GRID MODERNIZATION LABORATORY CONSORTIUM
U.S. Department of Energy

Technical Assistance for States: Grid-Interactive Efficient Buildings

GEB Potential Working Group Call

July 17, 2020

Chioke Harris[1], Sam Koebrich[1], Joyce McLaren[1]

[1]National Renewable Energy Laboratory

Agenda

1. Present regional level GEB potential data
2. Collect feedback
3. Present ideas on exploring customer participation
4. Collect feedback & data source ideas

Discussion

1. Would you benefit from seeing similar results, specific to your region?
2. Is the granularity of the results sufficient for your use?
3. What other data or information would be particularly useful? How can we provide more helpful information that can be applied to your needs?
4. How would/will you use data on GEB potential? (Inform goal-setting? Inform program design?)

Assessing the potential for energy flexibility from buildings at the regional level

Chioke Harris[2]

with Jared Langevin[1], Handi Putra[1], Andrew Speake[2], Elaina Present[2], Rajendra Adhikari[2], and Eric Wilson[2]

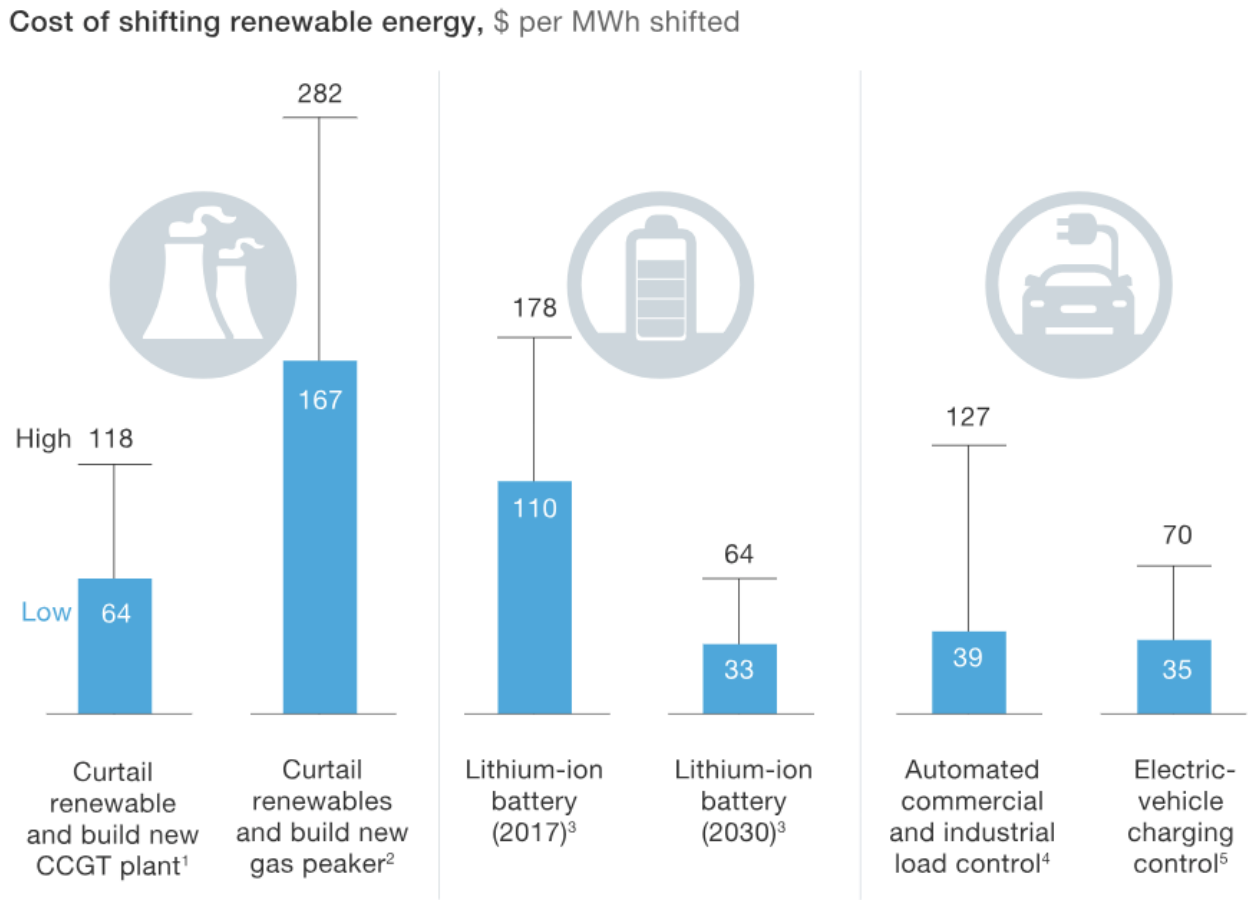
[1] Lawrence Berkeley National Laboratory
[2] National Renewable Energy Laboratory

Motivating question

How much can grid-interactive efficient building technologies impact system load shape in the SRVC region?

What is the electric load "resource" available from buildings if they can operate flexibly?

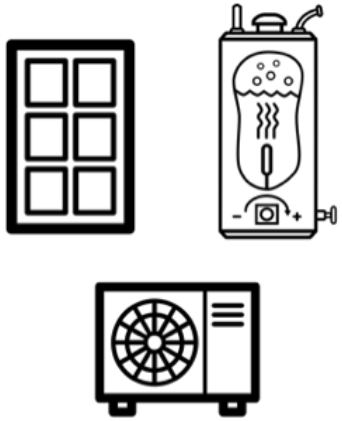
- Buildings comprise 75% of U.S. electricity demand.
- Demand-side flexibility can support variable renewable electricity penetration cost-effectively.
- The magnitude of the potential grid resource from flexible building technologies has not yet been quantified.



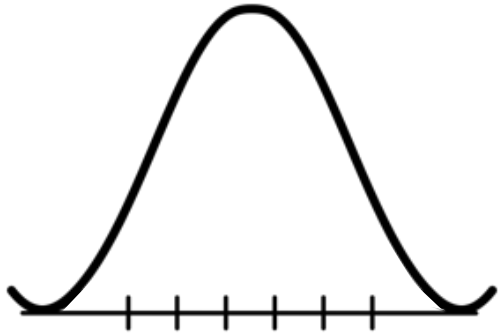
Comparison of the costs per MWh of shifting renewable energy from generation sources, and battery storage/distributed energy resources. Aggregated demand-side flexibility resources are found to be cost-effective and frequently cheaper than the generation alternative. Source: McKinsey.

A bottoms-up stock-and-flow model of buildings is used to evaluate the time- and location-specific effect of efficiency, flexibility measures

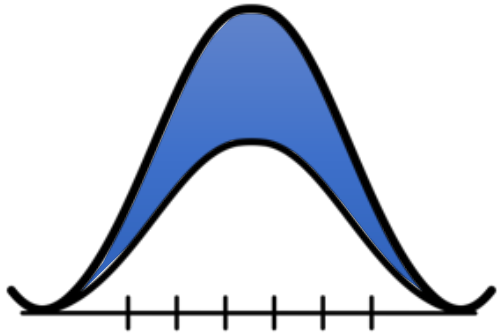
1. **Define individual measures, rolled up into three (3) measure portfolios:**
   - energy efficiency (EE)
   - demand flexibility* (DF)
   - EE + DF



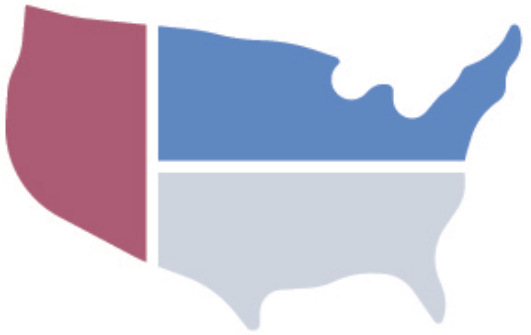
2. **Develop 8760 (hourly) fractions of annual baseline electricity demand by location, building type, and end use**



3. **Develop bottom-up EnergyPlus measure simulations and hourly savings fractions based on regional system needs**



4. **Translate measures to Scout and assess regional/national portfolio potential, annually and sub-annually (2015-2050)**



* "Flexibility" measures can reduce load during peak hours ("shed") or move electricity use out of the peak period ("shift"). Further details on demand flexibility can be found in the Building Technologies Office Grid-interactive Efficient Buildings Overview.

Residential measures were modeled using ResStock

ResStock, a framework for simulating a statistically representative sample of residential buildings in OpenStudio and EnergyPlus, was used to explore the effect of various measures on hourly residential building energy use.

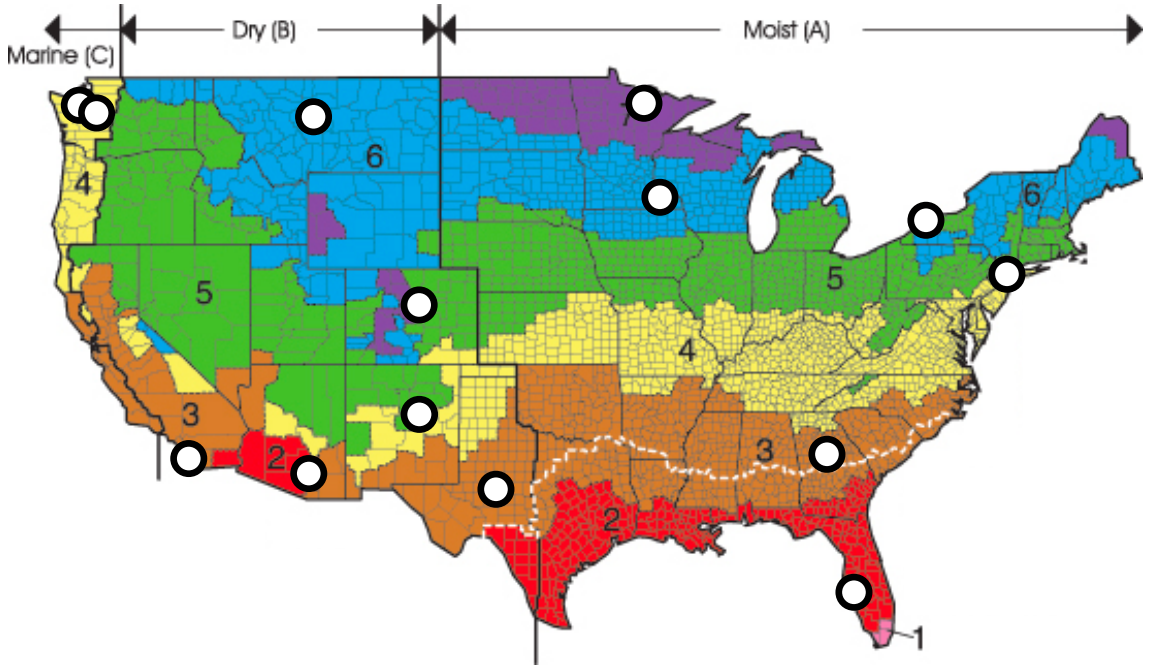
Scenario	Measure Name	End Use(s)	Description
Energy Efficiency (EE)	Scout "Best Available" ECM portfolio	All major end uses	Current best available residential efficiency ECMs, definitions posted on Scout GitHub repository
	Programmable thermostat (PCT) setups and setbacks	HVAC	Apply thermostat setups and setbacks while maintaining temperature setpoint diversity
Demand Flexibility (DF)	PCT + pre-cooling and heating	HVAC	Decrease/increase temperature set points during peak period
	Grid-responsive water heater	Water Heating	Increase temperature setpoint at beginning of take period, decrease setpoint at beginning of peak period
	Grid-responsive washer/dryer, variable-speed pool pump	Appliances	Shift washer/dryer cycles and pool pump power to off-peak hours
	Low priority plug load adjustments	Electronics	Shift or switch off/unplug some low-priority electronics during peak hours (e.g., TVs, set top boxes, laptops/PCs)
EE + DF	PCT + pre-cool/heat + efficient envelope and HVAC equipment	HVAC, Lighting	Combine EE HVAC and envelope upgrades with DF HVAC controls
	Grid-responsive cycling/control + efficient equipment	Appliances, WH, Electronics	Combine DF WH, appliance, and electronics strategies with most efficient equipment
	All remaining EE ECMs	Refrigeration	Account for efficiency outside of other EE+DF measures

Commercial measures were modeled with prototype buildings

The Commercial Prototype Reference Models were used with OpenStudio and EnergyPlus to explore the effect of various measures on hourly commercial building energy use.

Scenario	Measure Name	End Use(s)	Description
Energy Efficiency (EE)	Scout "Best Available" ECM portfolio	All major end uses	Current best available commercial ECMs, definitions posted on Scout GitHub repository
Demand Flexibility (DF)	Global temperature adjustment (GTA)	HVAC	Increase zone temperature set points for one or more peak hours
	GTA + pre-cooling		Decrease zone set points prior to peak period
	GTA + pre-cooling + ice storage		Charge ice storage overnight and discharge during peak period
	Continuous dimming	Lighting	Dim lighting, and shut off lighting in unoccupied spaces, for one or more peak hours
	Low priority device switching	Electronics	Switch off low-priority devices (e.g., unused PCs, equipment) for one or more peak hours
EE + DF	GTA + pre-cool/heat + efficient envelope and HVAC equip.; daylighting controls + dimming	HVAC, Lighting	Combine DF HVAC/lighting strategies with more efficient envelope/equipment, daylighting, and controls to maximize EE and DF
	Device switching + efficient electronics	Electronics	Combine DF electronics strategy with the most efficient electronic equipment
	All remaining EE ECMs	Refrigeration, WH	Account for efficiency outside of combined EE+DF measures above

Results are generated across multiple scales, each with specific geographic resolution, and aligned by county

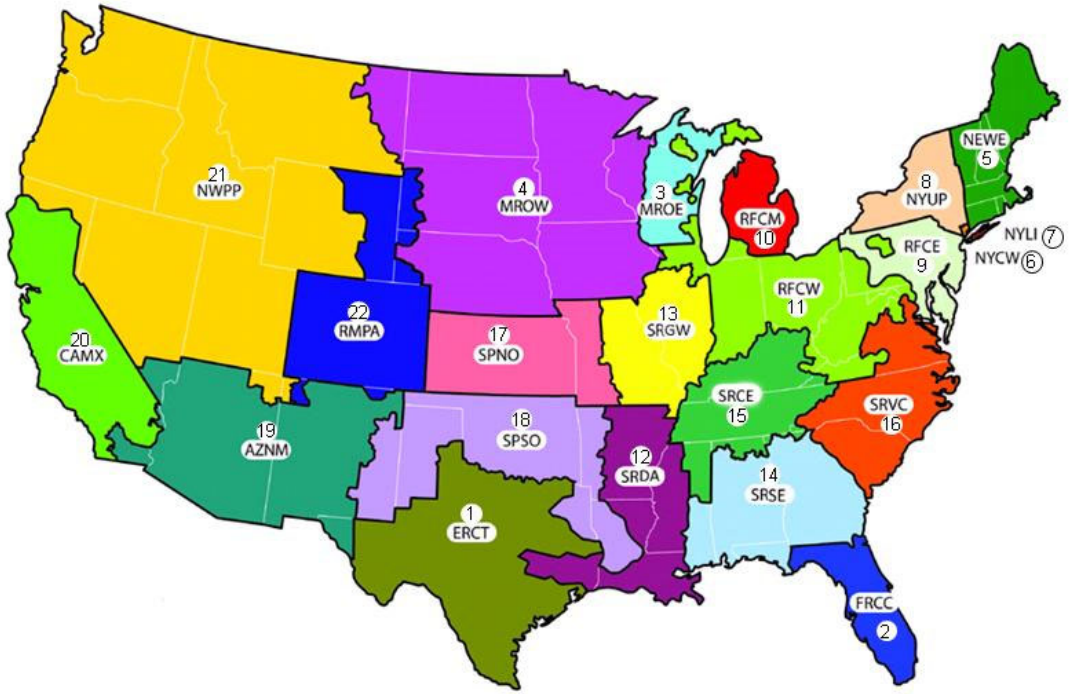


Building-scale simulation

Tools: ResStock, DOE Commercial Prototype Models

Boundaries: Representative cities for 14 mainland ASHRAE 90.1-2016 climate zones

County-level mapping



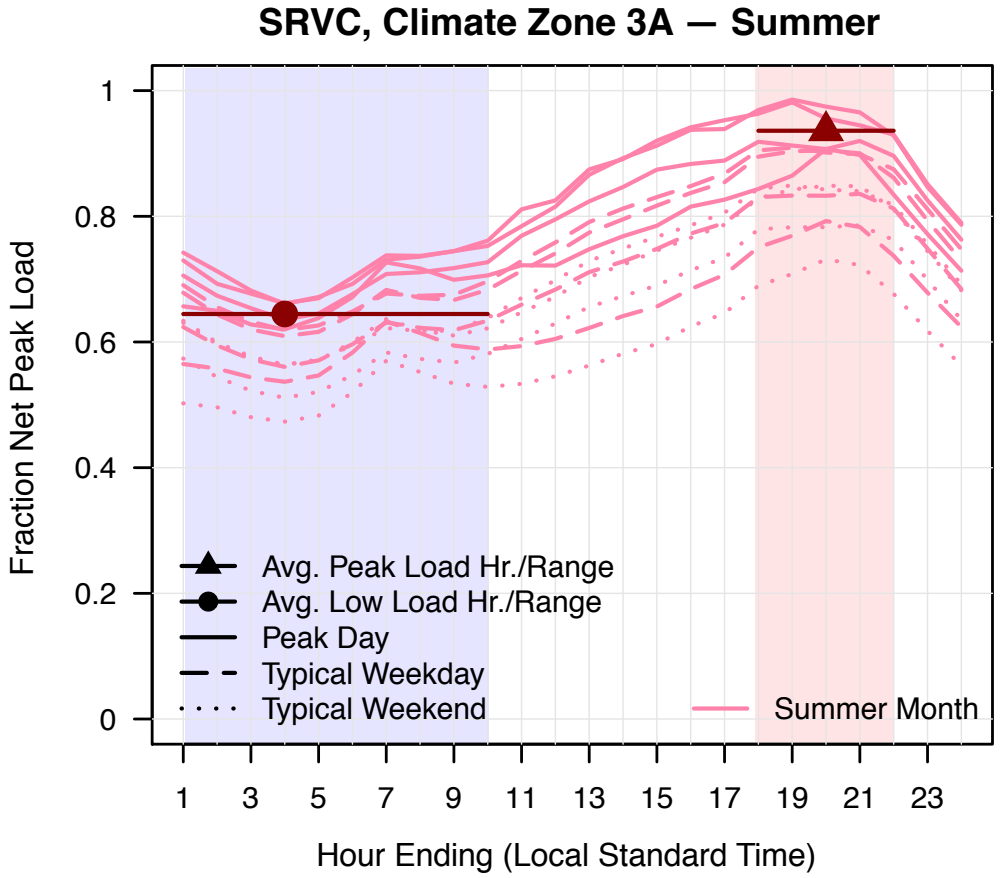
Region-scale simulation

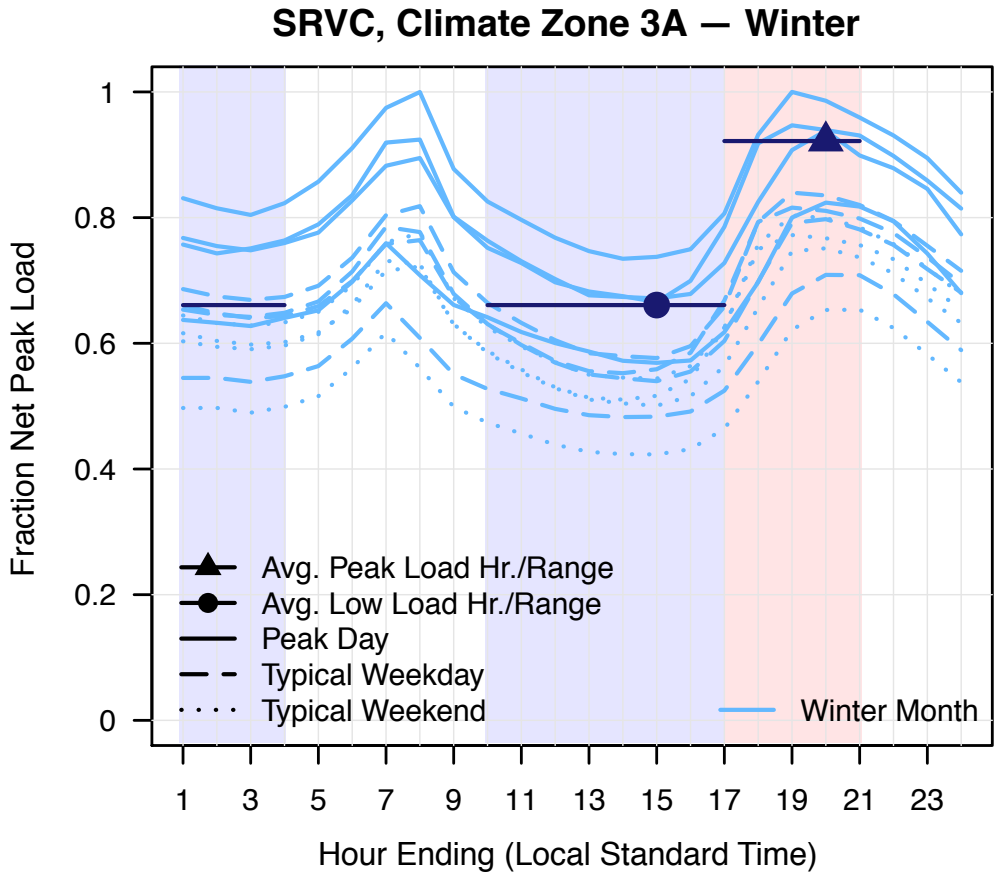
Tools: Scout

Boundaries: 22 U.S. EIA Electricity Market Module (EMM) regions

Net load shapes projected for 2050 for summer and winter inform flexible measure operation

- Flexibility measures are designed to remove load during net peak periods and build load during low net demand periods (if possible), flattening the net load shape.
- The year 2050 is used because it includes the highest renewable penetration levels.



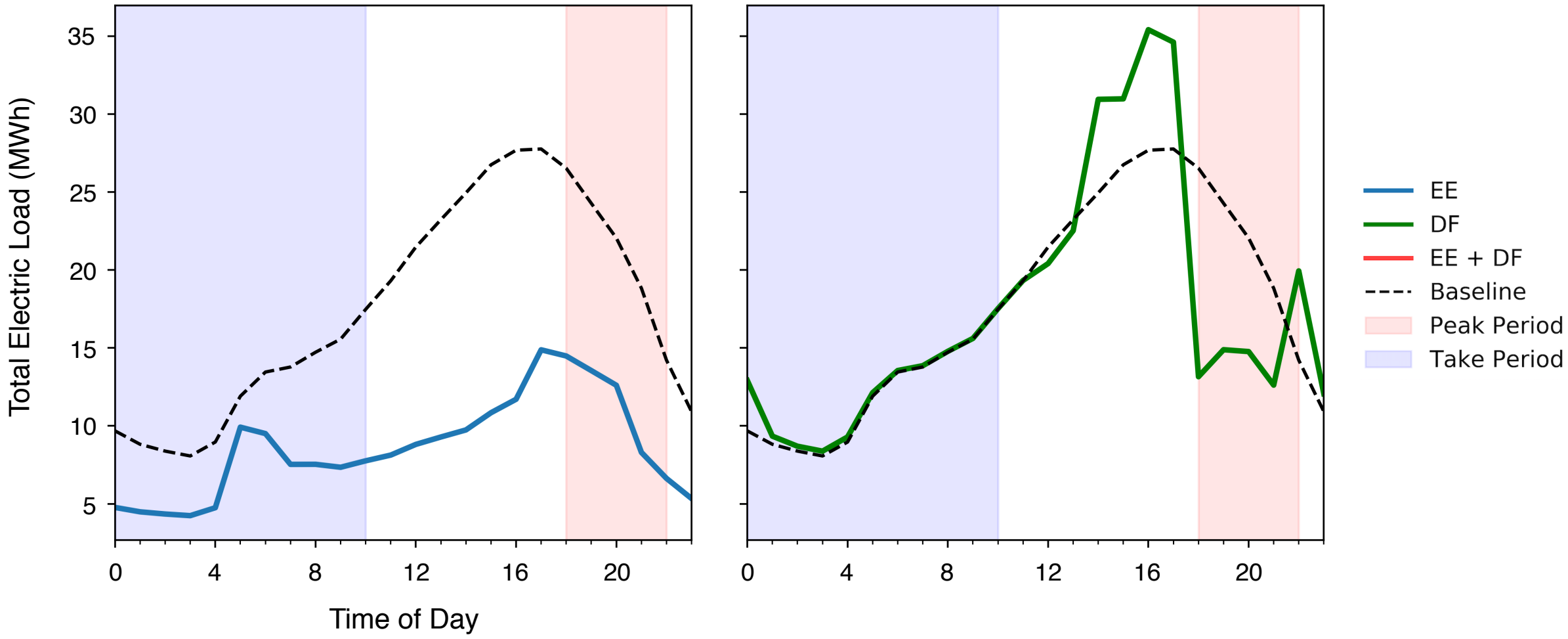


Data: EIA EMM, projection year 2050

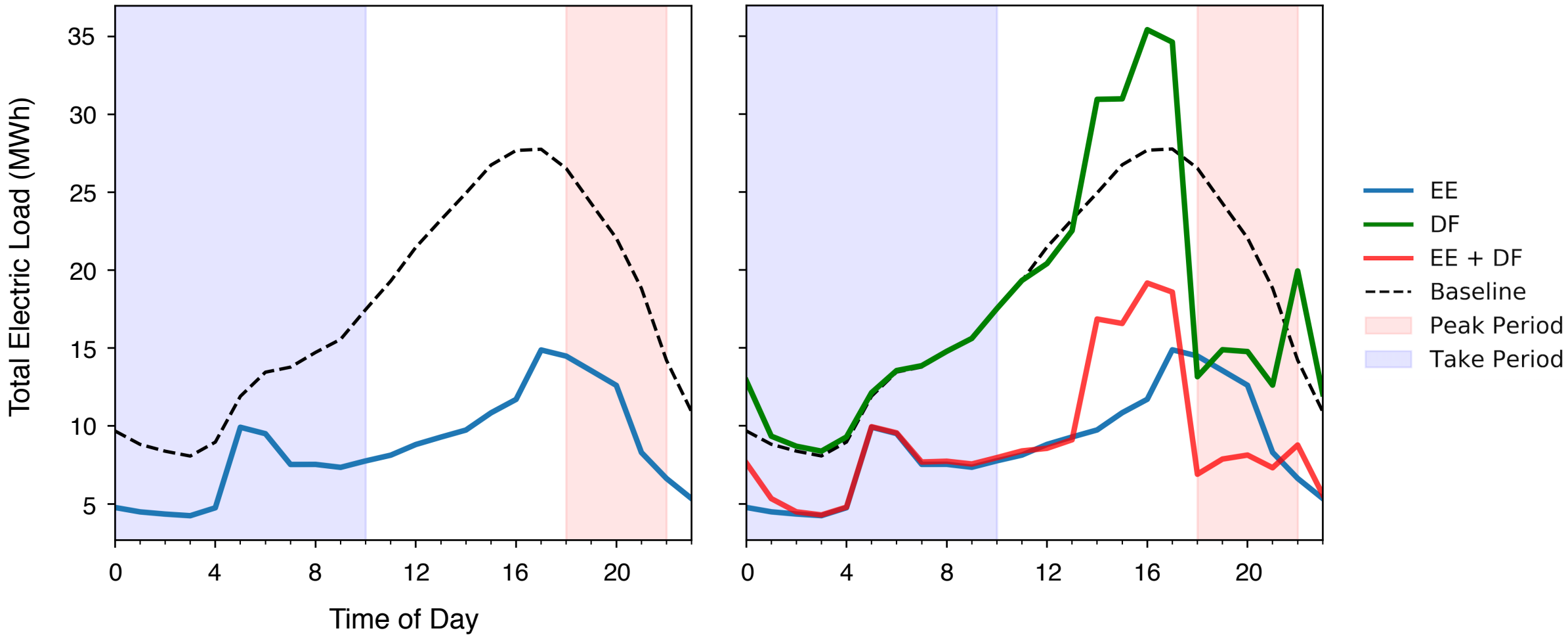
Current limitations

- **Primary focus is on technical potential results**
  - Results do not generally consider market conditions, consumer preferences, payback period, or price elasticity
- **Measures are based on the highest performance technologies currently available**
- **Does not include prospective technologies currently in development**
- **Measure operation is not based on real-time signals**
  - Flexible operation is defined based on preset net peak (high demand) and low demand periods set by EMM region

EE measures reduce load throughout the day, DF measures decrease load at peak times



Combining EE and DF measures together has the effect of combining the savings from EE with the shift/shed of DF



Efficiency and flexibility are complementary for peak demand reduction

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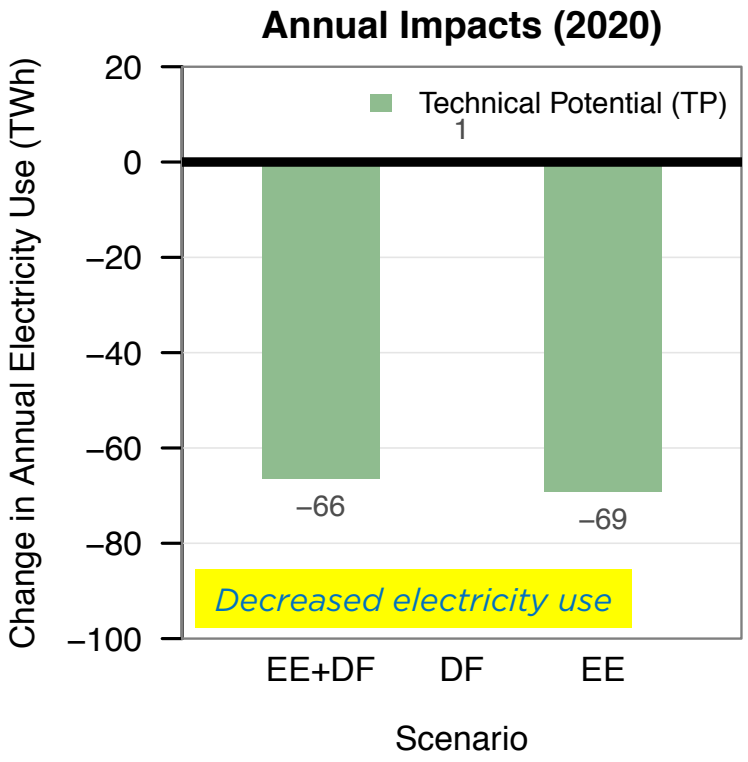

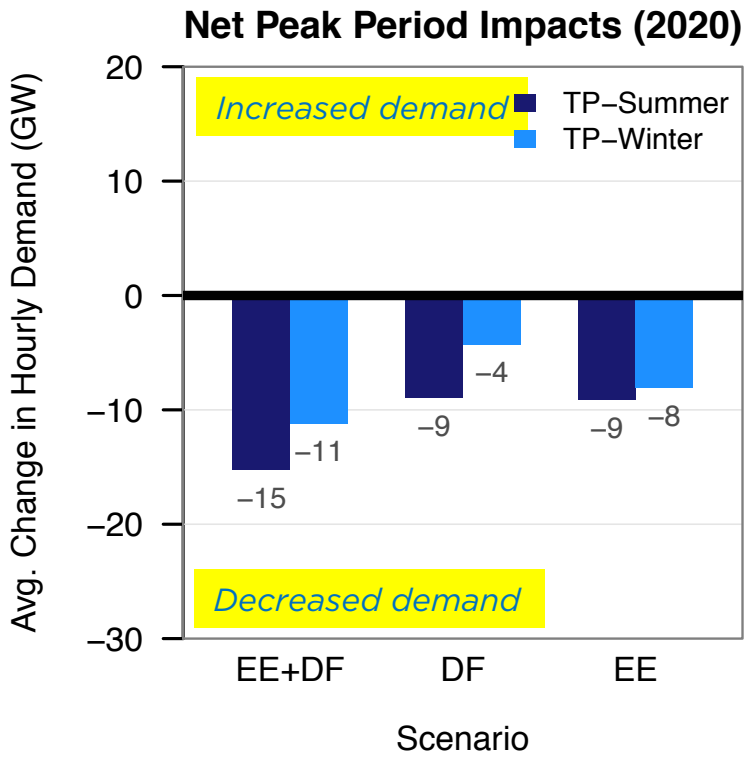

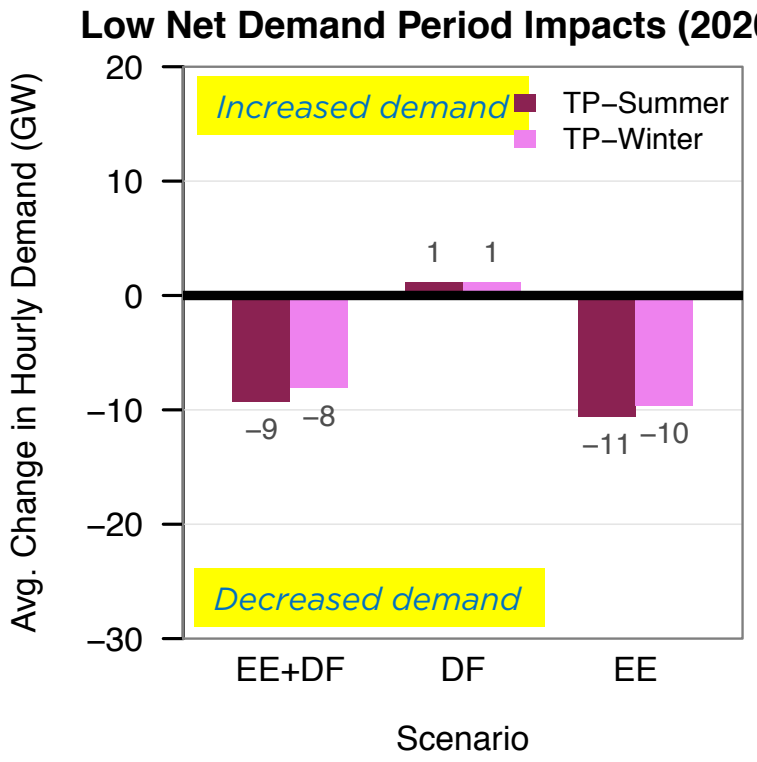

Data: Scout
Acronyms: Energy Efficiency (EE), Demand Flexibility (DF)

Residential buildings drive changes in load across metrics

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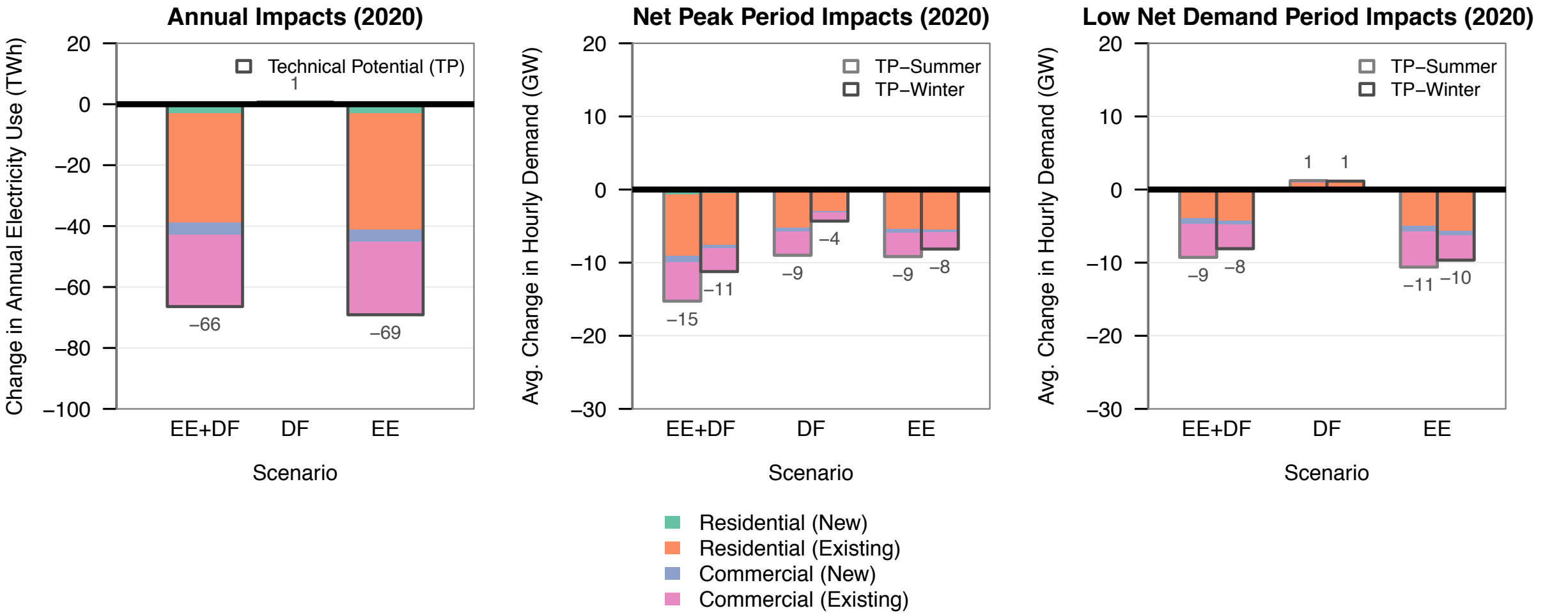

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Cooling and heating drive peak reductions, water heating adds load

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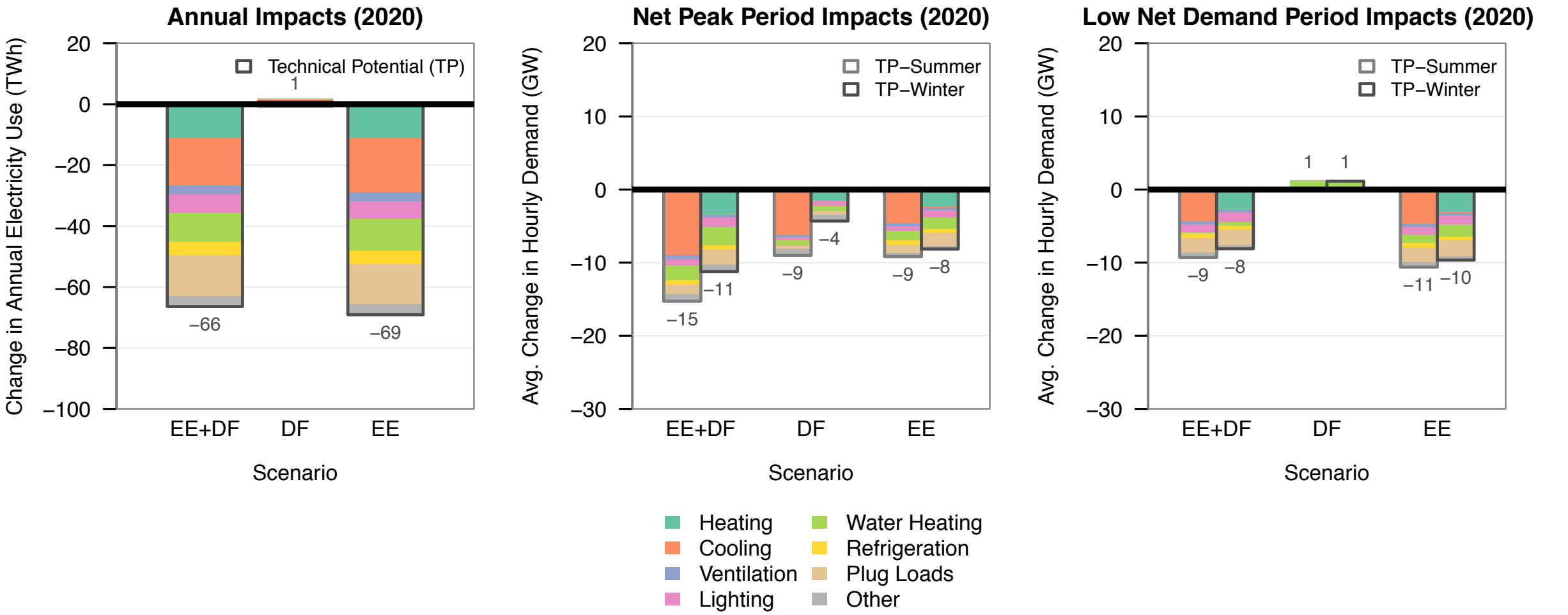
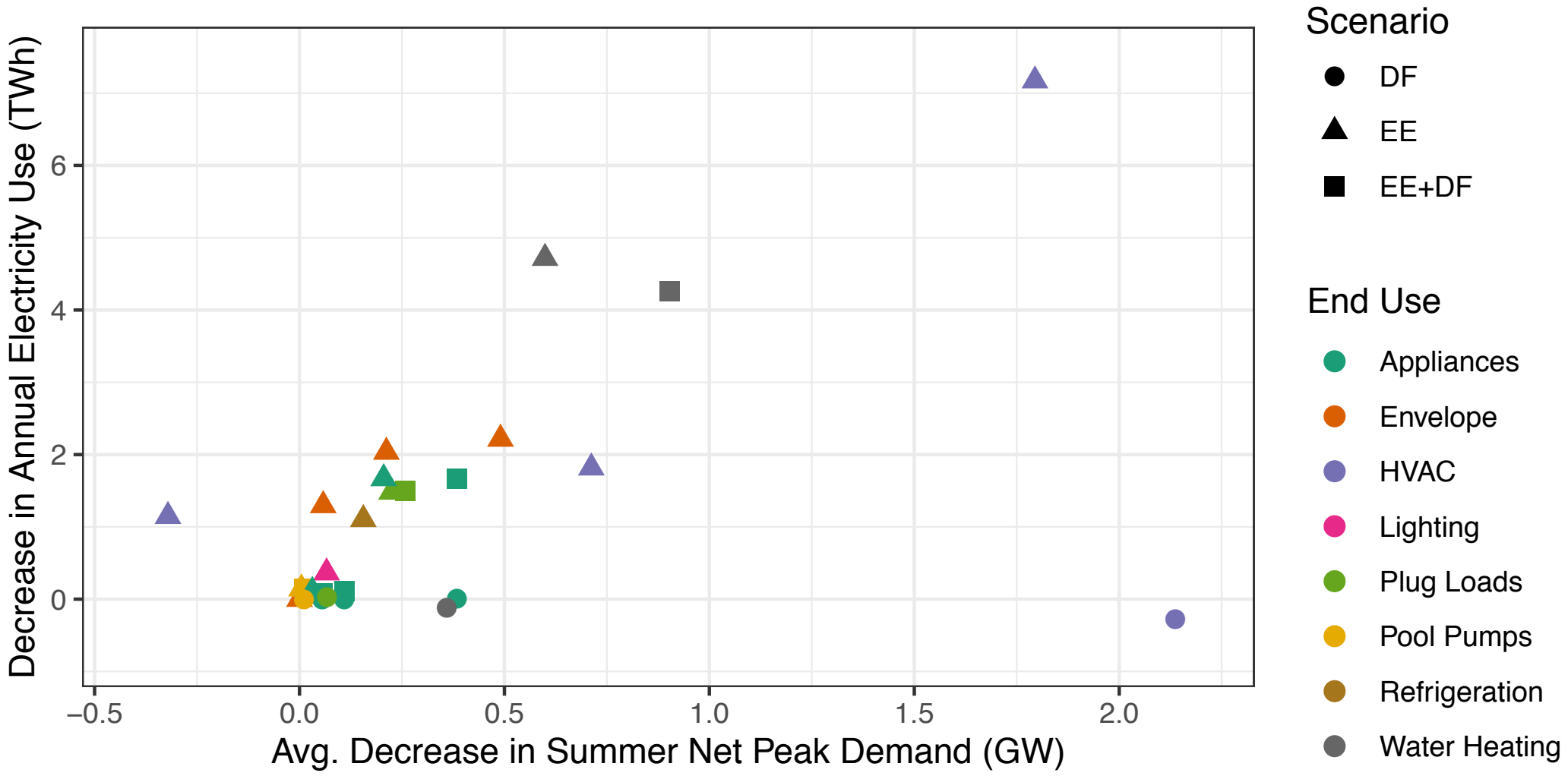
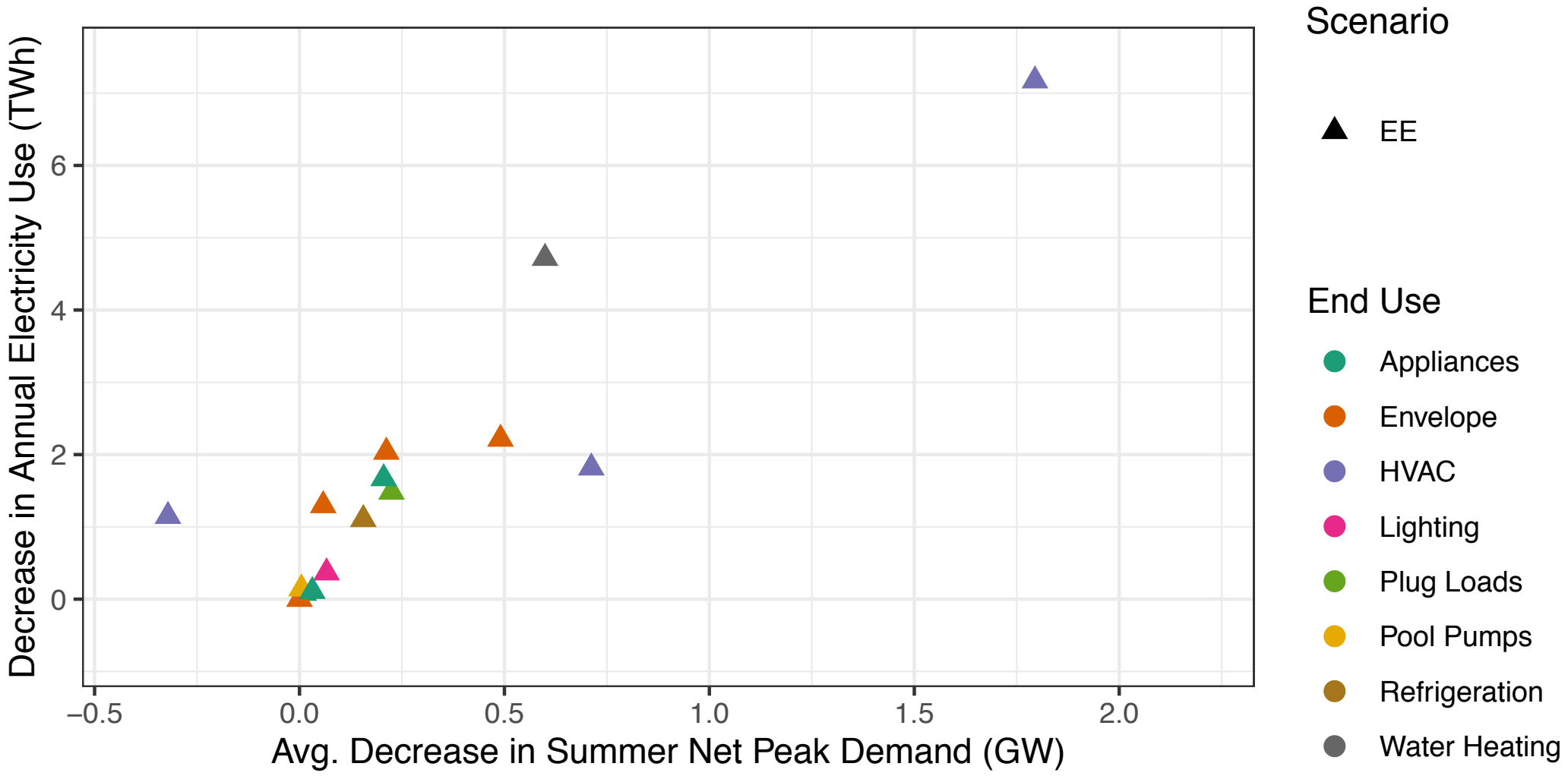


Data: Scout
Acronyms: Energy Efficiency (EE), Demand Flexibility (DF)

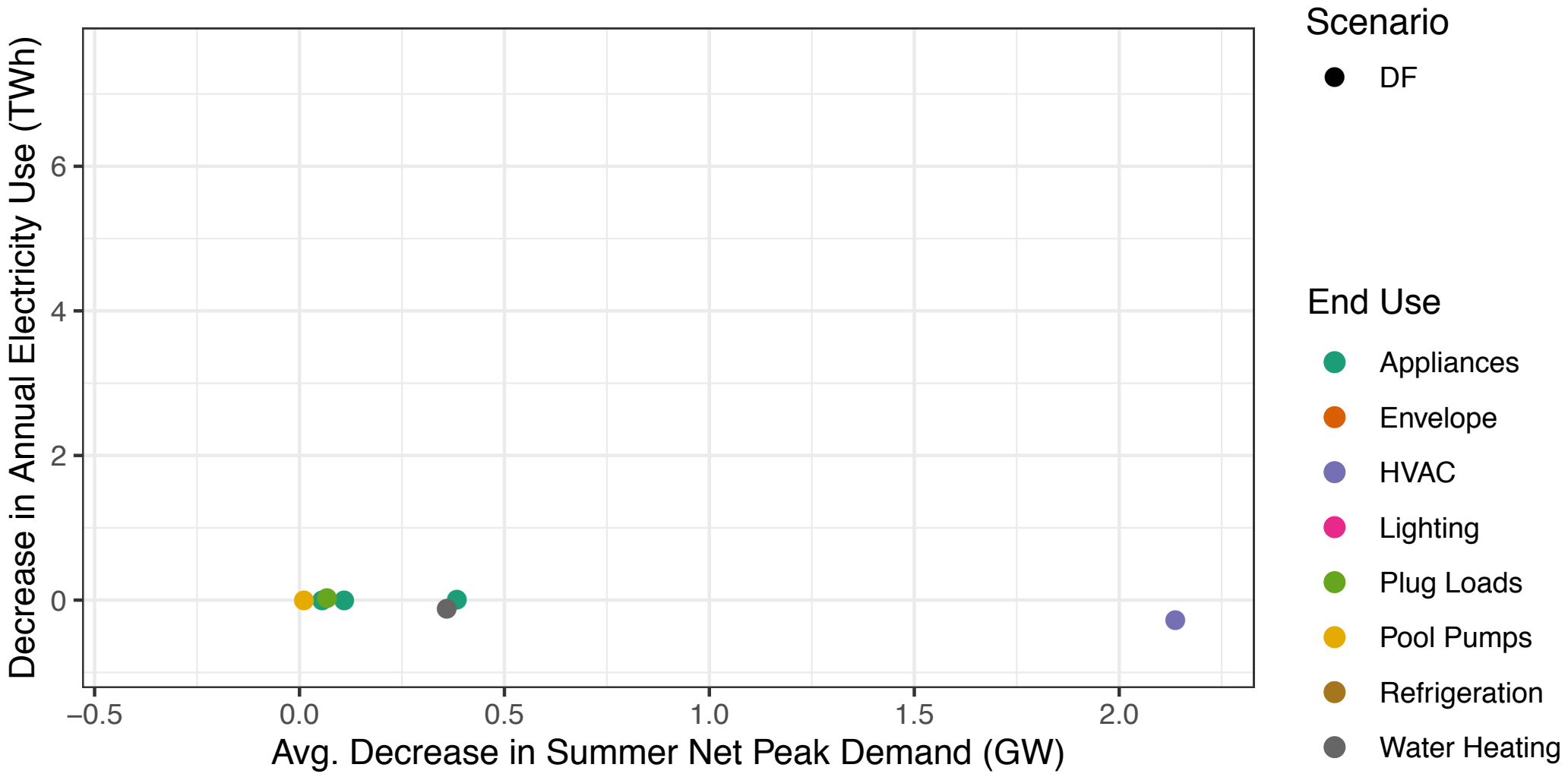
Residential measures show a diversity of summer peak and total impacts among scenarios



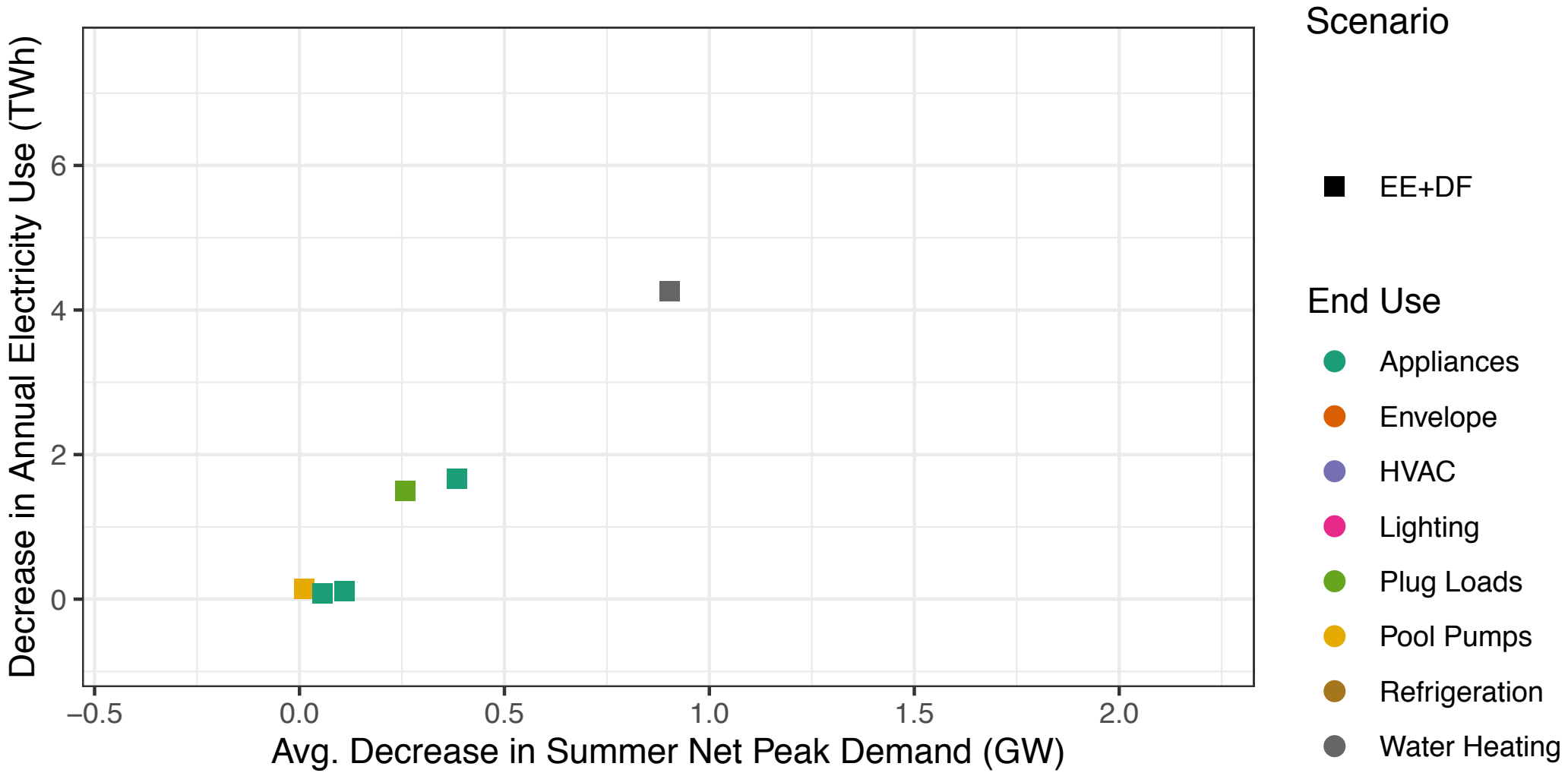
Efficiency measures that yield larger decreases in overall demand tend to also show larger decreases in peak demand



Demand flexibility measures do not substantially influence total annual electricity use



Combining efficiency and flexibility splits the difference in peak demand reductions and annual electricity use reductions



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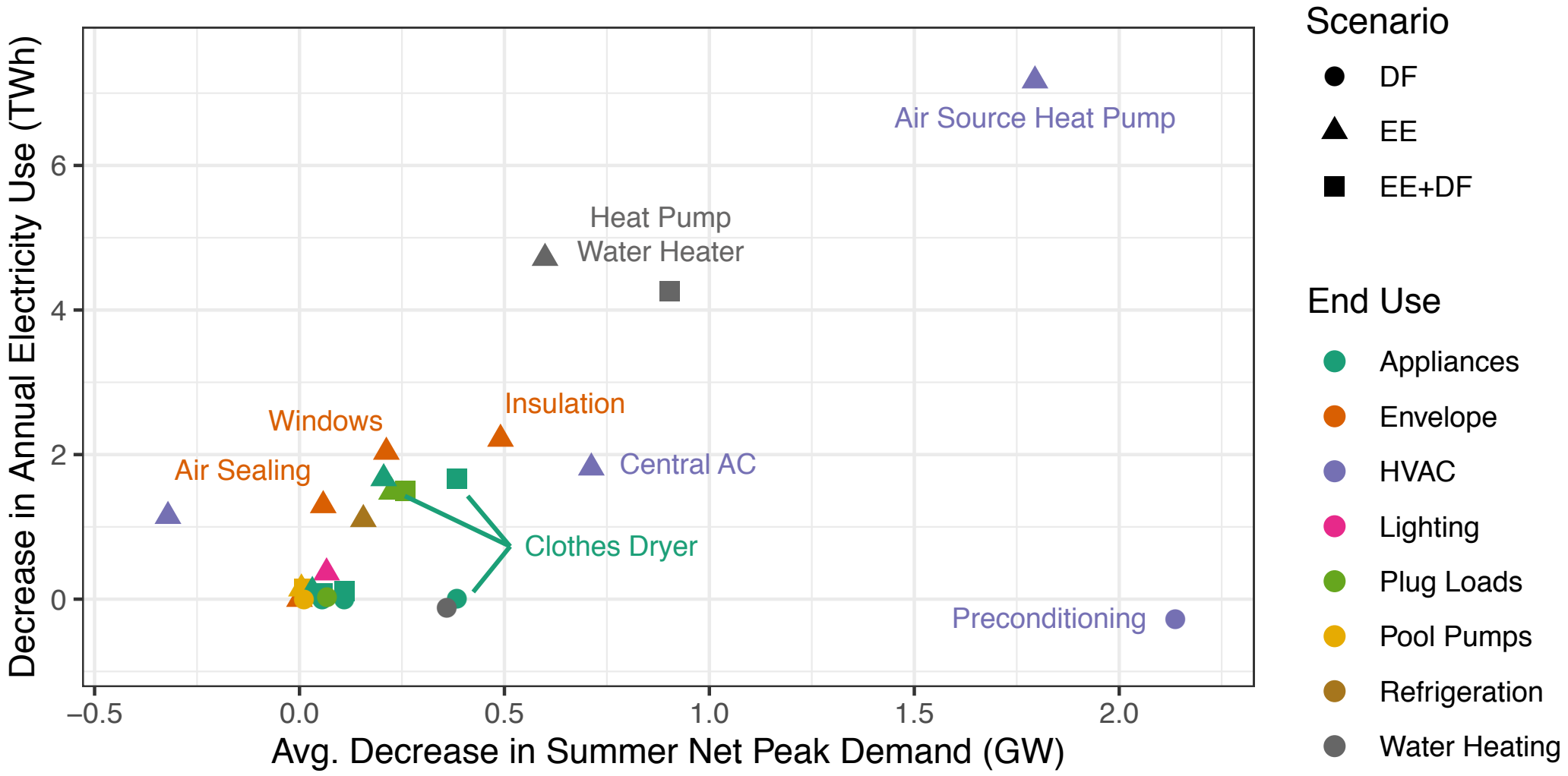
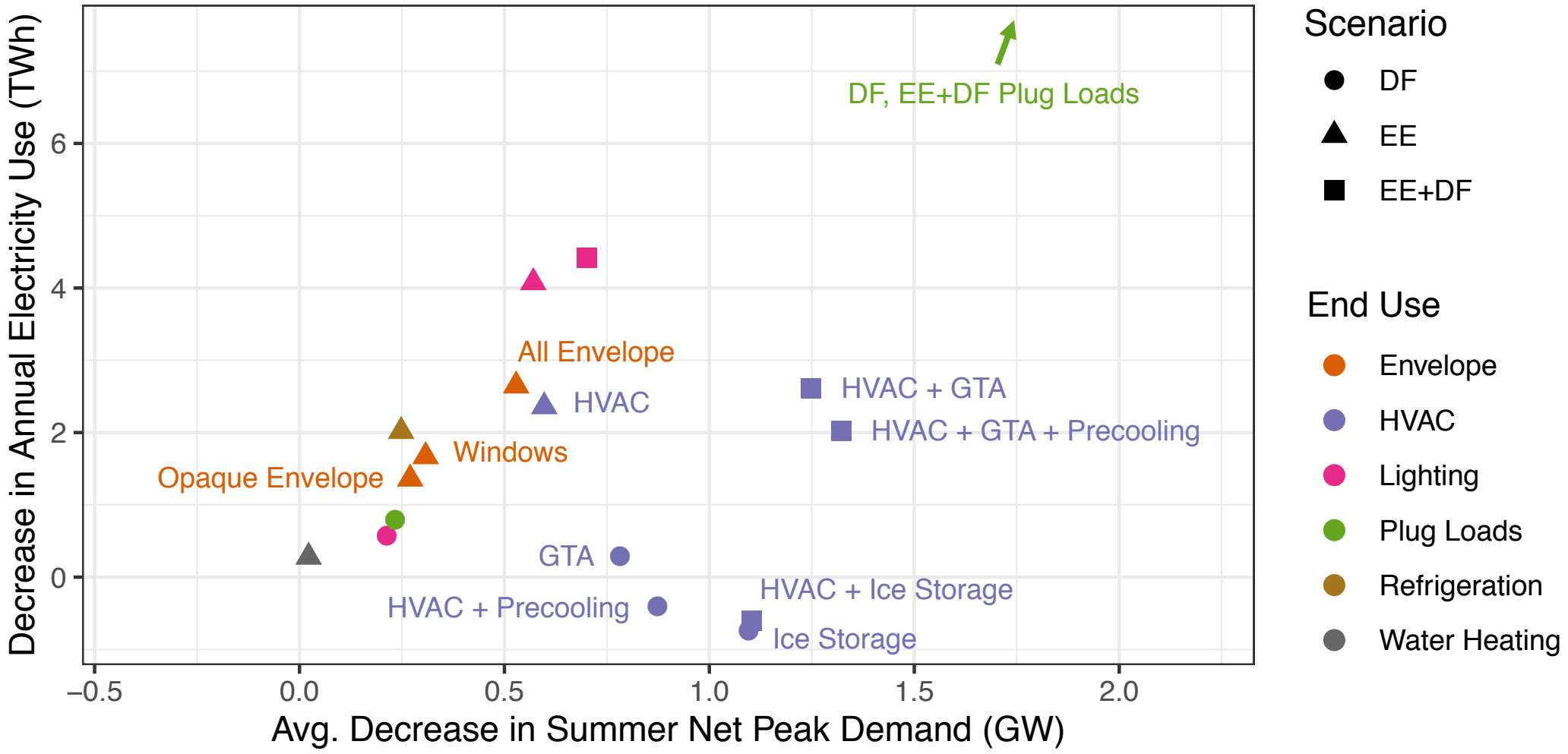


Commercial measures also show significant diversity, particularly among various HVAC strategies



Conclusion

Results from Scout can help quantify the potential for individual technologies, portfolios to impact peak, total electricity use

A quantitative framework was established for time-sensitive evaluation of building efficiency and flexibility measures, with results shown for a single region (and available for other regions of the U.S.)

- Adapts the Scout impact analysis software to enable assessment of hourly building electricity use under baseline conditions and with efficiency/flexibility measure adoption
- Leverages ResStock (residential) and DOE Prototype Models (commercial) to develop hourly baseline and measure electric load shapes across 14 climate zones

Initial results show a large potential peak reduction resource from buildings, interactions between efficiency and flexibility

Residential and commercial cooling, residential heating, and commercial plug loads show large potential for impacts on peak electricity demand and overall electricity use

Discussion

1. Would you benefit from seeing similar results, specific to your region?
2. Is the granularity of the results sufficient for your use?
3. What other data or information would be particularly useful? How can we provide more helpful information that can be applied to your needs?
4. How would/will you use data on GEB potential? (Inform goal-setting? Inform program design?)

Additional Tool Development

Additional Tool Development and Next Steps

NREL is preparing to conduct additional analysis in 2020/2021 expanding the Scout modeling to provide:

- Estimate upper and lower bound of customer participation for various DR technologies.
- Speed of adoption of DR technologies and diffusion into customer base.
- Analysis of elasticity of customer participation when influenced through changes in compensation (i.e., rates, tariffs)
- Using this analysis, we are hoping to develop a tool or simple web-app allowing states and utilities to simulate novel compensation mechanisms and estimate their impact on participation.

Additional Tool Development and Next Steps

In order to conduct this analysis and begin developing a tool, NREL is looking for data and input including:

- Any anonymized data on residential or commercial utility demand response programs (i.e., participation rates, compensation structures, availability)
- Data detailing customer participation in any ‘EV’ or ‘smart’ rates.

Additionally, and fitting with the larger technical assistance efforts of GEB, NREL is looking for an initial cohort of users that may be interested in piloting and contributing to the specification of the tool.

Thank you

Chioke Harris chioke.harris@nrel.gov

Joyce McLaren joyce.mclaren@nrel.gov

Sam Koebrich sam.koebrich@nrel.gov

Scout: scout.energy.gov

ResStock: www.nrel.gov/buildings/resstock.html

Commercial Prototypes:
https://www.energycodes.gov/development/commercial/prototype_models

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