

# Electric System Impacts of Utility Large-Scale Investment in Building Energy Efficiency

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PNNL

2011 ACEEE National Conference on  
Energy Efficiency as a Resource  
9/26/2011



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# Electric System Impacts of Utility Large-Scale Investment in Building Energy Efficiency

## ▶ Forthcoming PNNL report:

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## ▶ Sponsored by DOE Building Technologies Program

## ▶ Not affiliated with nor addressing Smart Grid



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# The questions

- ▶ How much can adding large-scale energy efficiency resource deployment actually delay or avoid new “bricks and mortar” generation resources at the utility system level?
- ▶ What happens to dispatch in four geographically representative utility service areas, accounting for transaction behavior?
- ▶ How does the emissions profile change in each of the four example utility service areas?



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# Issues for Energy Efficiency Resources

- ▶ Institutional barriers abound for large-scale deployment
  - Compensation model for cost recovery
  - Rate-payer financing of new resources
  - RPS in many states, but no accompanying recovery system
  - What to do in deregulated states?
  - How to acquire LARGE amounts of EE resource? – program design
  - Perceptions that favor central station for reliability and risk avoidance
  
- ▶ Market barriers also abound – this is just RESIDENTIAL
  - Impose major appliance decisions on consumers
    - Consumer choice versus command and control
  - Rate-payer financed?
  - Mobility of the resource
  - Reliability of the resource



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# The Model: PROMOD IV by Ventyx

- ▶ *“PROMOD IV is the industry-leading Fundamental Electric Market Simulation software, incorporating extensive details for understanding generating unit operating characteristics, transmission grid topology and constraints, and market system operations.”* from the Ventyx website.
- ▶ Allows zonal or nodal market (bus level) behavior to be simulated
- ▶ Comprehensive database of generators by utility service area
- ▶ Database is fully customizable if you have the data
- ▶ Visibility at all points of the analysis
- ▶ As much or as little summary detail as desired
- ▶ Utility system load forecasting and resource acquisition
- ▶ Simulates purchases and sales in the wholesale market



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# Criteria for Example Utilities

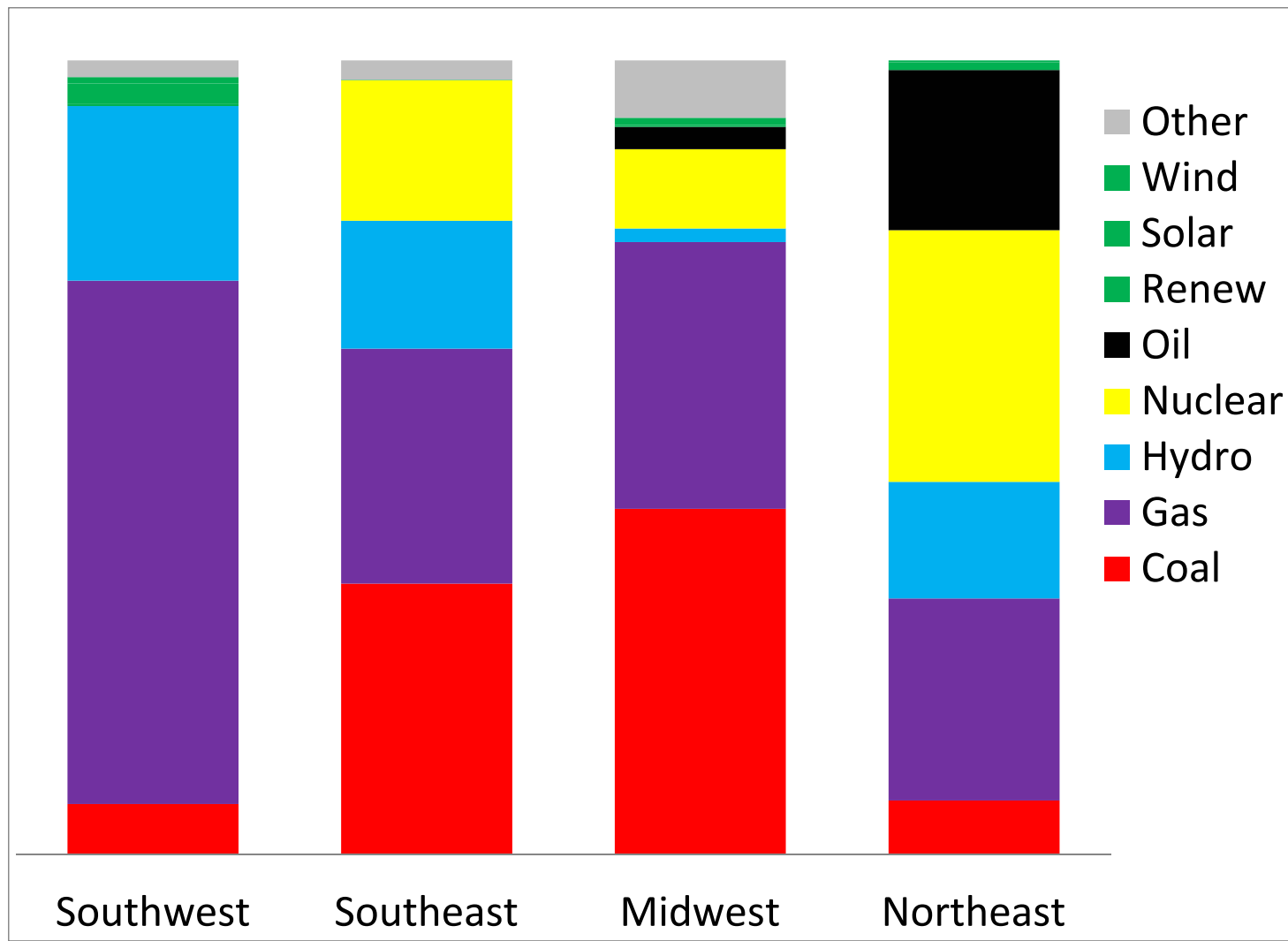
- ▶ Large enough to potentially consider new central station baseload
- ▶ Diverse fuel and technology mix of generation resources
- ▶ Geographically representative
- ▶ Regulated, no merchant generation
- ▶ Load forecasts are available



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# Example Utilities: 2010 Installed Capacity by Fuel



Source: Ventyx PowerBase

# Implementation Assumptions

- ▶ Utility can finance (and recover) costs of acquisition and installation of new major appliances for upwards of 500,000 residences or more
- ▶ Appliance upgrades would meet current Energy Star labeling criteria
- ▶ “Project” budget would be set at \$3-4 billion (overnight) and require a 10-year build-out, similar to a large central station power plant
- ▶ Adequate supply of installers and inspectors could be trained and available to support the build out
- ▶ Volume purchase contracts with manufacturers would be implemented and annual unit installation goals would be met.
- ▶ Annual maintenance program to recommission



# Residential Measures Applied

- ▶ Current Energy Star-compliant models installed across residential customer base
  - CFL Lighting
  - Refrigerator
  - Stove, Range, Oven
  - Water heater
  - HVAC unit
  - Television
- ▶ Allowance for unrealizable installations or previous adopters
- ▶ Allowance for measure degradation
- ▶ Stock accounting to 2020 only



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# The Model: Getting Residential Loads Right

Extract hourly system load from  
PROMOD IV

Split residential out by its share of  
consumption

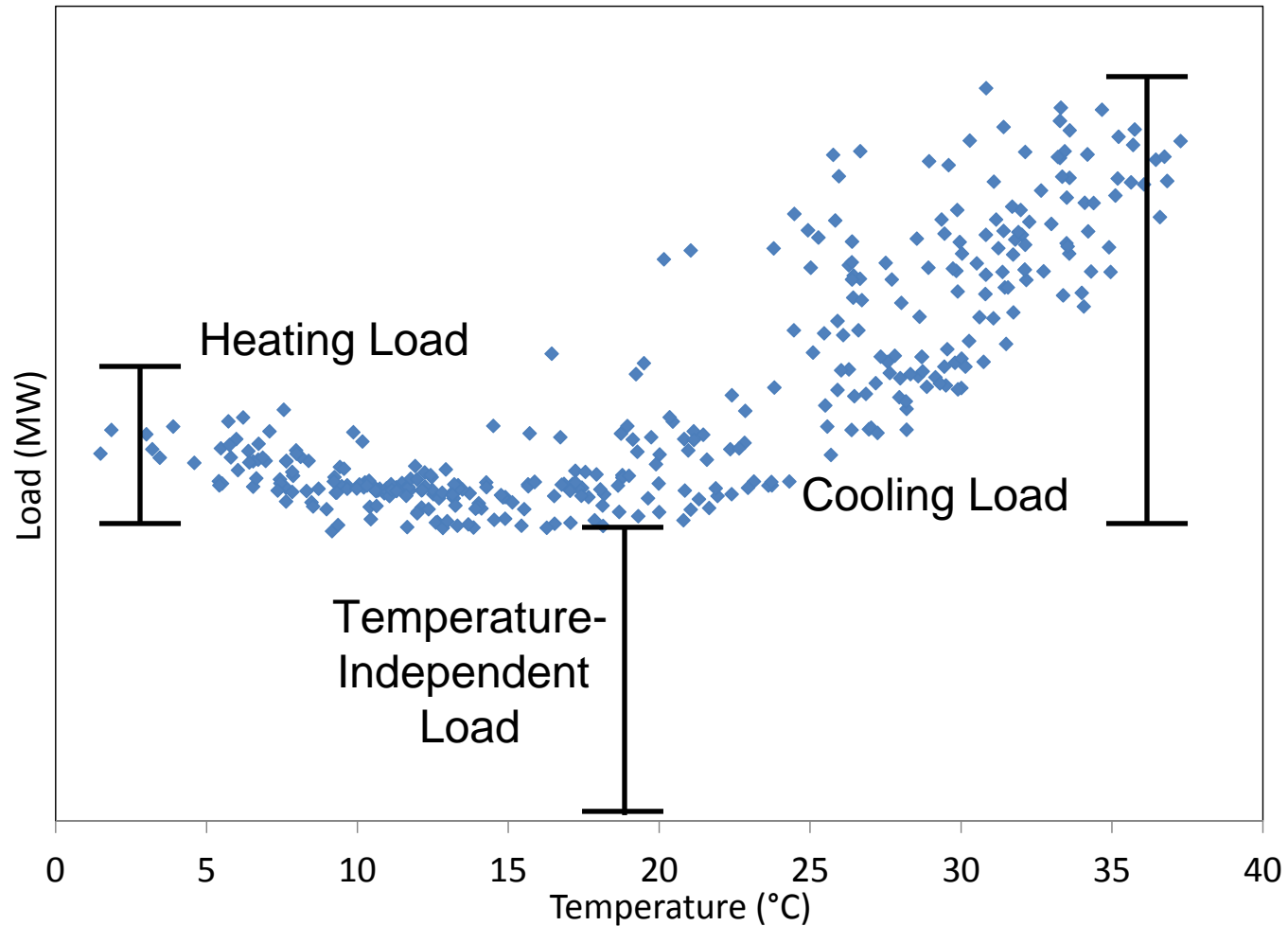
Use TMY data to determine the  
temperature-sensitive residential load  
(HVAC)



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# The Model: Getting Residential Loads Right



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# The Model: Getting Residential Loads Right

Start with EIA's National Energy Modeling System (NEMS) end-use load curves

Scale by energy use and saturation of each appliance, according to the California Residential Appliance Saturation Survey (CA-RASS)

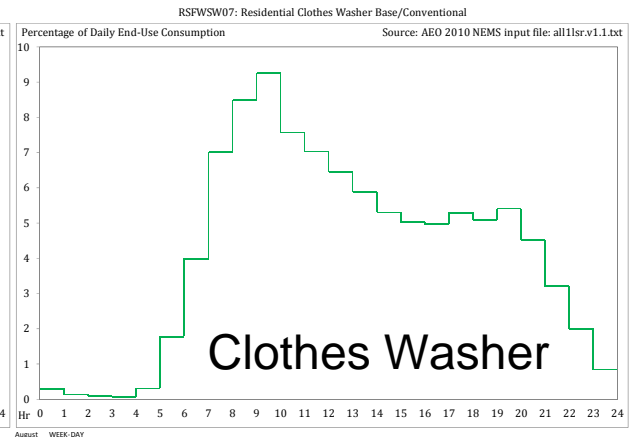
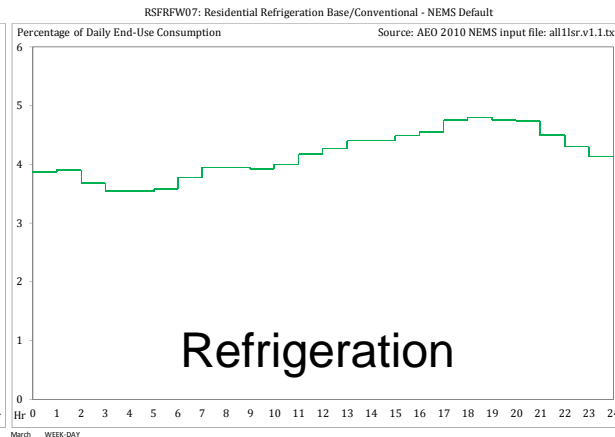
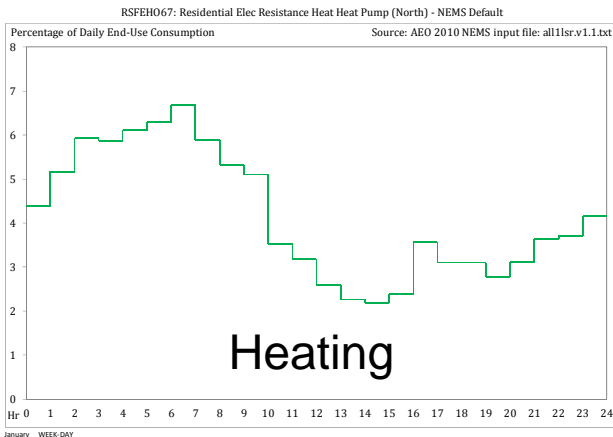
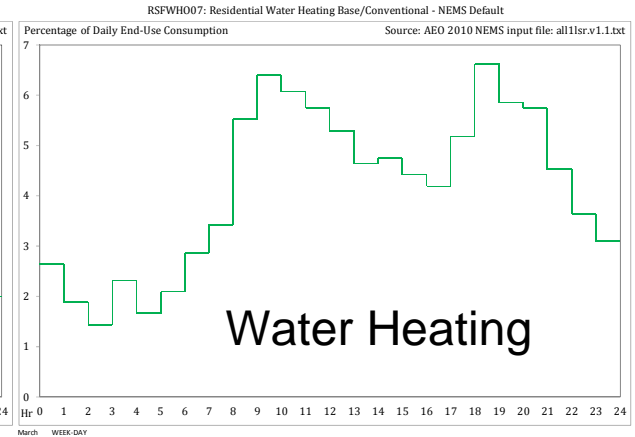
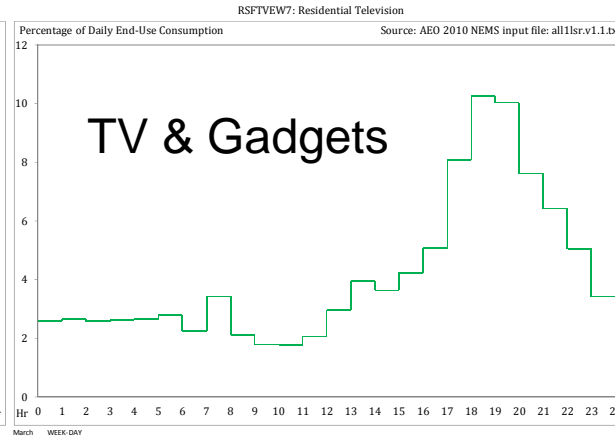
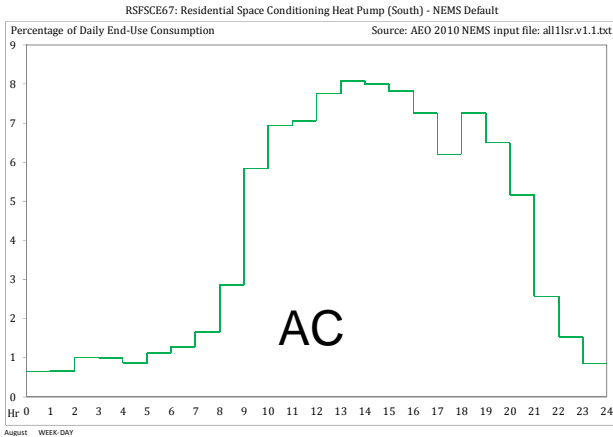
Scale all load curves so that allocated total equals non-temperature-dependent total



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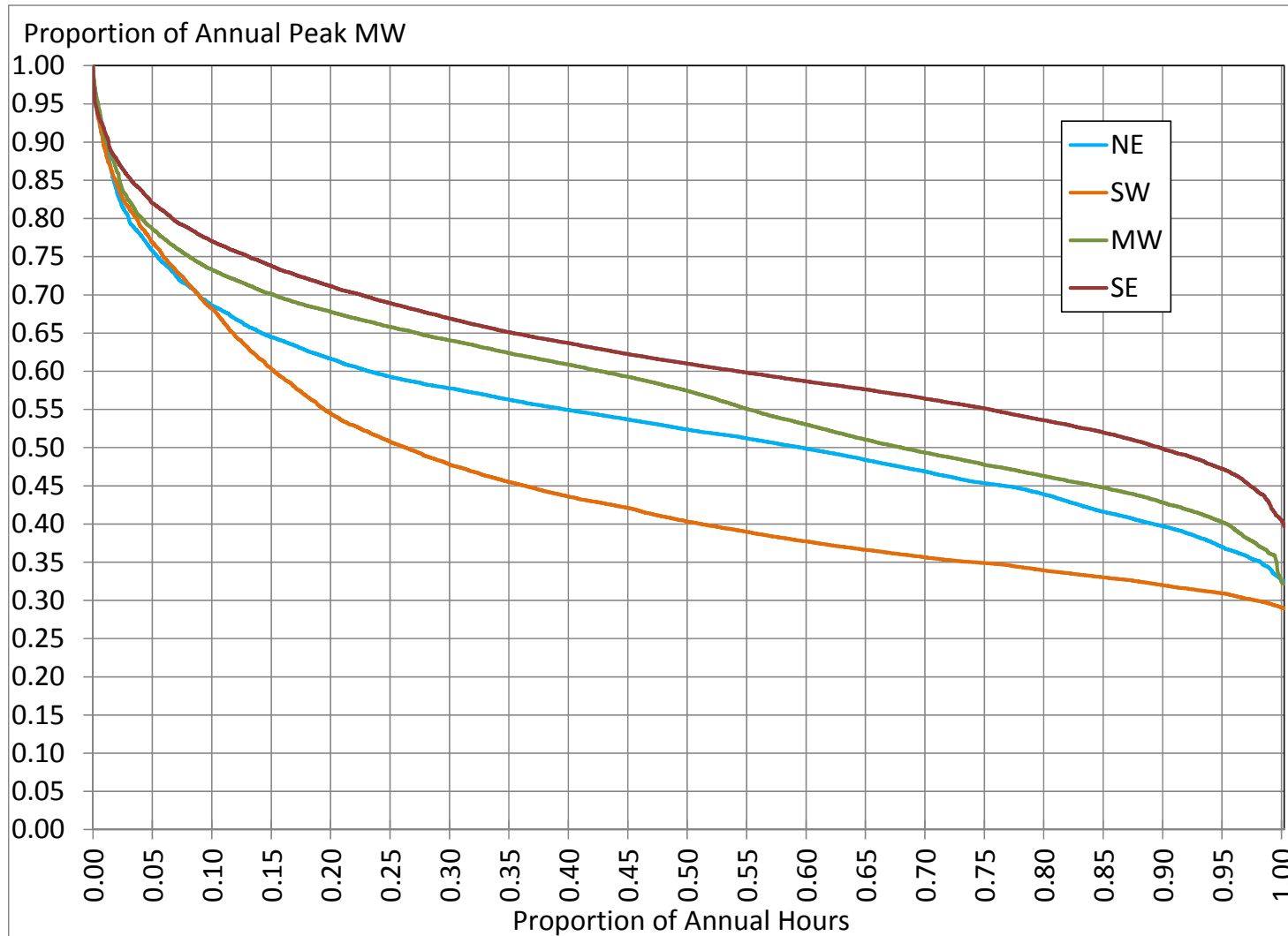
# End Use Load Shapes: Some Examples



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# Load Duration Curves for Example Utilities



# Modeling 2020 Savings

Estimate annual implementation effects on total system hourly load forecast

Feed revised annual hourly system loads for 2011-2020 to PROMOD

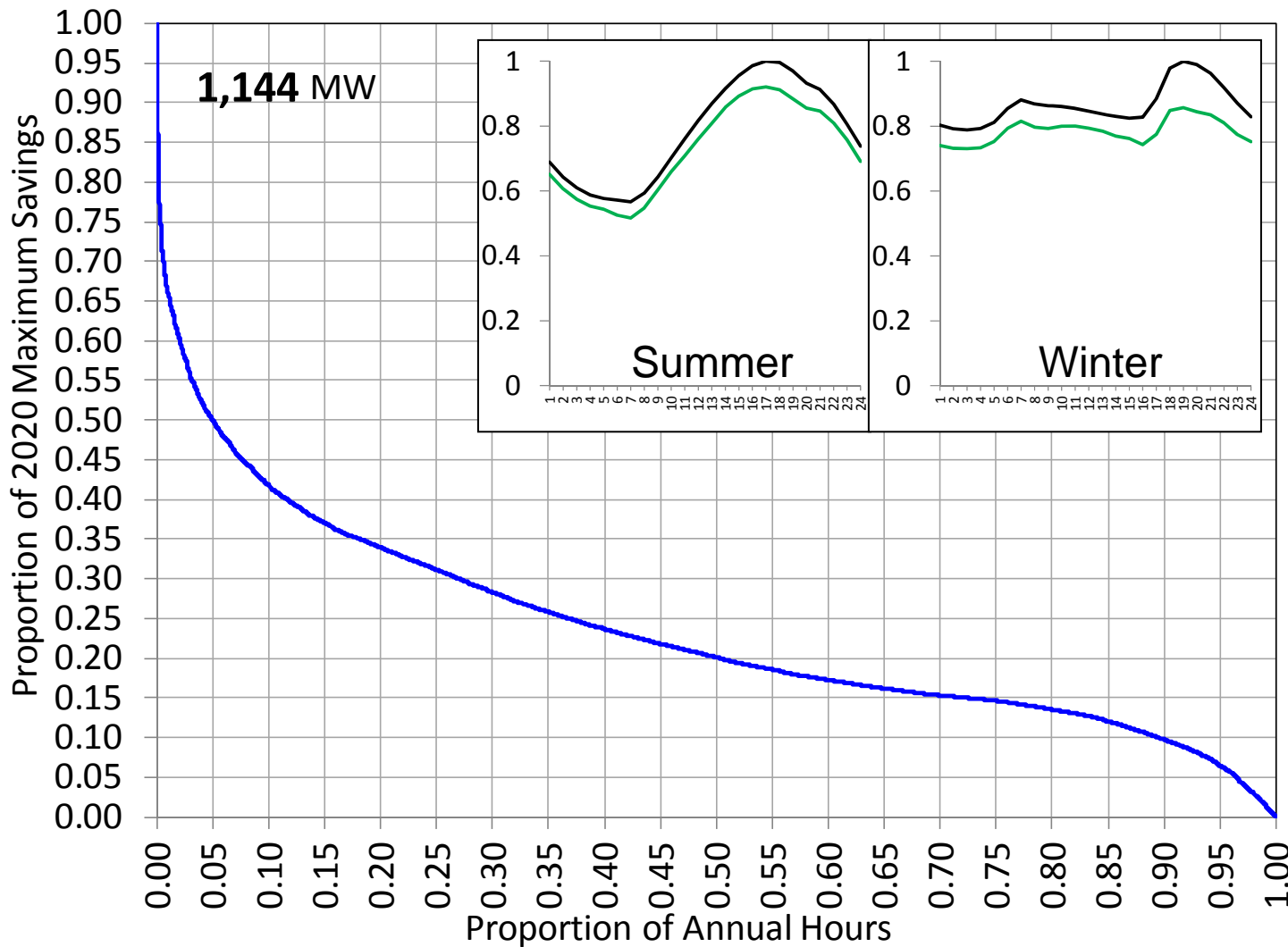
Summarize impacts for 2020



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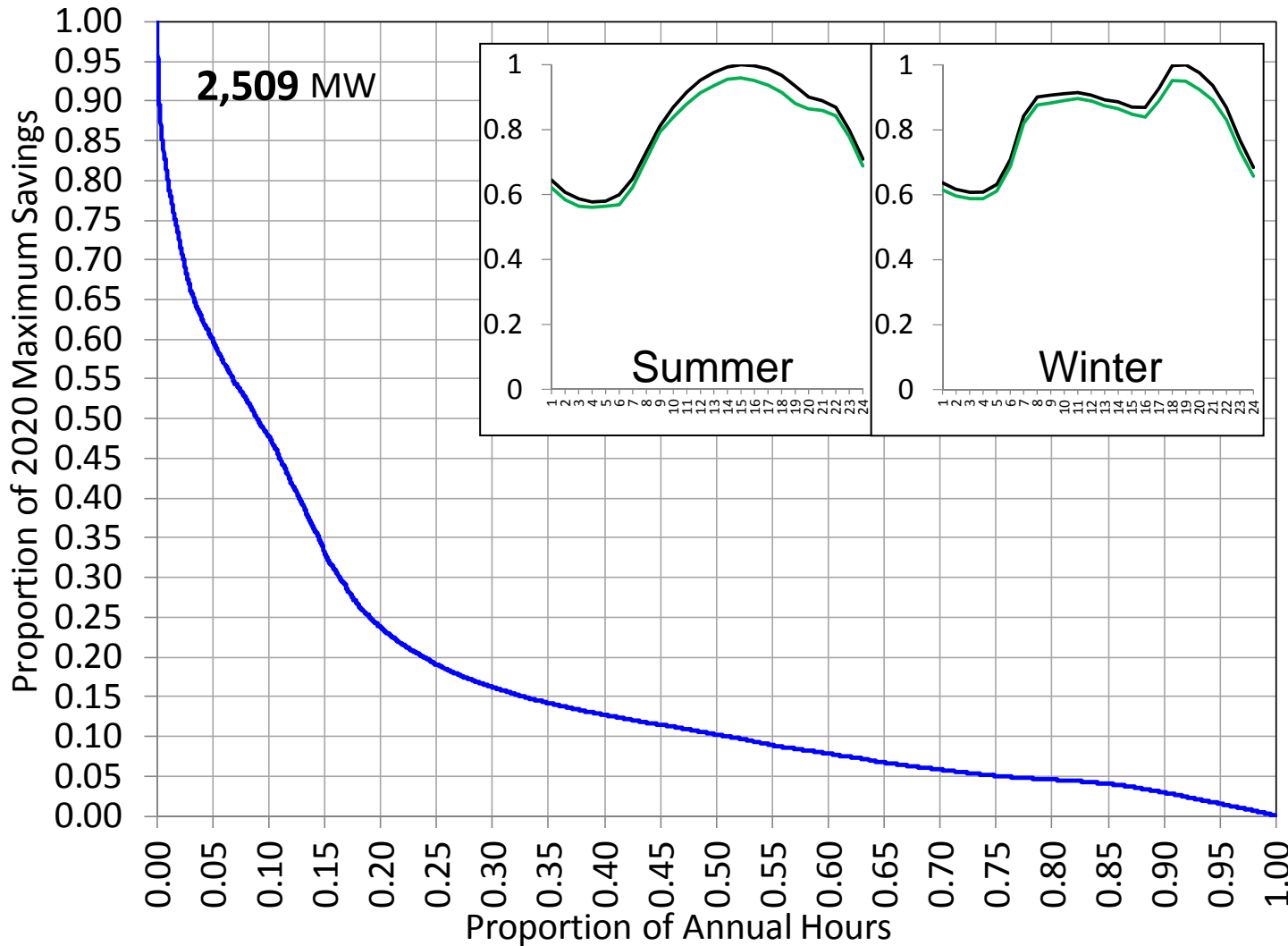
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# Savings Duration: Southwest Example





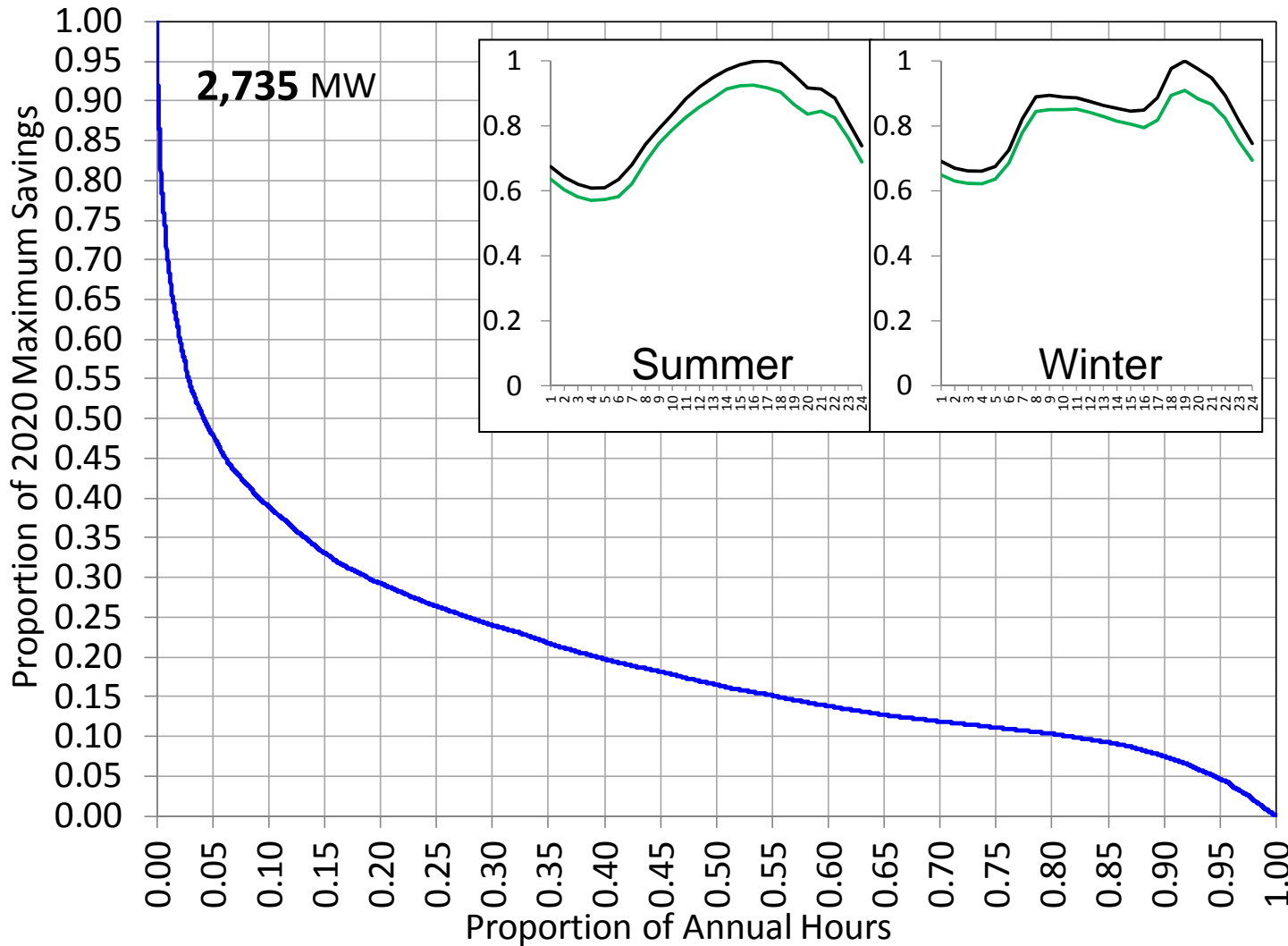
# Savings Duration: Midwest Example



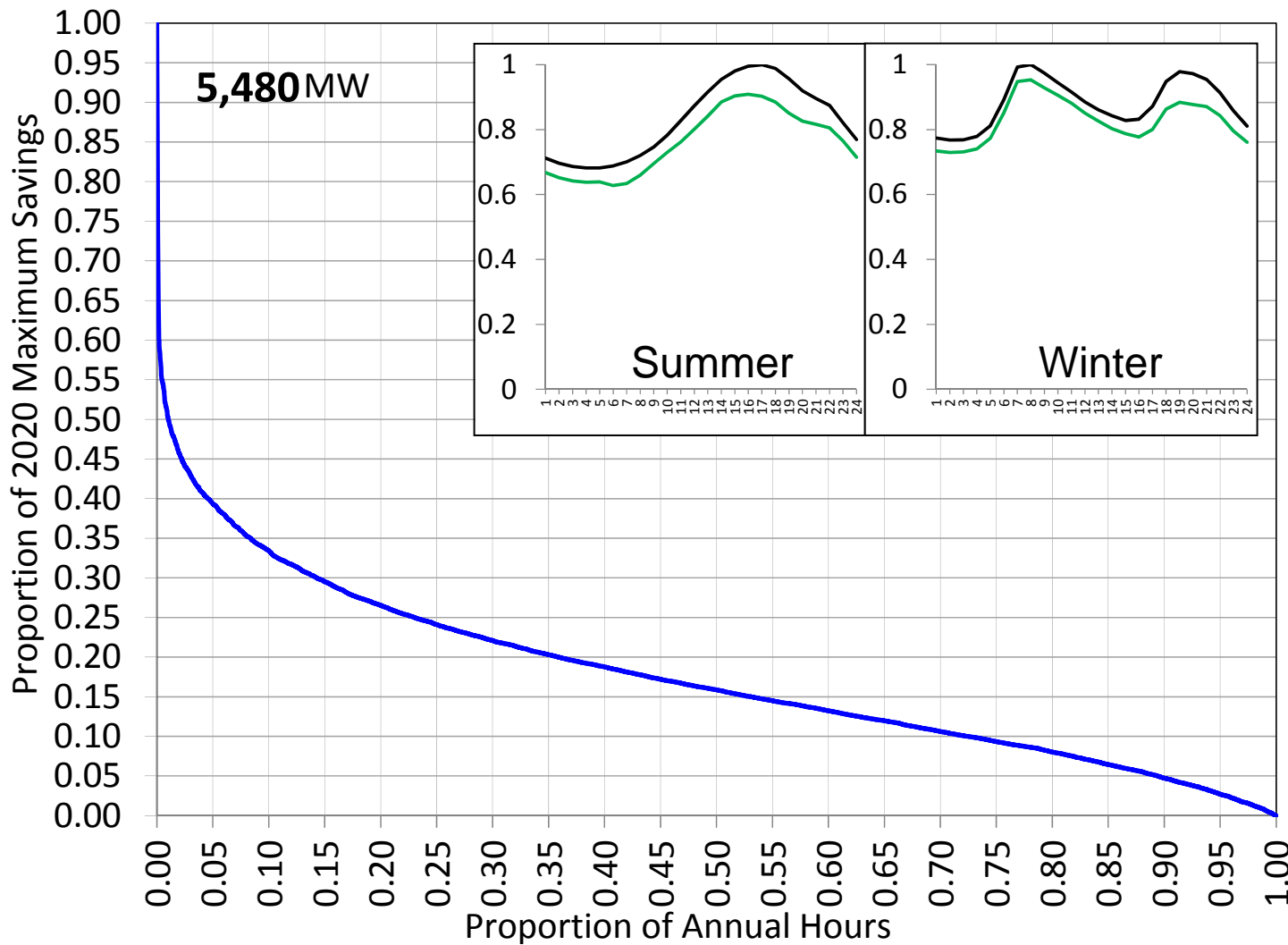
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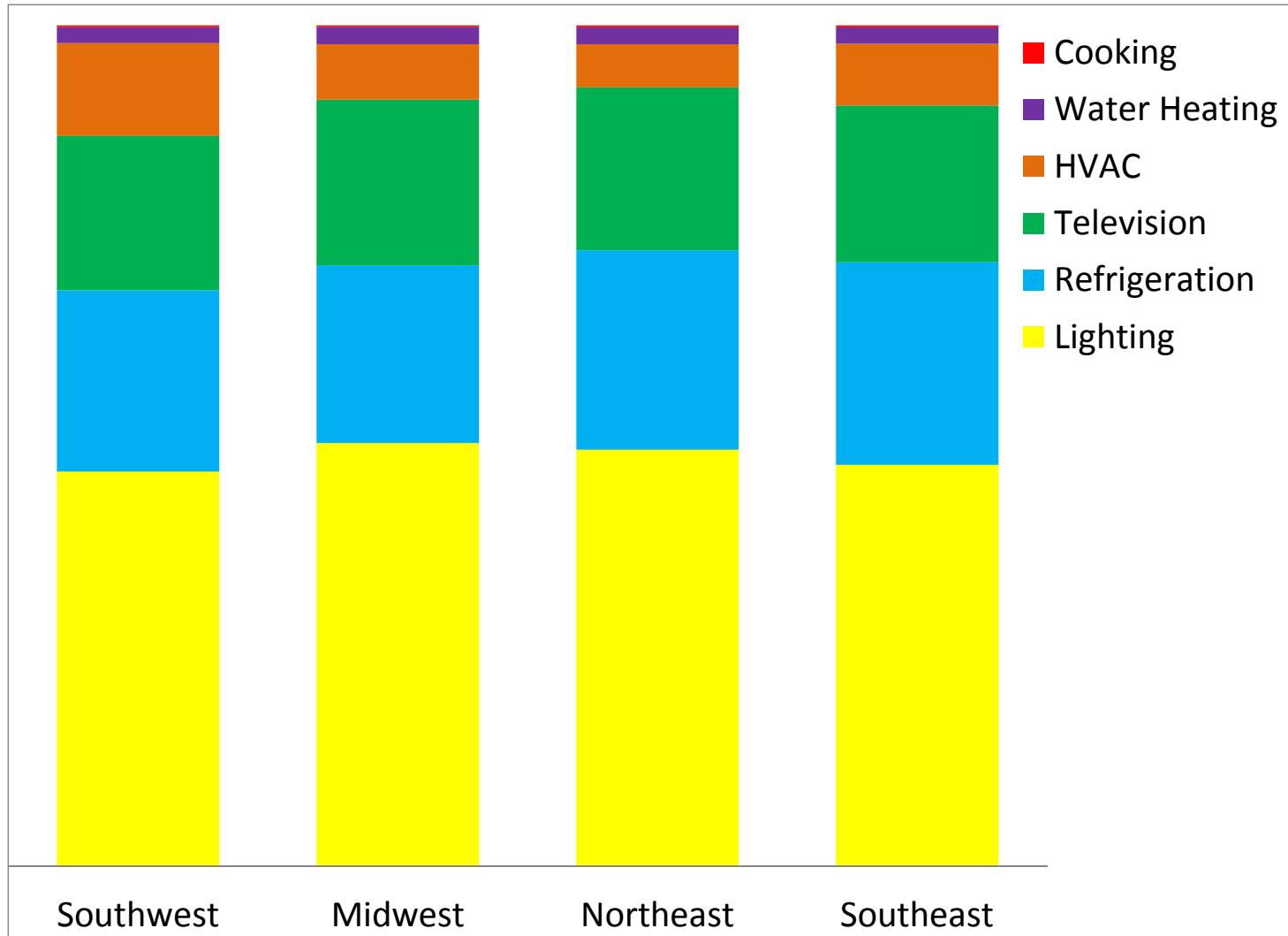
# Savings Duration: Northeast Example



# Savings Duration: Southeast Example



# Savings Proportions by End Use



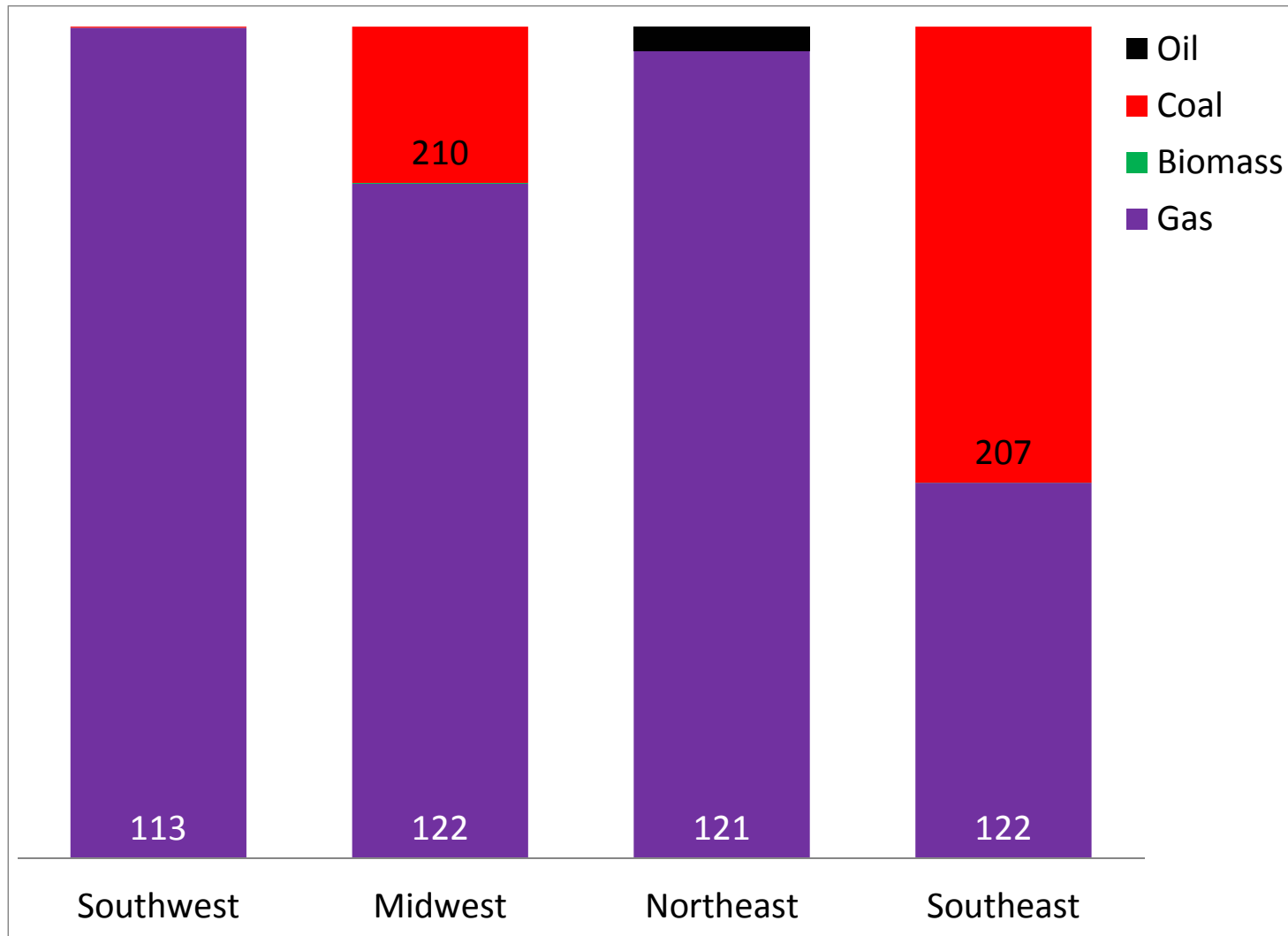
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# Results Summary

<b>Example Utility</b>	<b>2020 Peak-Hr MW % Savings</b>	<b>2020 Mean Savings Capacity Factor</b>	<b>2020 MWh % Savings</b>	<b>2020 Net change in Transactions MWh (%)</b>	<b>2020 Carbon Savings %</b>
Southwest	11.9	23.3	6.8	17.2	1.8
Midwest	24.9	11.8	3.1	19.9	0.6
Northeast	27.6	18.3	7.6	28.9	3.9
Southeast	9.4	17.7	2.9	2.4	2.0

# Relative Carbon Emissions Savings by Fuel



(CO<sub>2</sub> lbs/MMBTU)

# Conclusions and Discussion

- ▶ Large-scale (\$3-4 Billion) acquisition of efficiency provides baseload savings in 2020 during 70-75 percent of the year for utilities that might afford it
- ▶ Baseload savings amount to 5-15% of maximum hourly savings (150-500 MW in the example utilities)
- ▶ Modeling shows that utilities will sell excess generation saved by efficiency when possible – reducing savings
- ▶ Starting point of load forecast matters – results vary widely depending on forecast trends
- ▶ Barriers to large-scale acquisition are significant, but worth discussing and analyzing
- ▶ Next up: Commercial sector



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- ▶ Feedback is requested and welcome