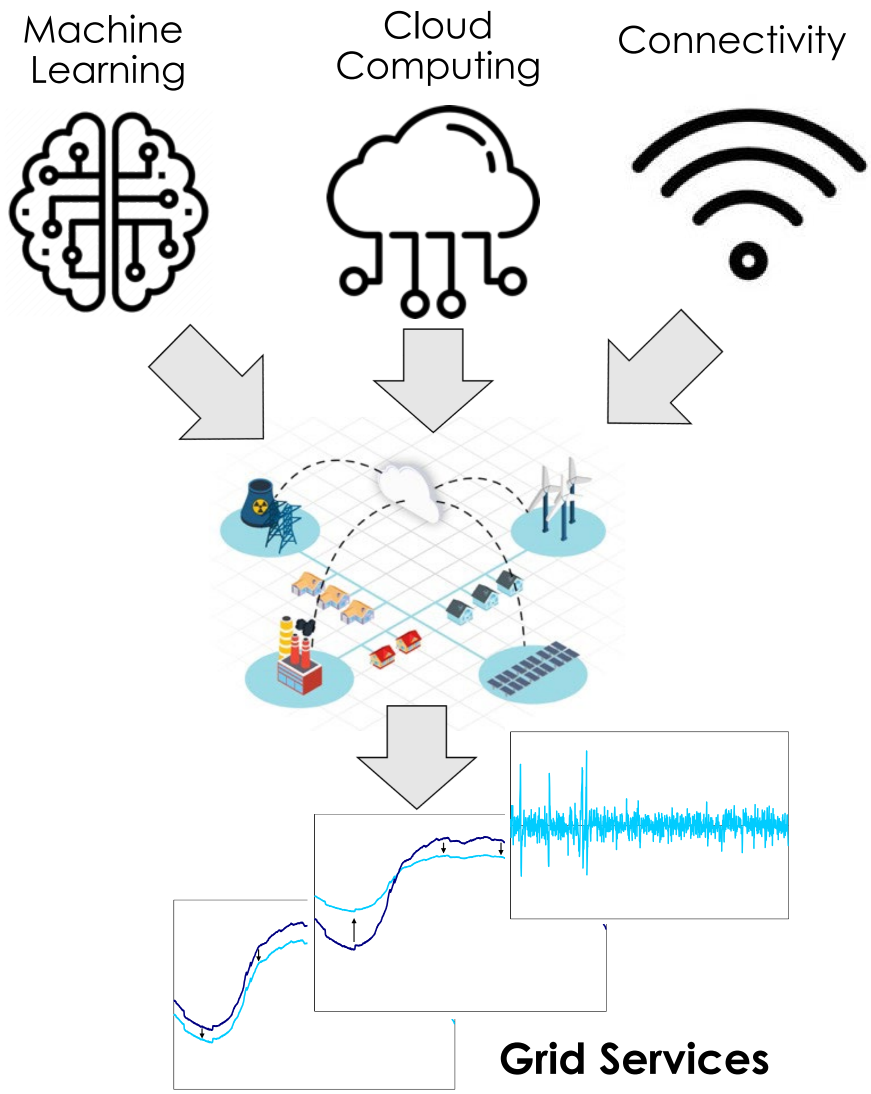
Lessons learned

Demonstrated utility integration of large-scale smart neighborhood with distributed energy resources and GEB control

- **Cost Reduction:** Significant potential for homeowners and reduced peak load to the utility
- **Scalable automation:** Systems-of-systems architecture; Reducing computational footprint is key
- **Control Design:** Cloud-in-th-loop feedback control; authentication; data security
- **Design Requirements:** A rich understanding of requirements - design, automation architecture, transactive controls, deployment
- **Training Requirements:** Continuous engagement and education on how to interact with the the system
- **Understanding customer adoption**: Data analytics and visualization to continuously understand impact of optimization.



How Connected Communities Might Evolve

- Customer journey and education (must) remain at the center.
- Utilities and partners will offer seamless (for customer and grid) technology packages that enable building retrofit at scale.
- Industry will have a shared methodology for determining value.
- Increased resiliency will continue to be a focus. Pilots will test geothermal, low-carbon fuels, including dual-fuel system designs.

Discussion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MANAGED BY UT-BATTELLE
FOR U.S. DEPARTMENT OF ENERGY
August 2007

Scaling Edge-to-Utility Architecture

- **Technology convergence -** drives opportunity
  - A coordinated control framework and customer education
  - Reducing computational footprint for seamless deployment
  - Fault-tolerance built-in for improving resilience
- **Data management** and communications
  - Architectures for federating large numbers of IoT-driven devices
  - Data-centric architectures - design, automation, deployment
  - Simultaneous Development, Deployment, and Data Analysis
- **Robust control & learning**
  - Robust and distributed feedback control systems
  - Cloud-in-the-loop control – Tolerance to latency and jitter
  - Automatic commissioning and learning