Grid Interactive Efficient Buildings: Electric Utility Perspective

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Southern Company

Research & Development

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PhD in Interdisciplinary Engineering – UAB, 2017

BS & MS Mechanical Engineering – Univ. of Alabama, 2009/2011

Research & Project Summary

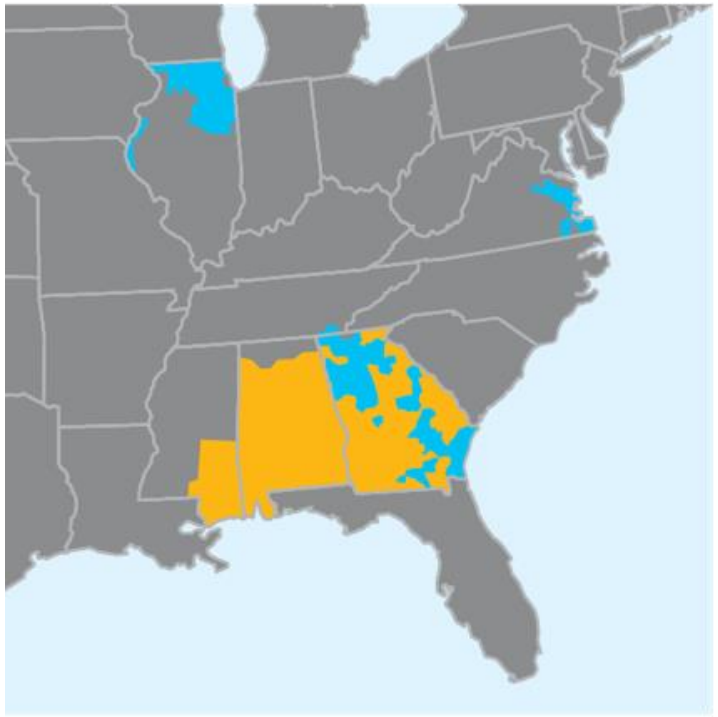
- Load Flexibility technology development & grid integration
  - Georgia Power Smart Neighborhood (Connected Communities)
  - GT Flex/Tide Flex (Campus Load Flexibility Demos)
  - Project DIBS (BESS, Solar & Building Automation grid integration)
- Load Flexibility Utility Modeling
  - Find full value of load flex in Prod. Cost & Reserve Margin Studies

Work History

2012-now: Southern Company Research & Development

2011-2012: Southern Nuclear – Vogtle 3&4

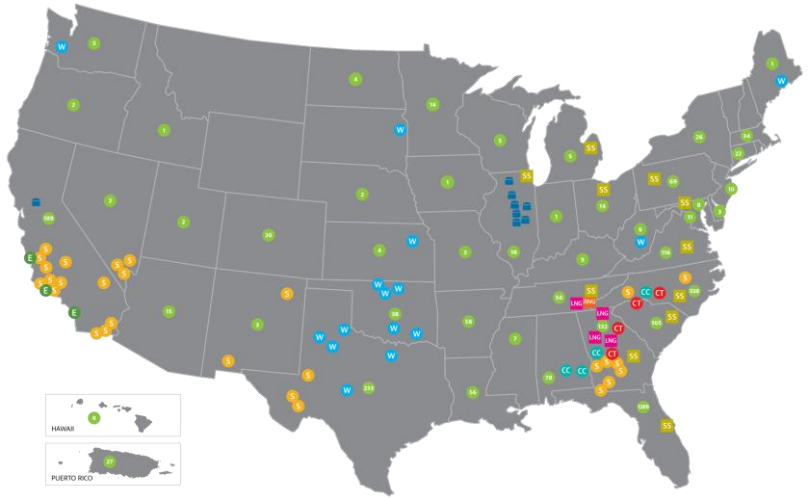
Southern Company provides clean, safe, reliable, affordable energy and customized solutions



Service territories

Electric

Gas



Southern Power

- Combined-cycle facility
- Peaking facility
- Solar facility
- Wind facility
- Energy storage

Southern Company Gas

- LNG facilities
- SouthStar
- Natural gas storage
- Renewable natural gas

PowerSecure

- Owned and/or managed sites per state

Capabilities in
50 States

7
Electric & Natural Gas Utilities

9 Million
Customers

Approximately
28,000
Employees

Approximately
43K MW
of Generating Capacity

*

* In September 2022, certain affiliates of Southern Company Gas entered into an agreement to sell the natural gas storage facility located in California.

March 2023

Greenhouse gas emissions reduction goals

2007 ▶ **2022** ▶ **2030** ▶ **2050**

Baseline

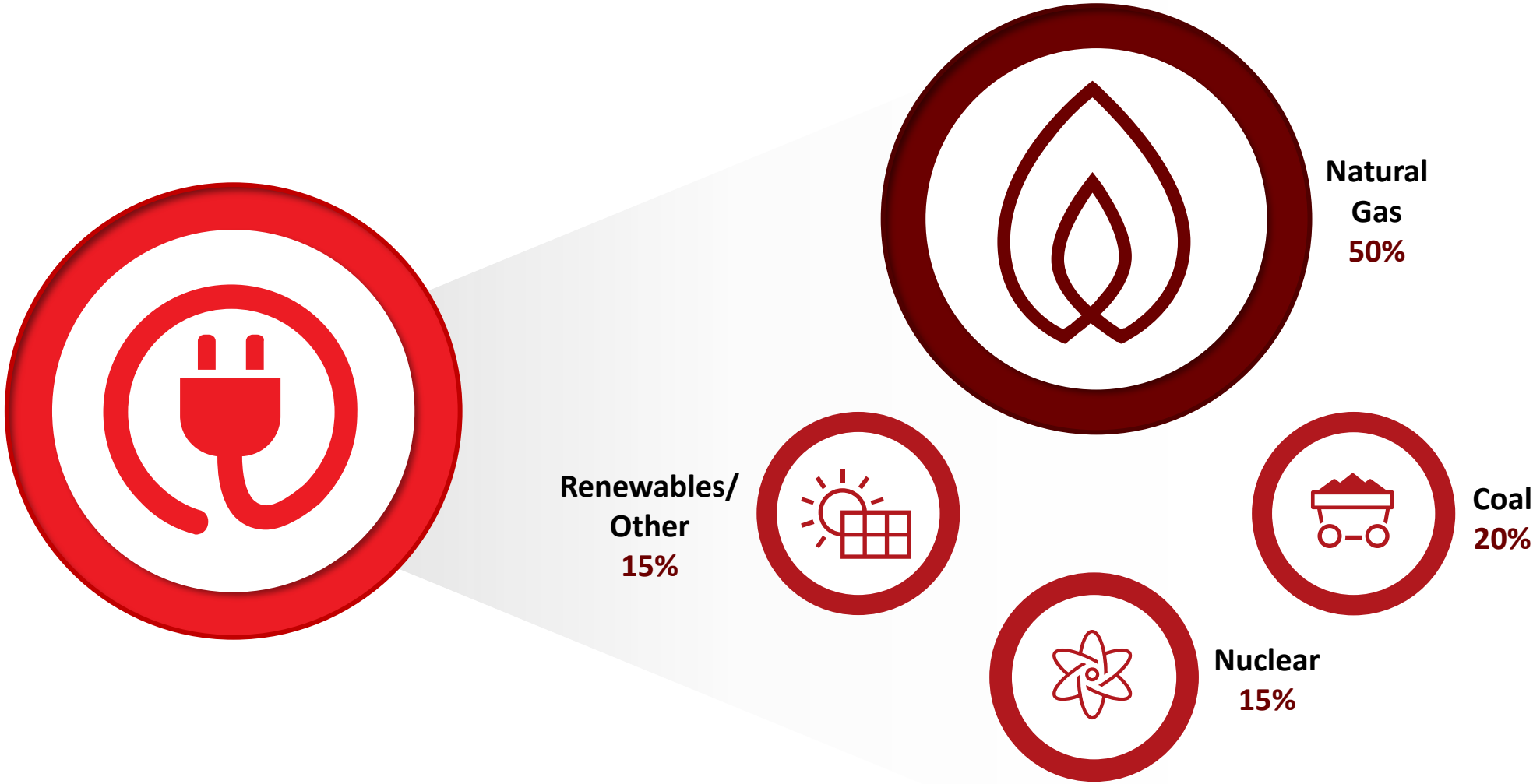
Reduced 46%

50% Reduction Goal

Net Zero Goal

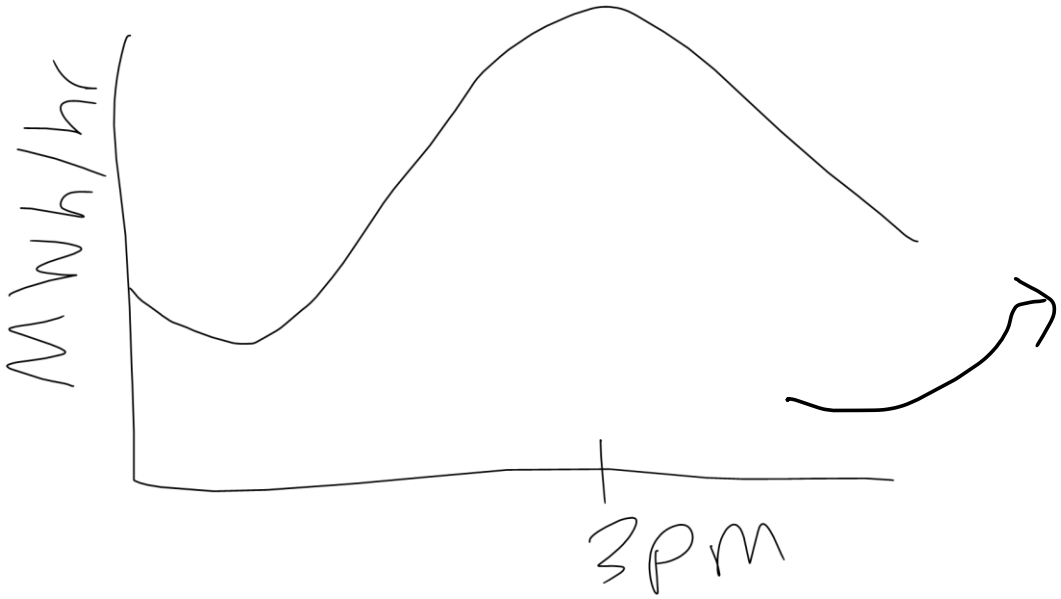
Electric

Energy mix in 2022

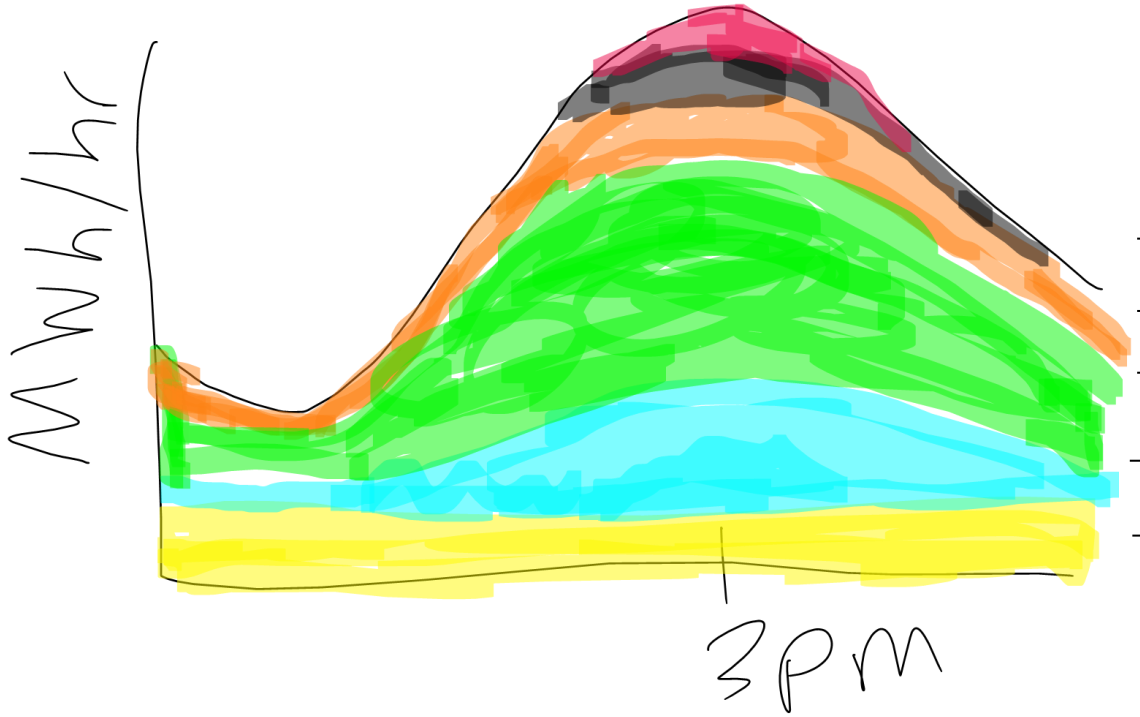


* For year ended December 31, 2022. Energy mix represents all of the energy used to serve retail and wholesale customers. This energy mix includes resources under the direct financial control of Southern Company subsidiaries, as well as energy purchased from others. It is not meant to represent delivered energy mix to any particular retail customer or class of customers. The renewables category represented in the charts above includes wind, solar, hydro, biomass and landfill gas facilities, whether owned by Southern Company subsidiaries or by third parties and whether Southern Company subsidiaries have the rights to the renewable energy credits (RECs) associated with energy from those facilities. To the extent Southern Company subsidiaries or affiliates retain or receive the RECs associated with energy from the facilities, they generally reserve the right to use those RECs to serve customers with renewable energy or to sell the RECs, either bundled with energy or separately, to third parties.

Meeting Demand at Lowest Cost with Generation Fleet



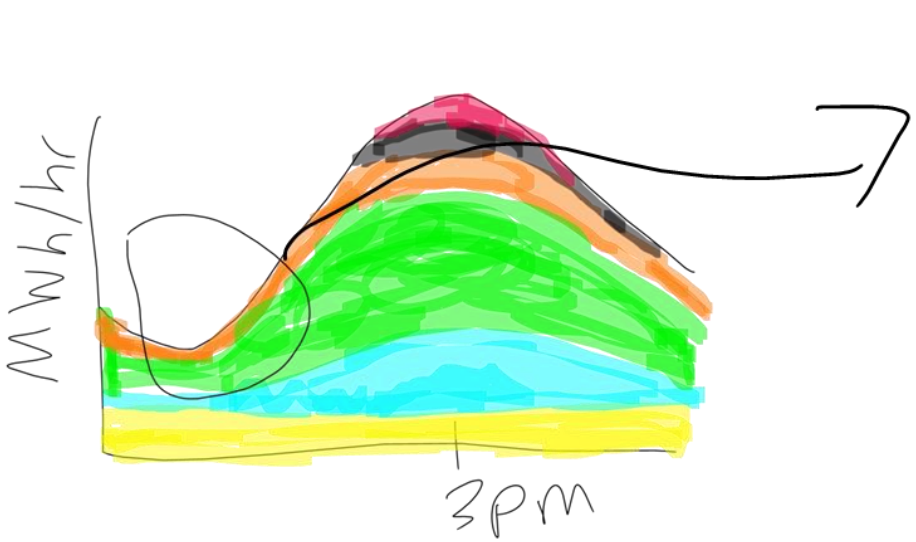
Typical energy demand shape in the summer

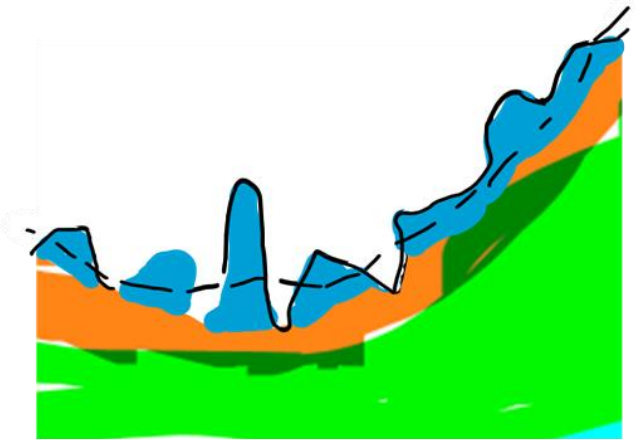


Stack generation using lowest cost assets*

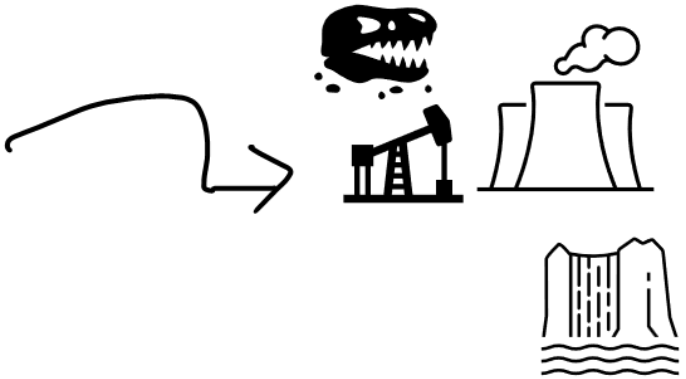
*Other barriers such as min up times, how fast they can start, etc.

Closer to Realistic Operations



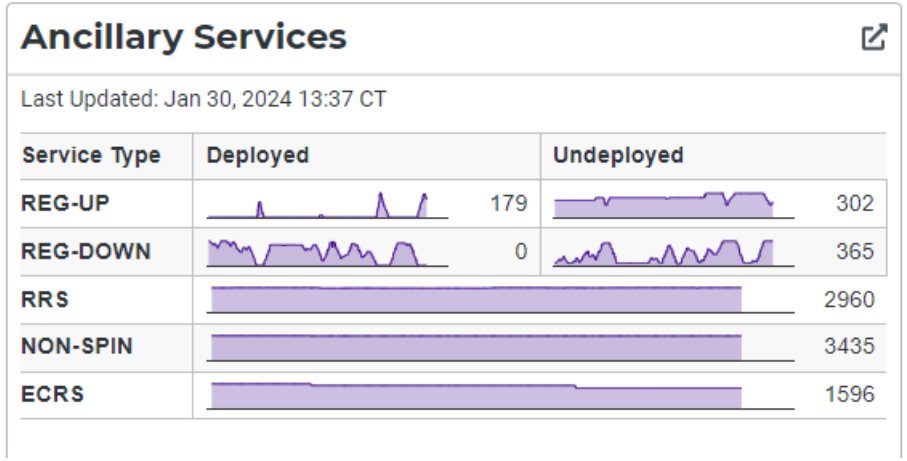


Demand fluctuates constantly



Hold back fossil generation & hydro

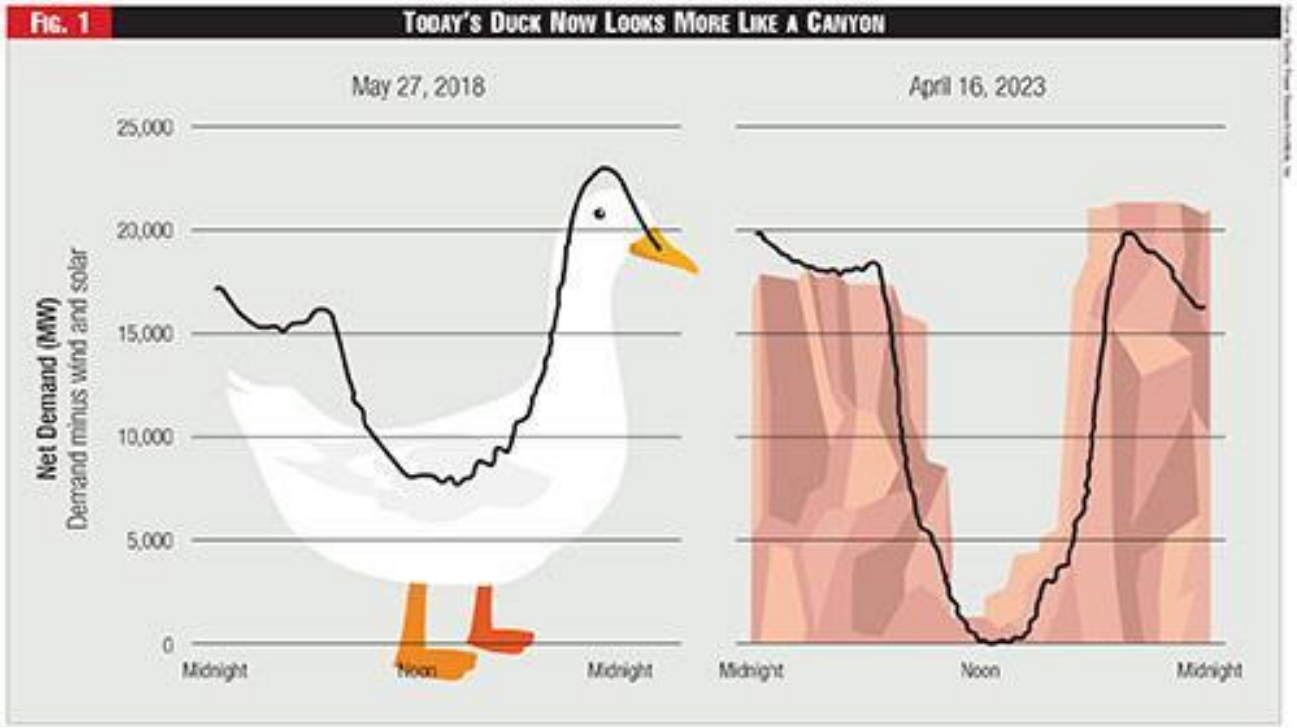
Grid Service	Response Time	Required Duration
Frequency Regulation (AGC)	6 seconds	Always responding
Regulation Reserve	Respond within 5 min	Up to 1 hour
Contingency Reserve	Respond within 10 min	Up to 1 hour
Operating Reserve	90 min	Up to 1 hour
Capacity (Demand Response)	2 hours	2-4 hours



ERCOT Example – 1/30/2024

Future with more renewables

- Less dispatchable generation options*
- Imperfect forecasting
  - Now have uncertainty on supply & demand
  - Increased need for reserves
- New services needed (climb the cliff)



EPRI

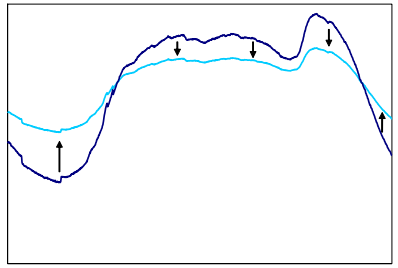
Southern Company's R&D Strategy

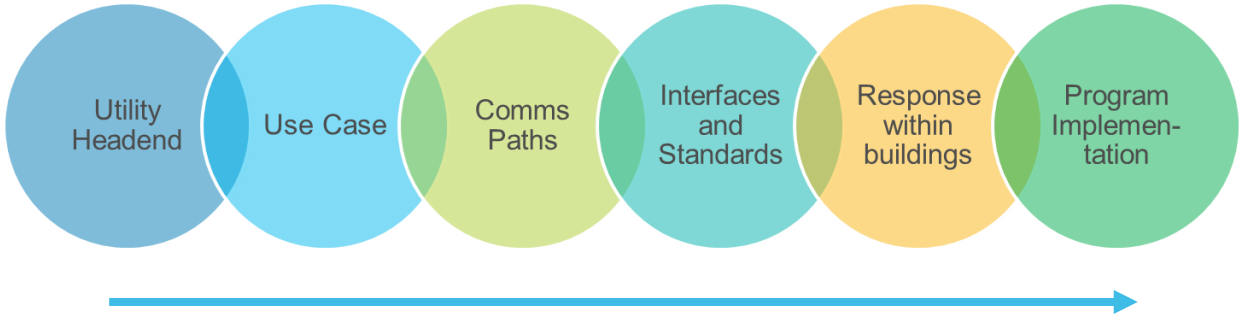
Technology Areas

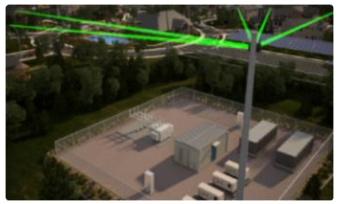
Develop a Sustainable Energy Future	Low-carbon Generation	Carbon Capture, Storage, & Utili.	Negative Emissions	Dispatchable Renewables	Modernized Nuclear Industry
Provide Delivery, Storage & Distributed Generating Solutions	Energy Storage	Enhanced Grid Resiliency	Advanced Grid Analytics	Grid Reliability and Flexibility	Distributed Energy Resources
Support Expanding Customer Needs	Building Technology	Sustainability Solutions	Low-Carbon Transportation	Data Analytics for Business Intelligence	Industrial Process Solutions
Advance Existing Infrastructure	Address Legacy Environmental Risks	Increase Flexibility, Maximize Efficiency, Reduce Cost	Minimize Stranded Assets		

Definition of Load Flexibility (or GEBs):

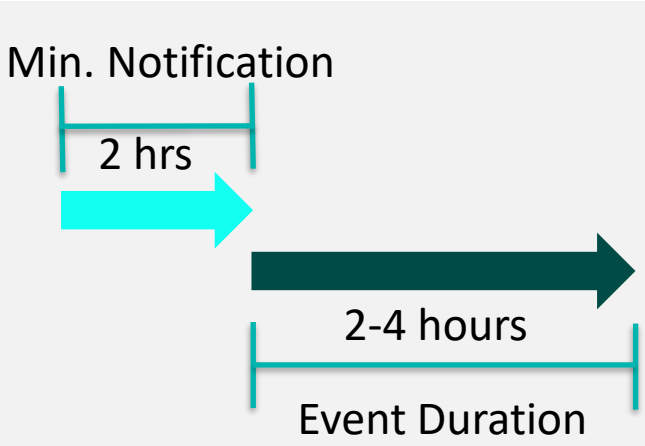
The ability to control & manage behind-the-meter storage, DG, HVACR, water heating, EVs, etc. in residential and commercial buildings and in certain industrial processes for customer, utility and societal benefit.

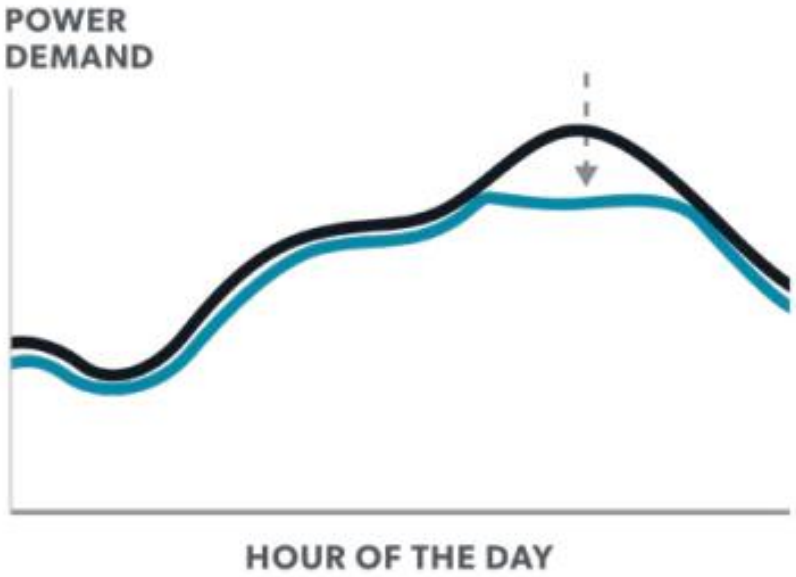






Pure Demand Response role in Net-Zero Carbon Future





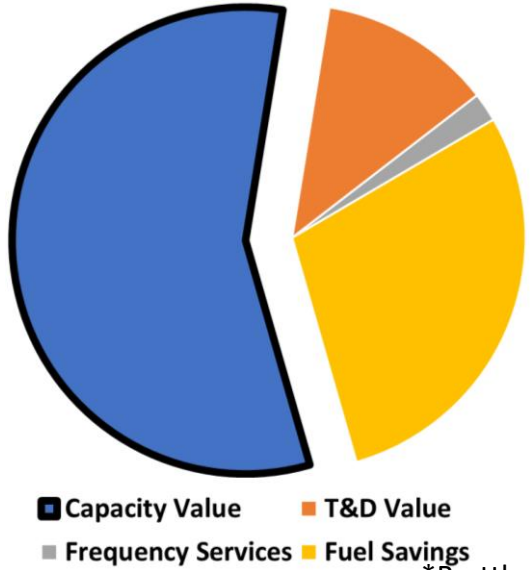
Pros:

- Highest value
- Easiest to implement
- Concept has been around for 40 years

R&D Needs/Gaps:

1) Move to Fleet Ops/out of marketing
2) Centralized DRMS/Control interface
3) Expand use case into commercial buildings
4) Can be more intelligent with preheat/precooling

Relative Value*

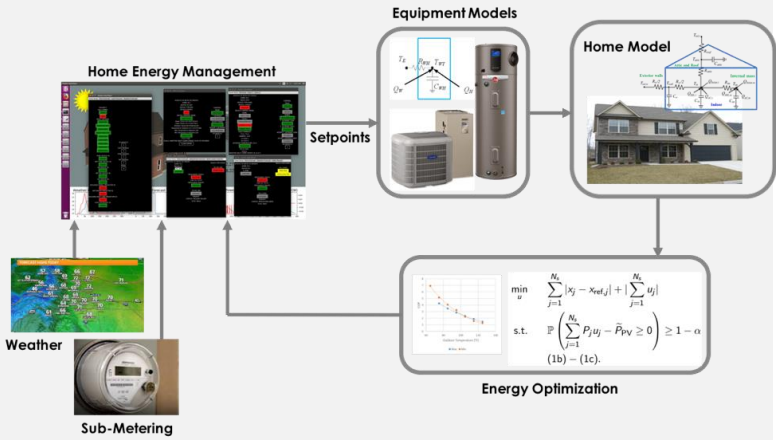


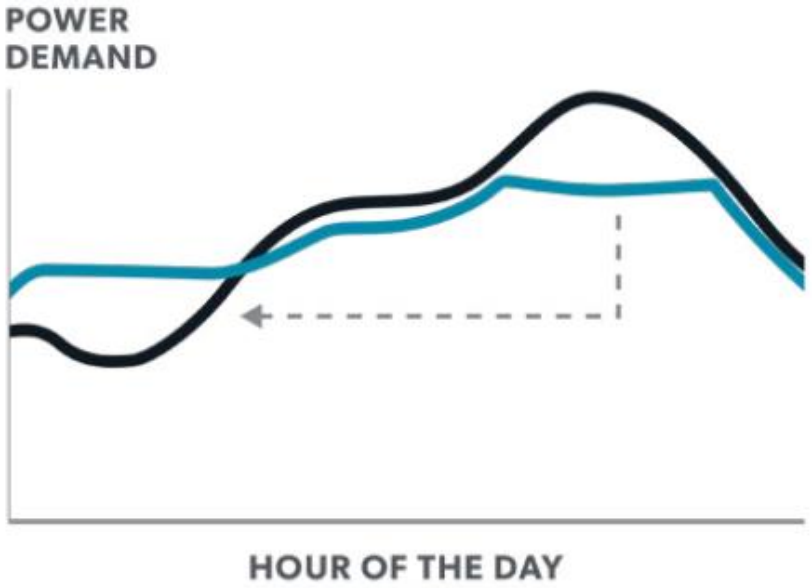
*Brattle Study

Cons:

- Intrusive to customers
- Highest impact to comfort/ convenience
- Not well liked

Load Flexibility/Load Shift role in Net-Zero Carbon Future





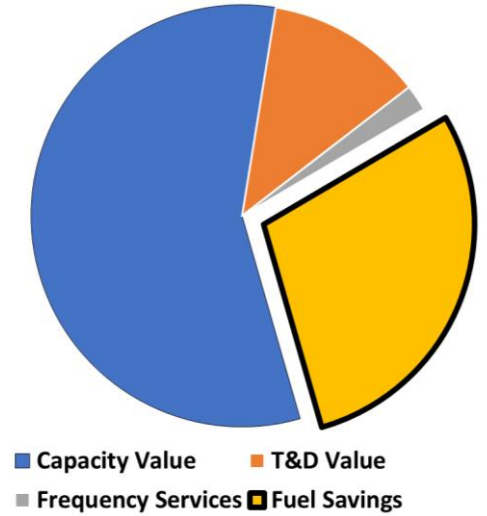
Pros:

- Continuously improves the correlation between price & usage
- Lowest impact on comfort/ convenience – provide value with no negative impacts
- Adaptable to needs: Allows solar load following when needed or CO_2 or price reduction

R&D Needs/Gaps:

1) Better controls & AI/ML/RL to lower cost & complexity of implementation
2) Data & product standardization to allow control
3) **How is RTP counted for capacity today in planning?
4) How to balance risks to SoCo & buildings (TX winter storm example with bills at $1k+/day)

Relative Value*



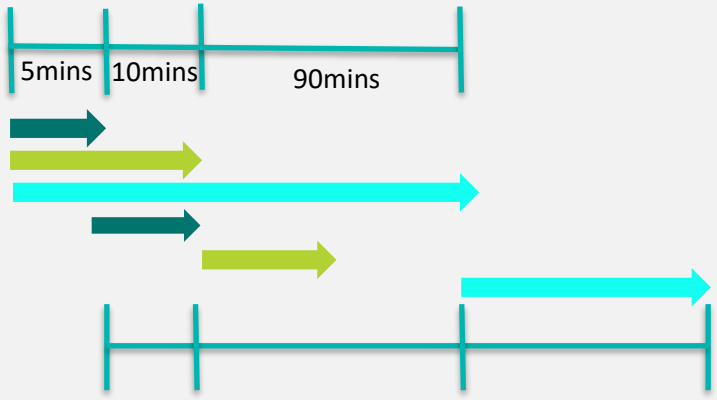
*Brattle Study

Cons:

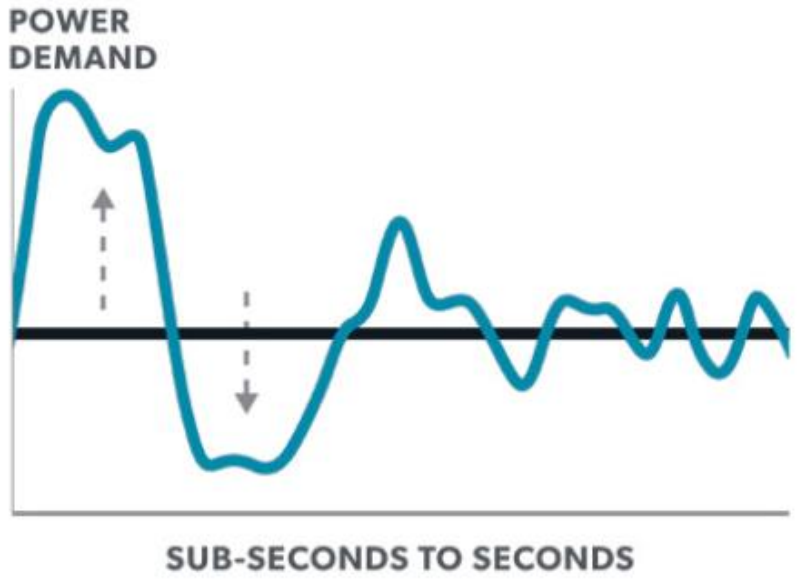
- Only saves fuel costs today
- Difficult to effectively implement
- Requires a lot of data & local controls
- Can be expensive to implement/ setup controls and data flows
- Complex data gathering

Grid Ancillary Services role in Net-Zero Carbon Future

Response Time



Up to 1 hour
Event Duration



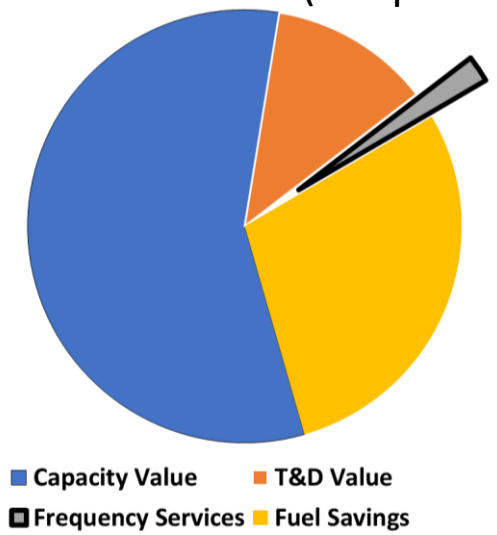
Pros:

- Value will only increase as more renewables come online
- Could rarely call as a resource and save $ for utility & customer

R&D Needs/Gaps:

1) Short term load & load flexibility forecasting
2) Production Cost Modeling & Resource Adequacy integration
3) Unknown true value
4) No platform is commercially available with these capabilities

Relative Value* (Freq. Only)



*Brattle Study

Cons:

- Difficult to model and capture value of it
- Unknown how to compensate customers for participation
- Frequency need is pretty small (MW)

Gaps in GEBs ™ pending

#	Gap	Lead
1	Quantification of Device Level and Building Level Grid Service Capabilities	R&D
2	Seamless Device Installation/Onboarding and Ongoing Information & Control	R&D
3	Planning & Operations Tools (may vary by application)	R&D
4	Data Management & Cyber Security	TO
5	Customer Appetite	Marketing
6	Regulatory Considerations	Regulatory Affairs
7	Utility Business Case (including Grid Services Valuation)	System Planning / Marketing / New Ventures
8	Legal (e.g. Data Privacy)	Legal / Regulatory Affairs
9	Planner & Operator Trust	System & Dist. Planning

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

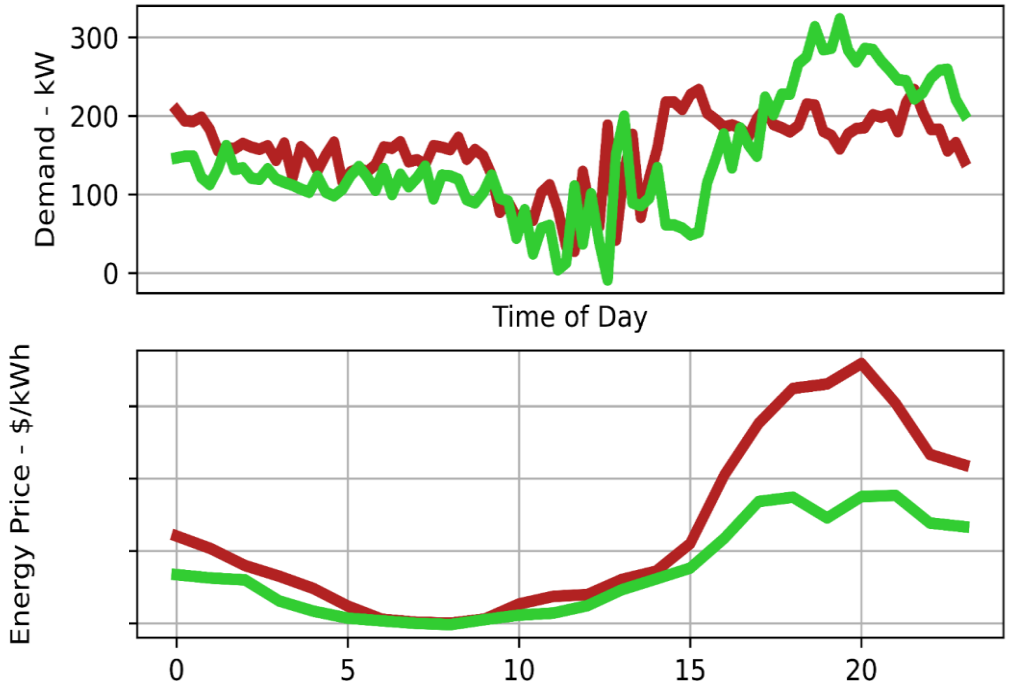
Key Vendor Partners

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

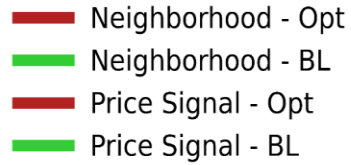
Key Results

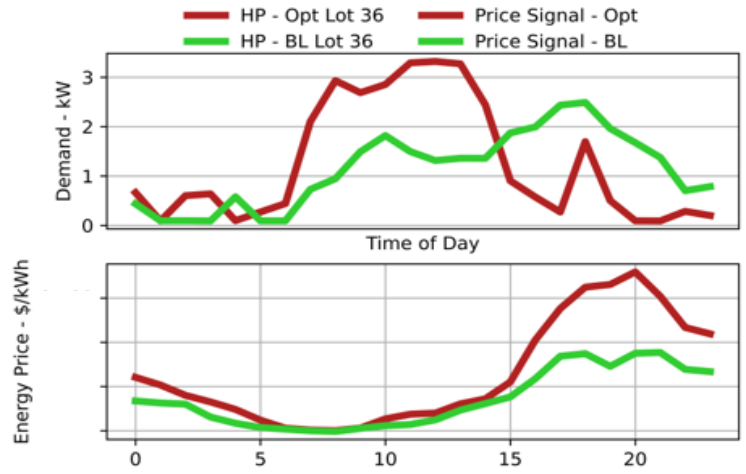
Homes are 30-40% more efficient
EV makes up 15-20% of total usage
Successful microgrid islanding
New business opportunities deployed

Georgia Power Smart Neighborhood R&D Results

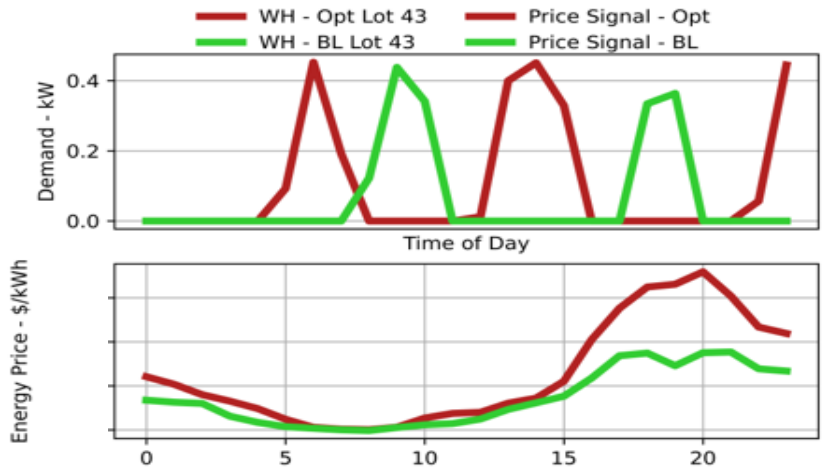


Neighborhood Level Response





HVAC Optimization



Water Heater Optimization

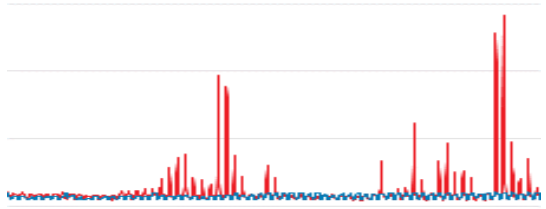
Occupant Centric GEBs – Challenges

Quantify Grid Service Capability

Is there enough additional value in continuous optimization vs. event driven DR

Ability to predict Comfort/Convenience/ Productivity

Forecasting Day-Ahead Cost is more difficult than predicting the weather



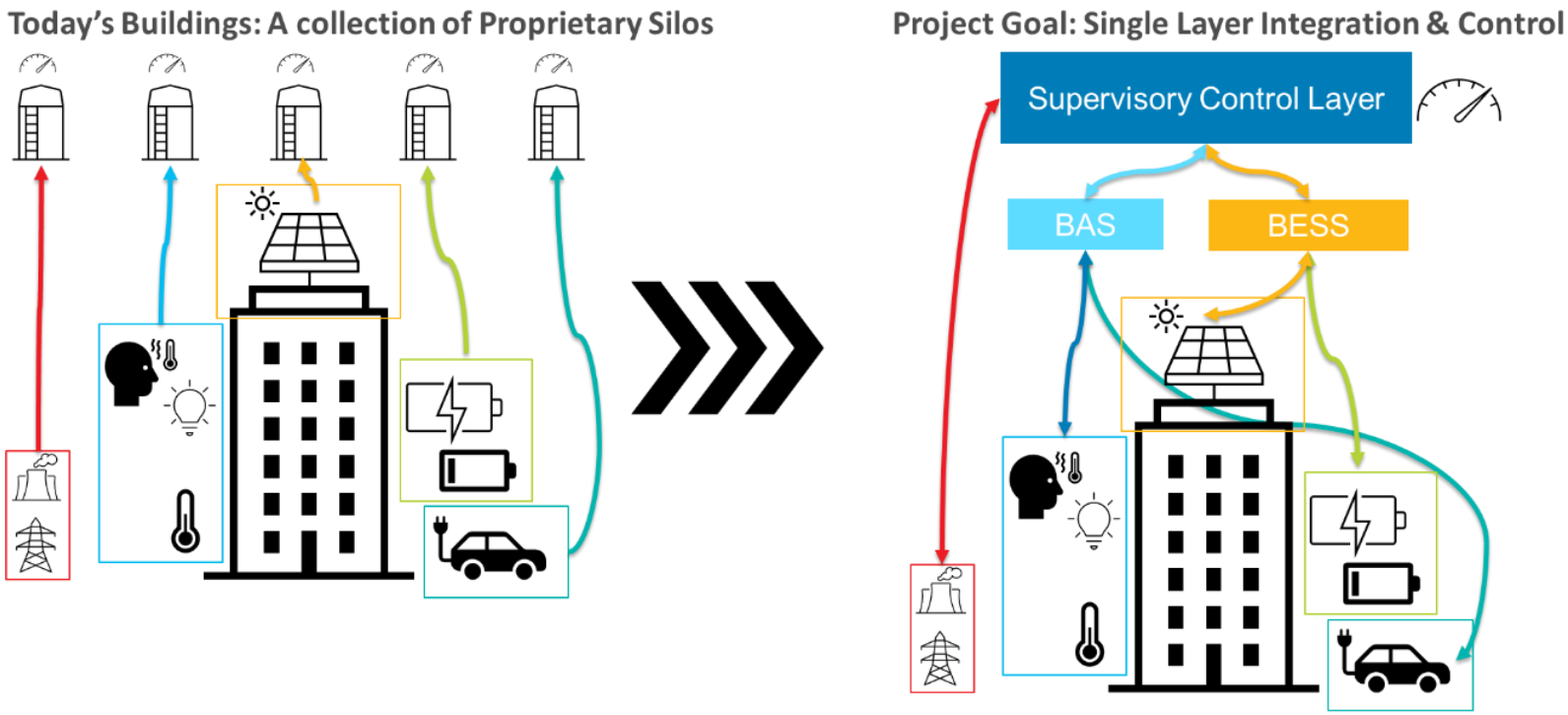
Planning tools use average data, which removes value

Device Capabilities, Device Connectivity, Data Collection & Storage

Integrated DSM Demonstration at GA Power HQ - (Project DIBS)

Project funded by U.S. DOE BTO as part of the 2023 BENEFIT FOA ($1.5MM over 3 years)

1. **Integration & Efficiency –** combine all DER assets into single system & add energy efficient controls
2. **Resiliency –** implement new approach to provide backup power to daycare
3. **Load Flexibility –** connect asset to the grid & VPP/DERMs platform
4. **Valuation** – determine value of integrated approach to buildings & grid
5. **Outreach** – transfer learnings to industry, partner for training & education in underserved and underrepresented communities



Southern Company

Georgia Power

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Southern Company's Smart Neighborhood Portfolio

1

Alabama Power

62 Homes

Birmingham, Alabama

Utility-Owned Solar + Storage + Natural Gas Microgrid

2

Georgia Power

46 Townhomes

Atlanta, Georgia

Homeowner-Owned Onsite Solar + Storage

3

Mississippi Power

32 Homes

Meridian, Mississippi

Homeowner-Owned Solar Glass Shingles + Storage

4

Nicor Gas

30 Homes

Aurora, Illinois & Carpentersville, Illinois

Homeowner-Owned Solar + Storage; natural gas as part of the Clean Energy solution

Simplified GEB Strategy

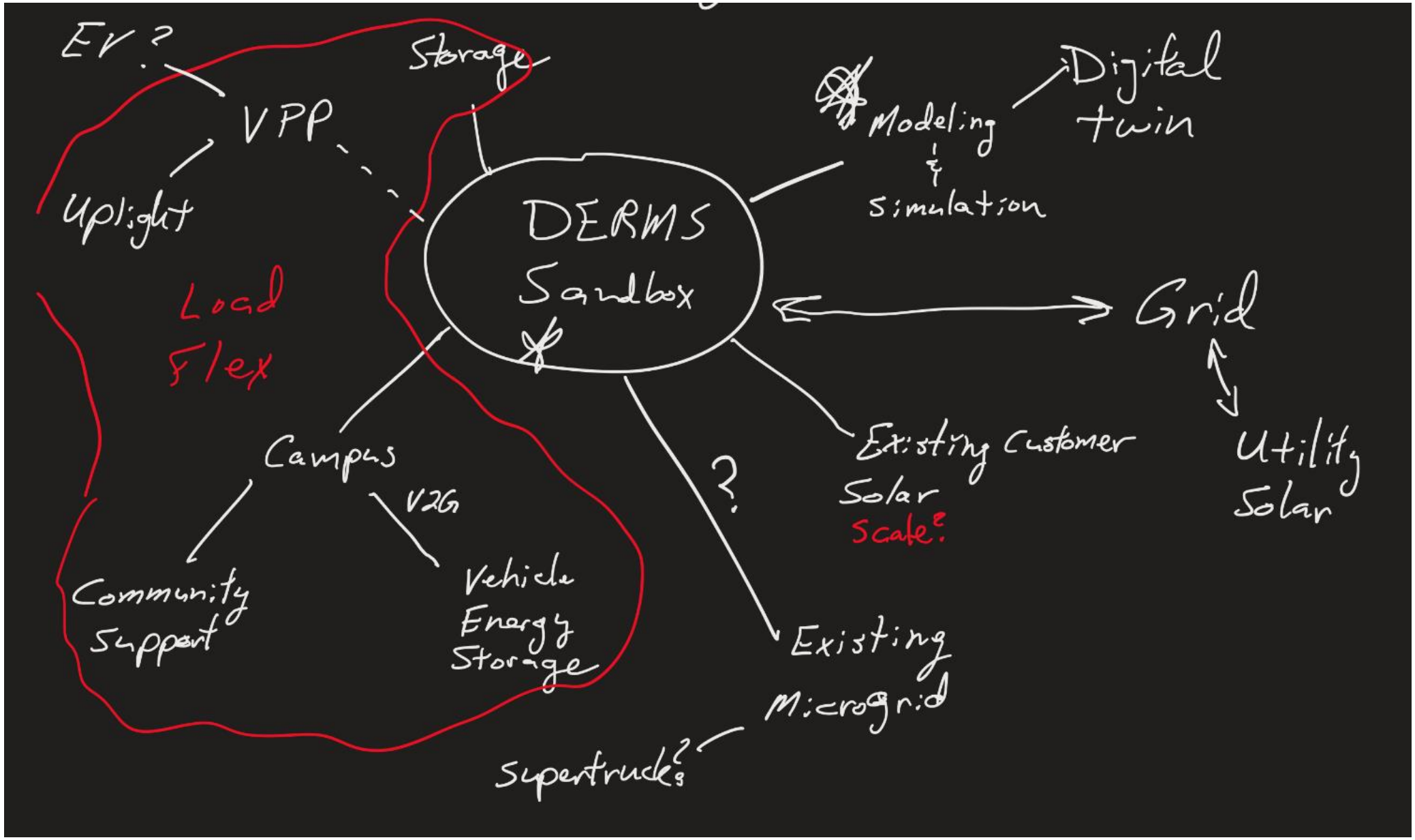
1. More kW per device and are more like a battery
   - Extending the Scope of GA Smart Neighborhood
   - Proposal & partnerships with ORNL & Universities to simulate & demonstrate how AI (RL) improves load flex
   - Extend flexibility to new devices: variable capacity HVAC

2. More kW per Site
   - GT Flex
   - Tide Flex
   - Muni Pumping
   - GPC HQ project
   - Big Box Retail Control development

3. Better Modeling tools
   - Improve Battery Equivalence Modeling work to aggregate load flex in familiar terms
   - Working with EPRI to figure out ways to get load flex in Planning tools
   - Partnered with University experts to develop frameworks
   - Low temp heat pump valuation

Lower Cost of VPPs & DERMs integration & incorporate DE&I objectives + low-to-moderate income

Locational Value (DERMS)

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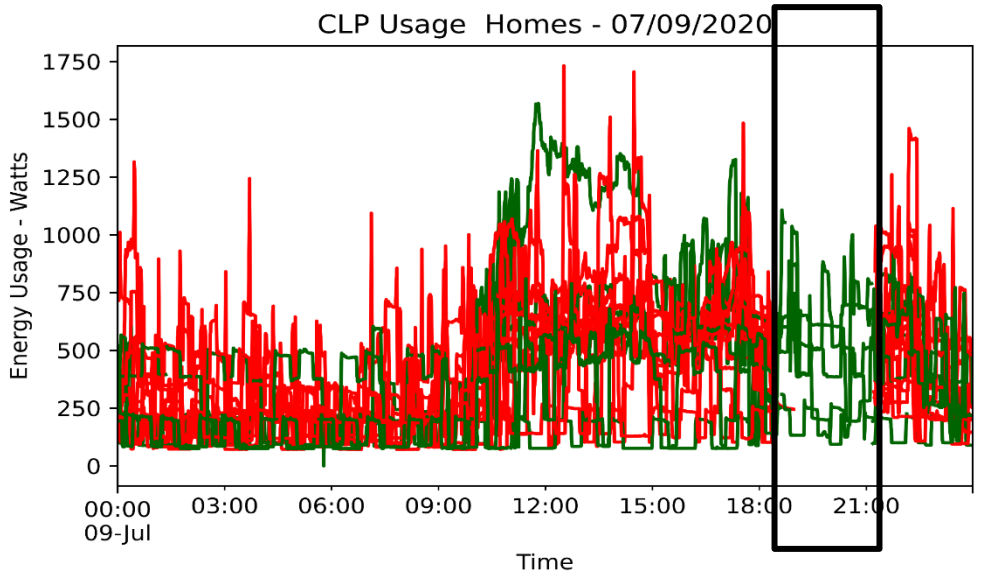
GT Flex

- Utilization of campus as a (replicable black box to GPC) grid resource to help achieve GT & SO sustainability & net zero carbon goals by incorporating GEBs and GT owned and operated DERs
  - Why
    - » Seamless integration of renewable generation
    - » Winter/summer peak mgmt. – Capacity
    - » Grid Ancillary services
      - Distribution services? - GT owned
    - » Quantify benefits of electrification to meet goals
    - » GT Cost avoidance/$ savings
  - Hows
    - » Enabling end-use load flexibility as a grid resource
      - Load shaping based on grid signals
      - Intelligent controls to improve building energy consumption (efficiency)
    - » Controllable DERs & Evs (include diesel/NG gensets)
    - » Onsite vs. PPA style renewables
    - » Central plant potential control

Some Lessons Learned

- It takes a lot of parties to bring a Smart Neighborhood together, each with different objectives – who leads to scale this?
- Newly commercial technologies still have issues
  - Lack of design experience
  - Lack of operational understanding
  - Unfamiliar installation challenges
- Data collection, storage and usage are not simple
  - Firmware updates can change data formats
  - Short Notice API Changes
- Device Connections from house to cloud
  - About half the homes are fully connected after ~ 2 years with reconnect visits
- Homeowner perception – balancing transparency and oversharing
- Local device features (ecobee's eco+) can fight against control signal but can also be helpful (Delta's local control)



Back of the Envelope Calculations: Comparing today's GEBs to Utility Owned Batteries

Key Takeaway:

NPV of GEBs is less than a battery until $/kW is less than published pricing[1]

Research & Development

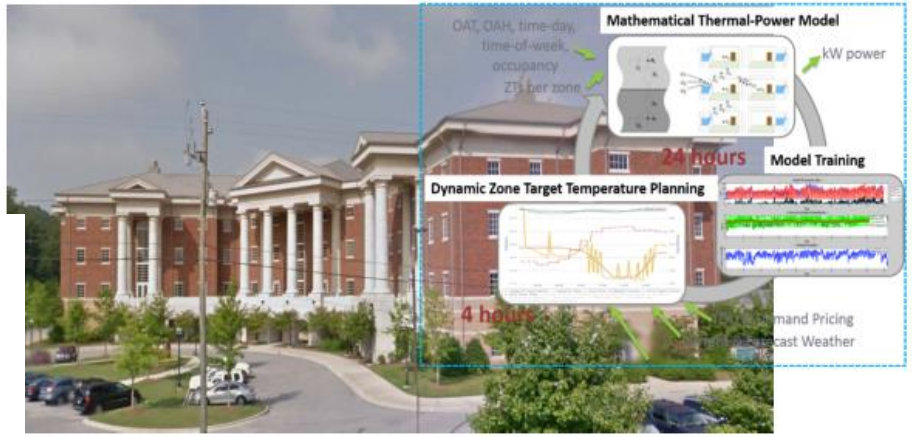
1 – How VPPs Reduce Both Costs and Emission in Meeting Peak Demands | AutoGrid (auto-grid.com)

Birmingham, AL Community College

- Project was to install a SaaS control system for energy efficiency
- Circa 2008 building, controls installed by lowest bidder
  - Proprietary system & required JACE installation to allow controls
- Networking & firewall issues: Once system was operational, building operator blocked outbound traffic on necessary ports for BAS to talk to cloud-based SaaS
- Mismatch in control signal & differences in building HVAC designs: SaaS controls were based solely on supply air temperature resets, but in reality, Temp settings were calculated indirectly from changing static pressure in the ductwork causing conflicts between setting & desired behavior

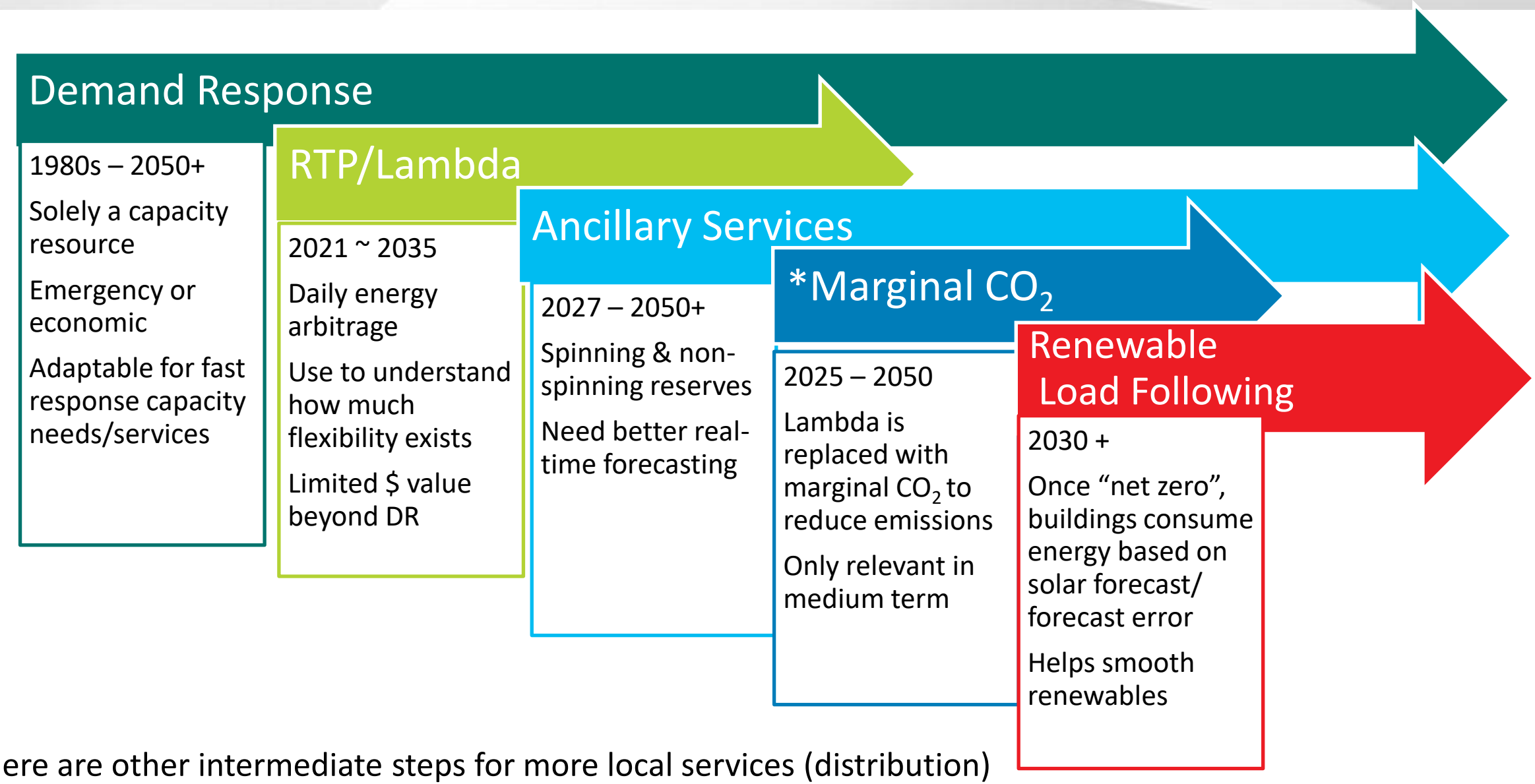
- Control signal flow:

  Control signal → BACNet → Niagra AX Supervisor → Ethernet → **JACE Box** → NOVAR system → VAV boxes for controls



Health Science Building, Birmingham AL

Building Flexibility's role in and path to Net-Zero Carbon Future



++ There are other intermediate steps for more local services (distribution)