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Energy Technologies Area Lawrence Berkeley National Laboratory

Michigan Public Service Commission Integrated Resource Planning Stakeholder Group Meeting

Tom Eckman and Natalie Mims

August 8, 2017

This work was supported by the DOE Office of Electricity Delivery and Energy Reliability under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231.

Today's Agenda

Time	Content
9:00 – 10:00 am	Review of IRP content and development process • Focus on treatment of efficiency and demand response
10:00 – 11:00 am	**Time-varying value of energy efficiency research**
11:00 - Noon	Uncertainty and Risk Analysis
Noon – 1:30 pm	Lunch break
1:30 – 3:30	Stakeholder engagement

Energy Technologies Area Lawrence Berkeley National Laboratory

Time-Varying Value of Energy Efficiency

Natalie Mims and Tom Eckman

August 8, 2017

This work was supported by the DOE Office of Energy Efficiency & Renewable Energy Building Technologies Office under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231.

Project Objective and Scope

- Advance consideration of the value of demand-side energy efficiency measures during times of peak electricity demand and high electricity prices through quantitative examples of the value of energy efficiency at times of system peak
- Increase awareness of available end-use load research and its application to time-varying valuation of energy efficiency
- Increase awareness of the gaps in, and need for, research on energy savings shape
- Recommend methodology(ies) to appropriately value energy efficiency for meeting peak demand
- Consider changes to efficiency valuation methodologies to address the changing shape of net load (total electric demand in the system minus wind and solar)

Study Approach

- Summarize state of end-use load research and existing analyses that quantify benefits of electric efficiency measures and programs during peak demand and high electricity prices
- Document time-varying energy and demand impacts of 5 measures in 4 locations:

Measures

- Exit sign (Flat load shape)
- Commercial lighting
- Residential lighting
- Residential water heater
- Residential air conditioning

State/Region

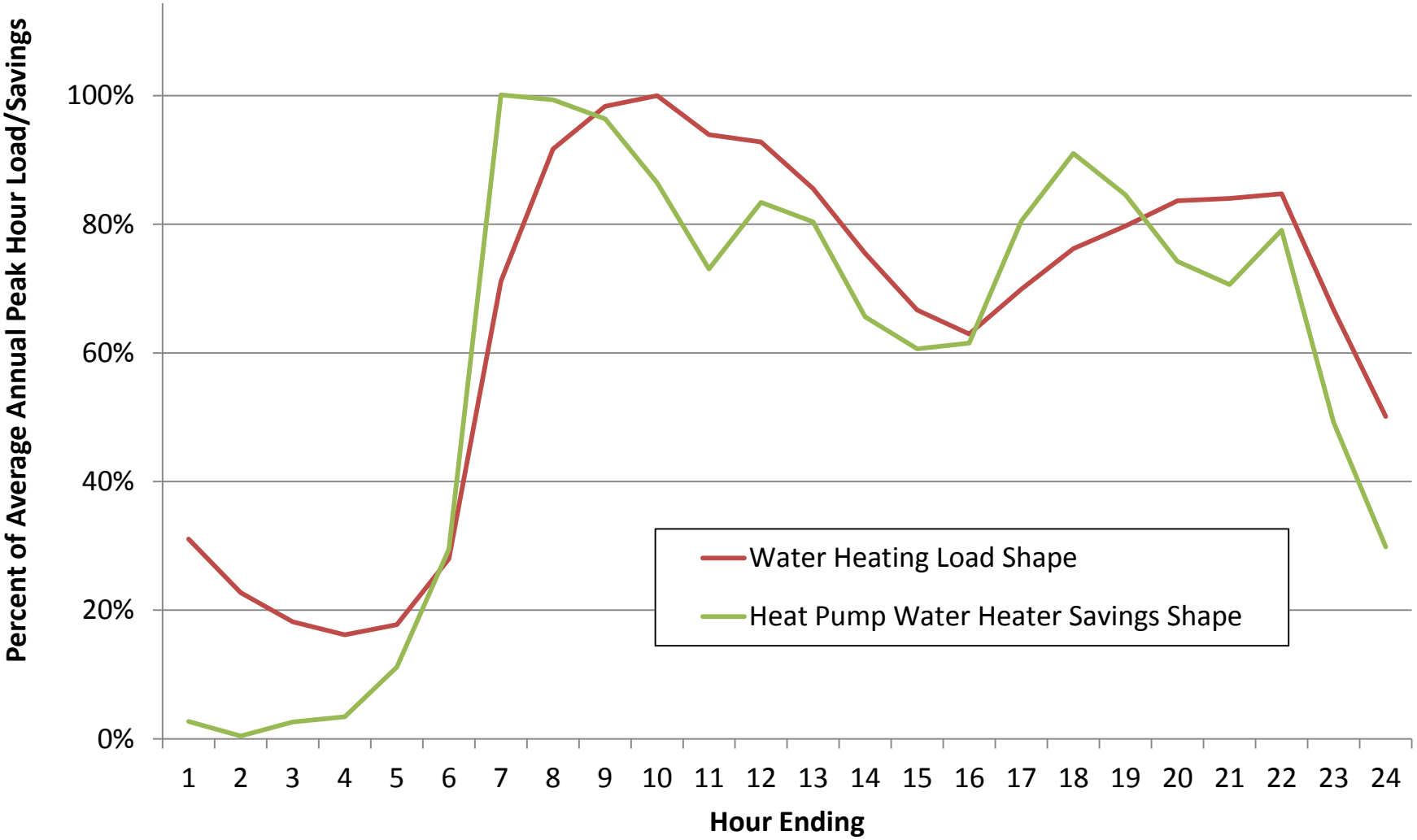
- Pacific Northwest
- California
- Massachusetts
- Georgia

- Use publicly available avoided costs from each location and one of the following methodologies:
  1. Use seasonal system peaks, coincidence factors and diversity factors to determine peak/off-peak savings and apply seasonal avoided costs to savings, *or*
  2. Apply hourly avoided costs to each measure load shape to calculate the time-varying value of measure.

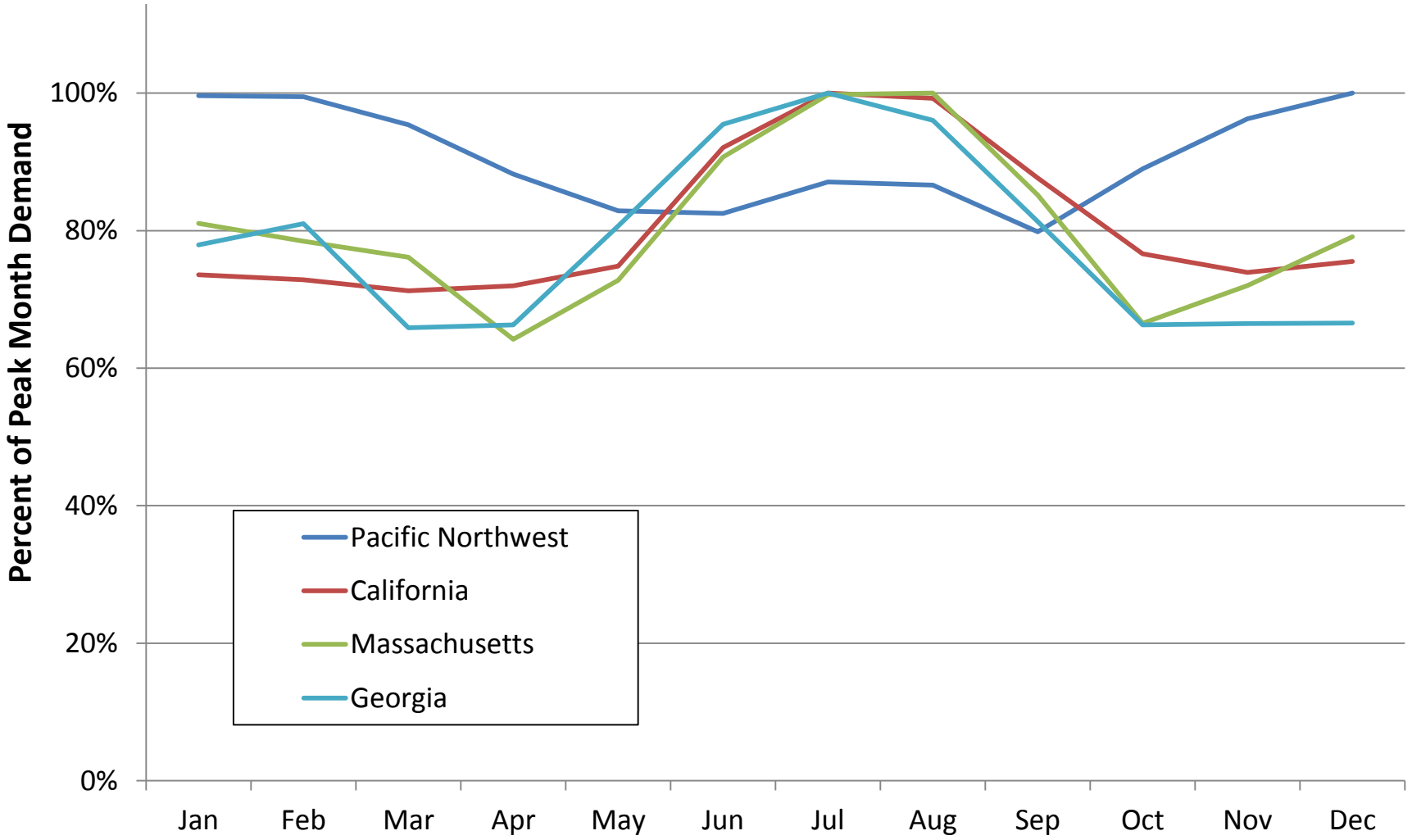
End-use Load Shapes and Energy Savings Shapes

- Definitions:
  - **End-use load shape:** Hourly consumption of an end-use (e.g., residential lighting, commercial HVAC) over the course of one year.
  - **Energy savings shape:** The difference between the hourly use of electricity in the baseline condition and the hourly use post-installation of the energy efficiency measure (e.g., the difference between the hourly consumption of an electric resistance water heater and a heat pump water heater) over the course of one year.
- The time pattern of savings from the substitution of a more efficient technology does not always mimic the underlying end-use.
- Examples:
  - Controls can reduce hours of operation (e.g., occupancy sensor or changing duty cycle), resulting in the shape of savings being different than the underlying end-use.
  - Improved end-use technology and controls (daylighting controls, sensors and software to power down computers when not in use)

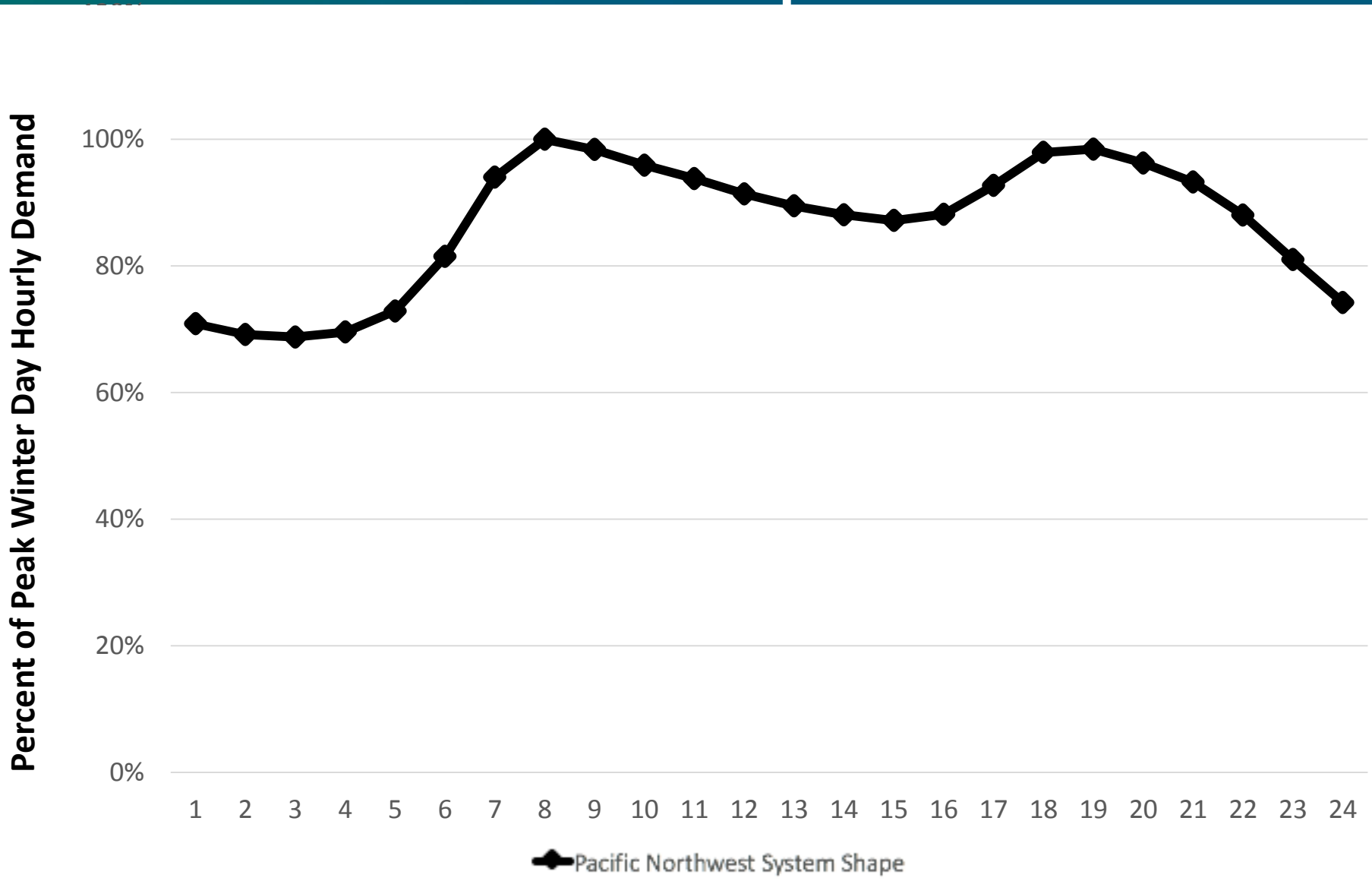
End Use vs. Energy Savings Load Shapes



2016 System Load Shapes



Pacific Northwest System Shapes and End-Use Load Shapes



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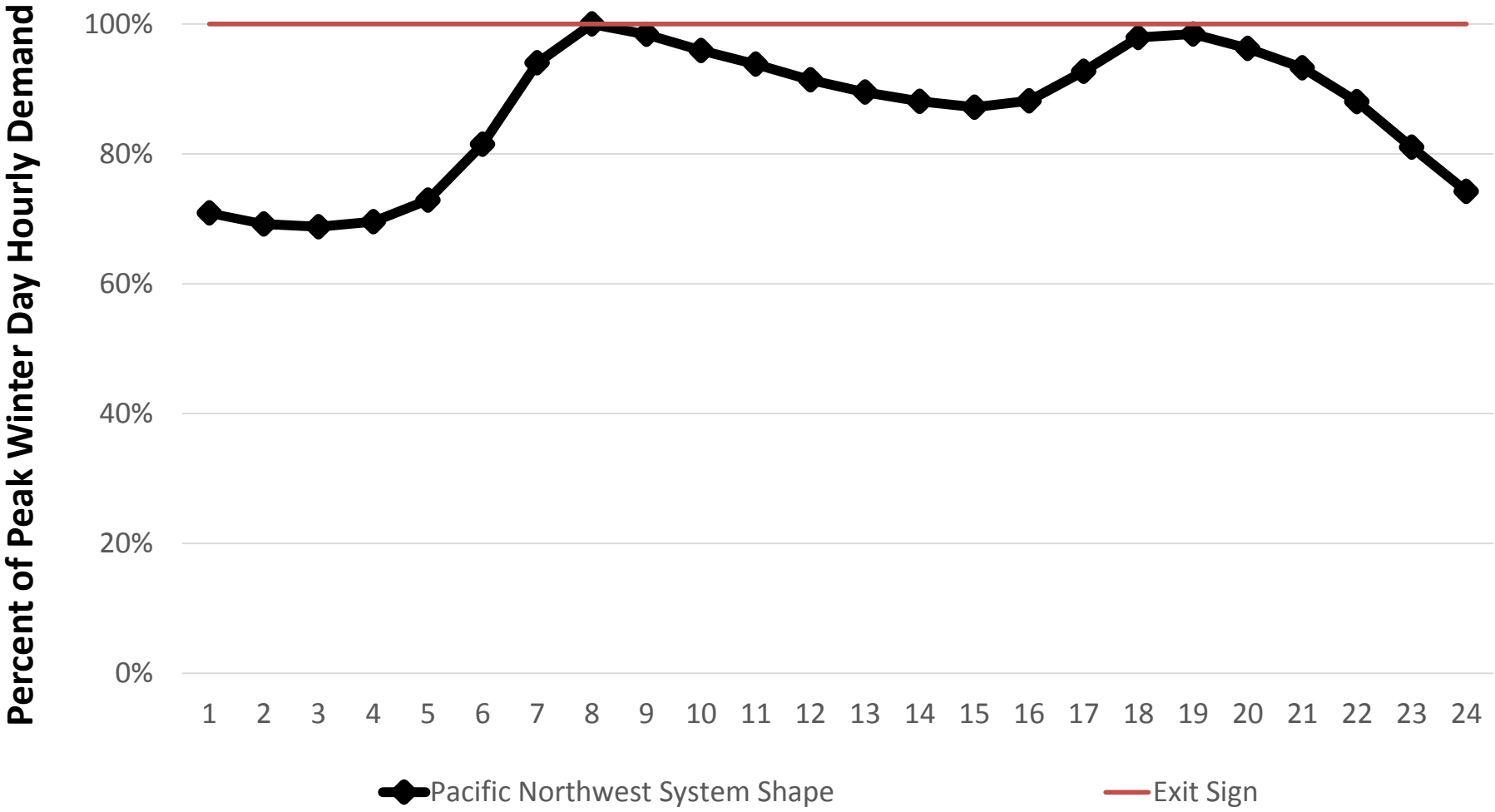

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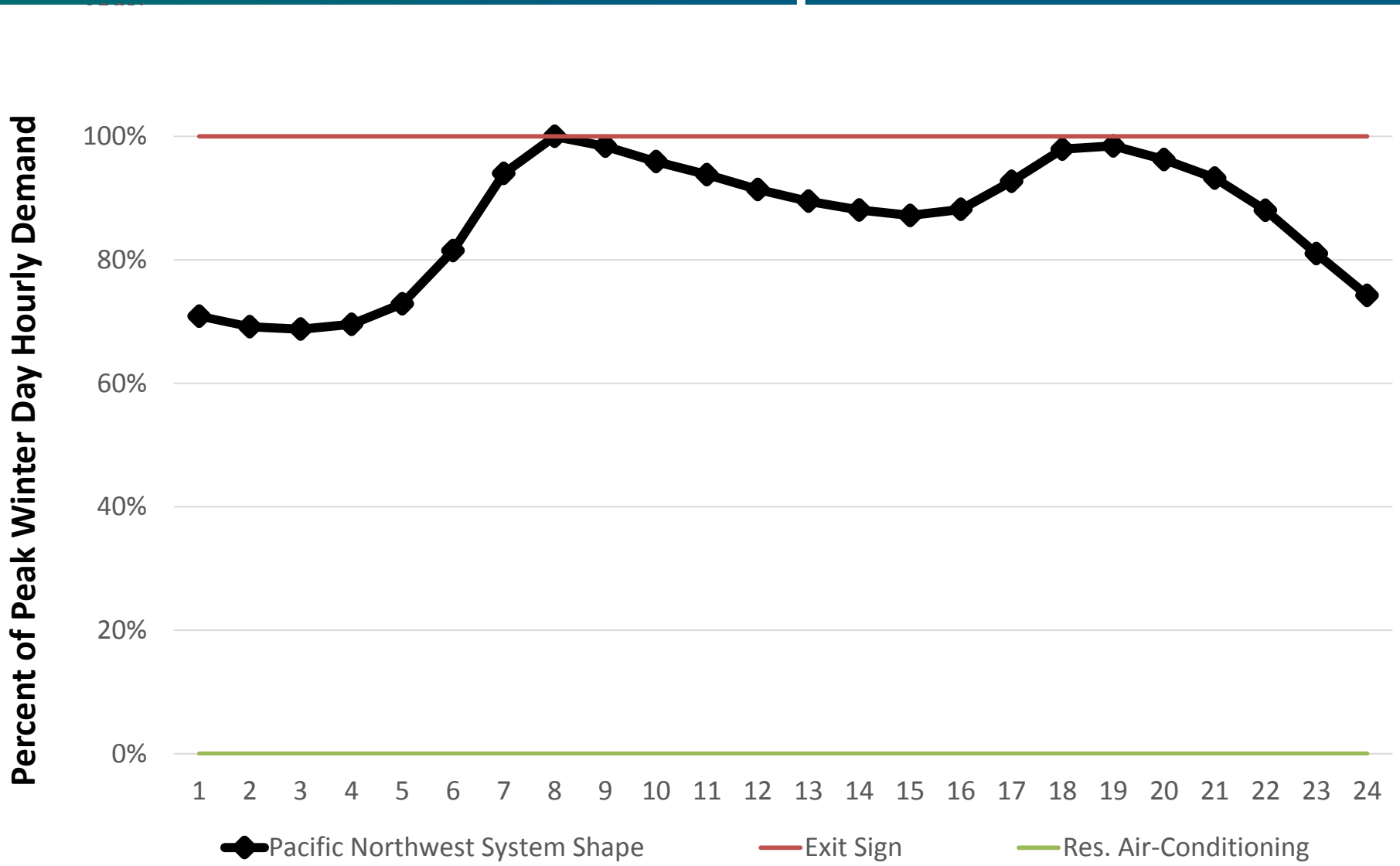

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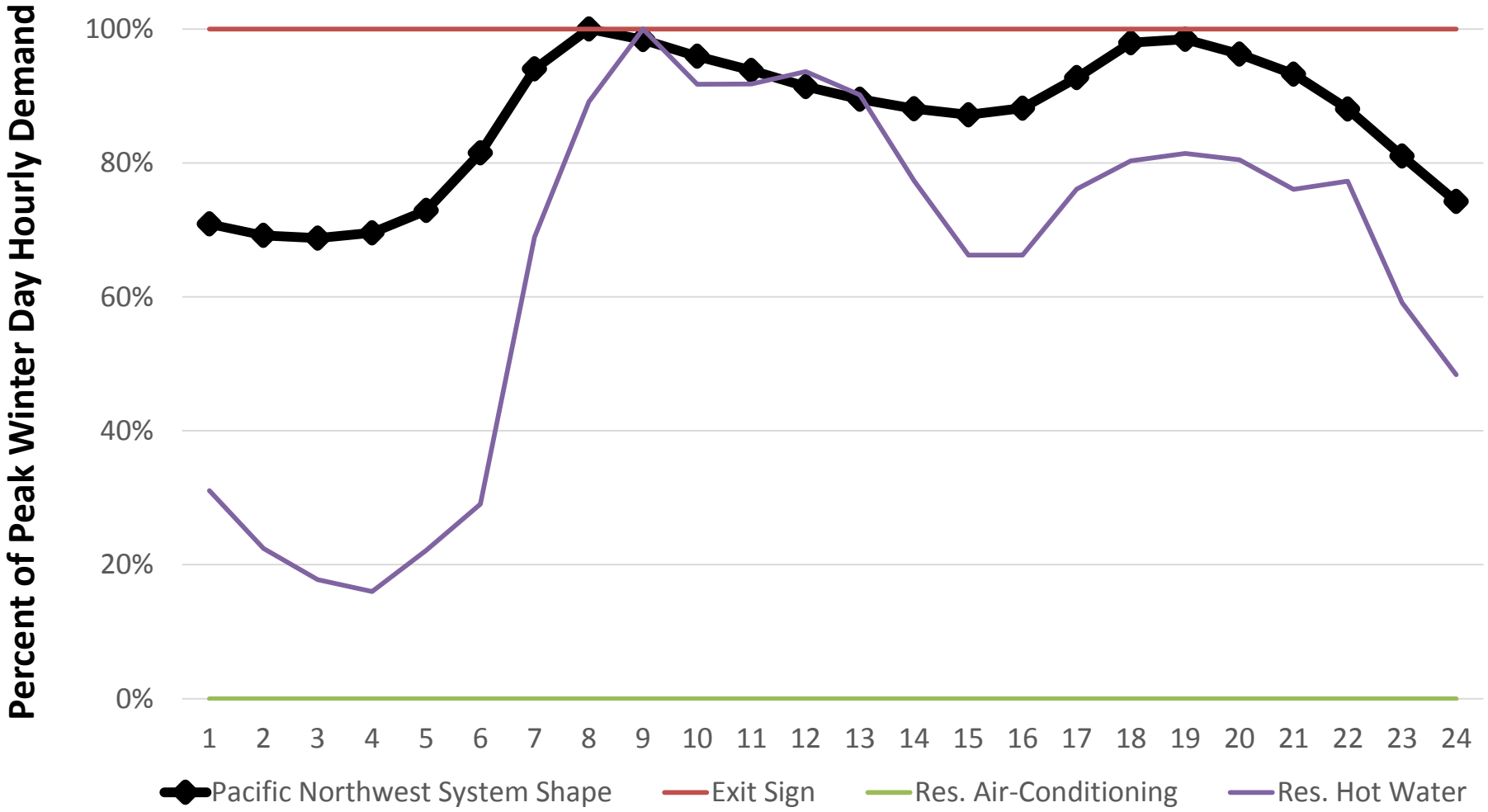

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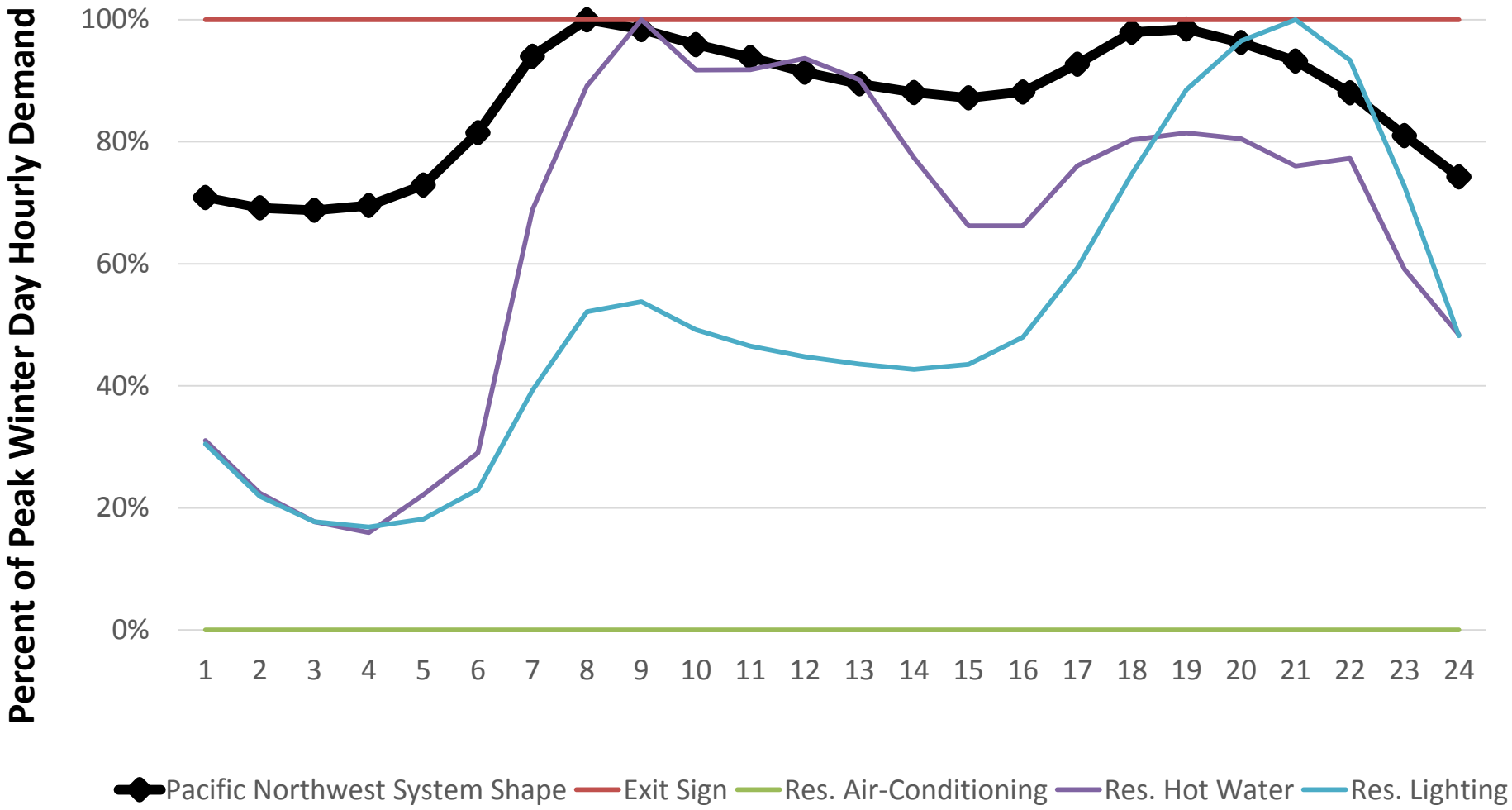

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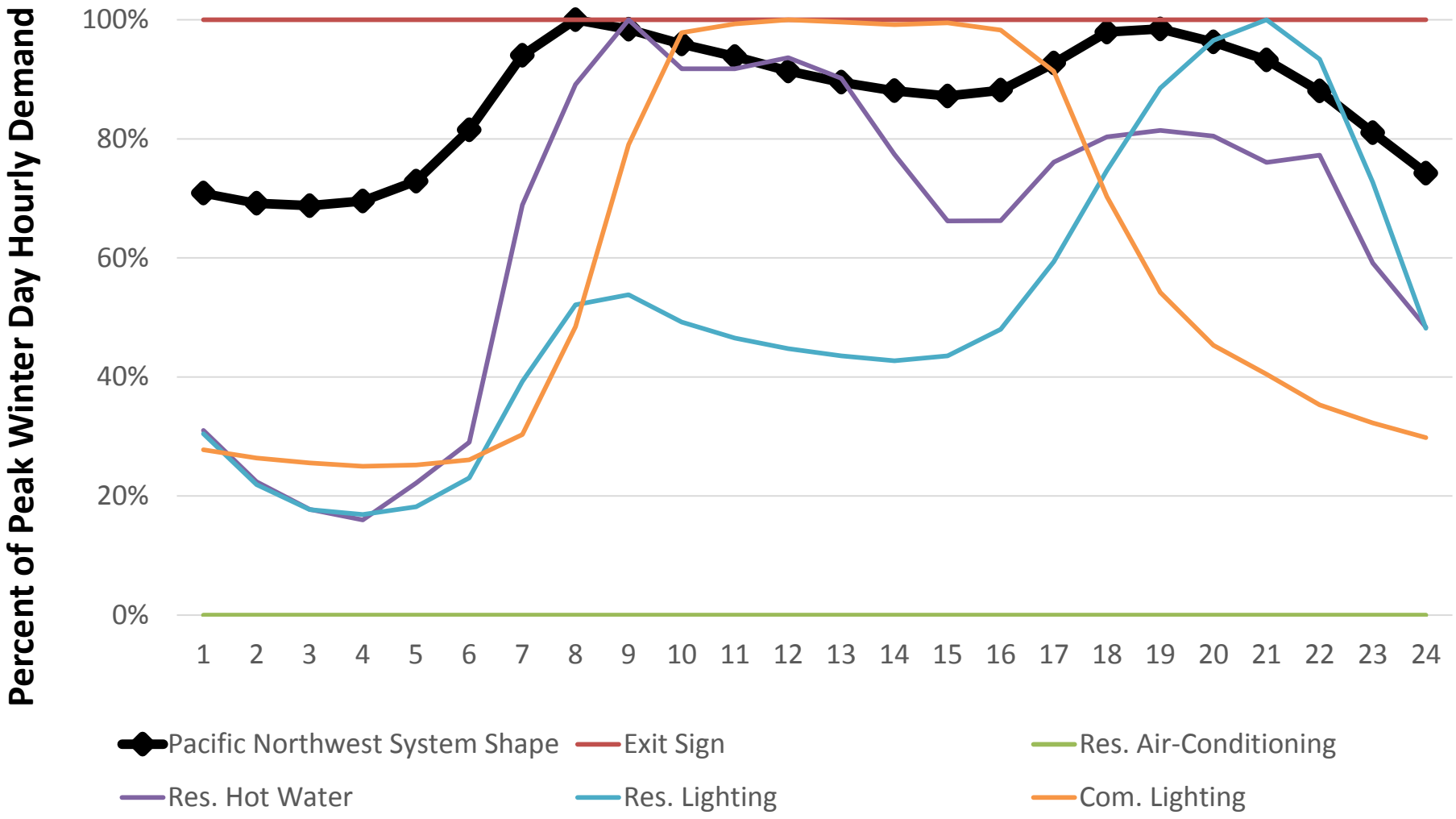
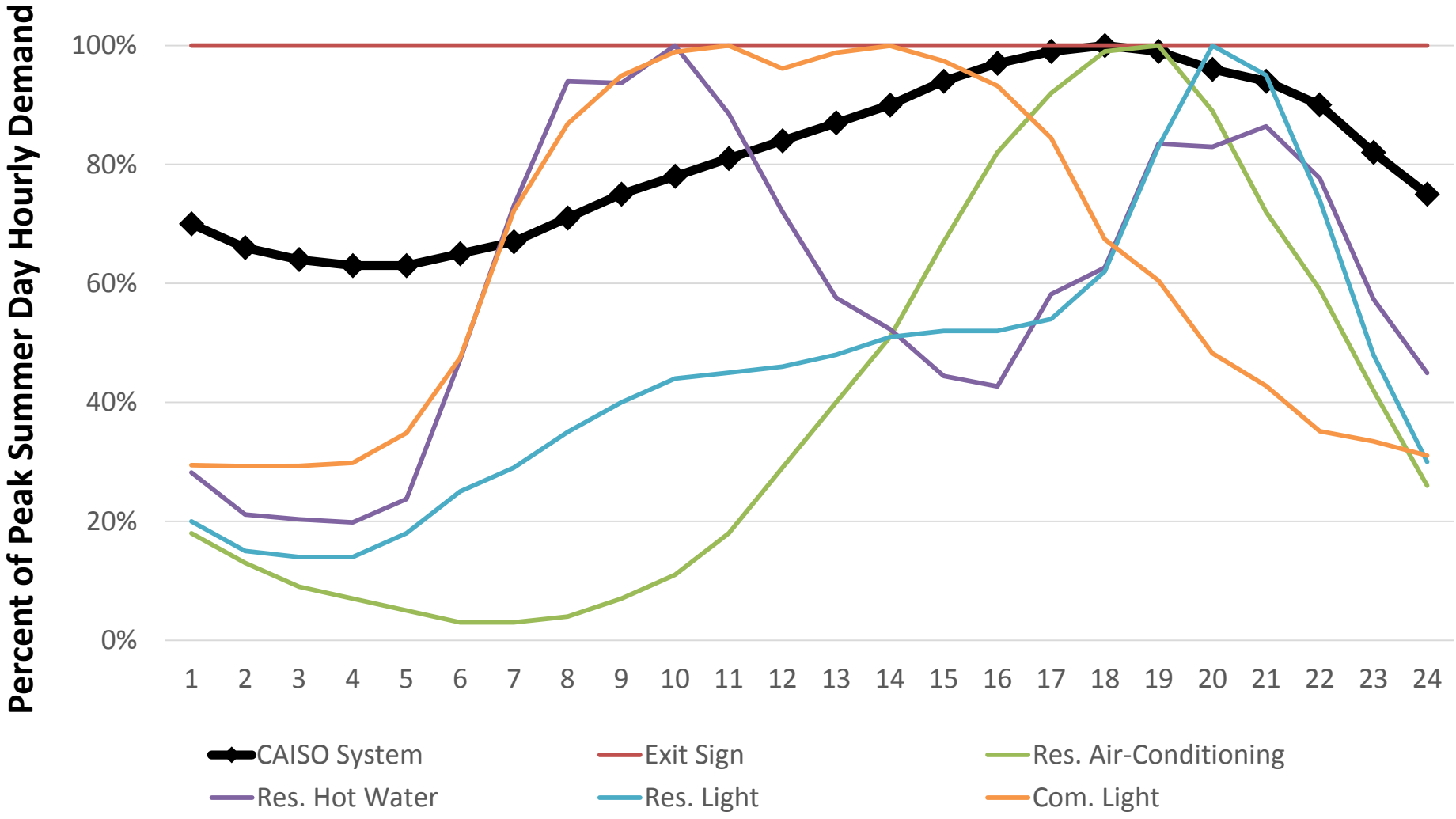
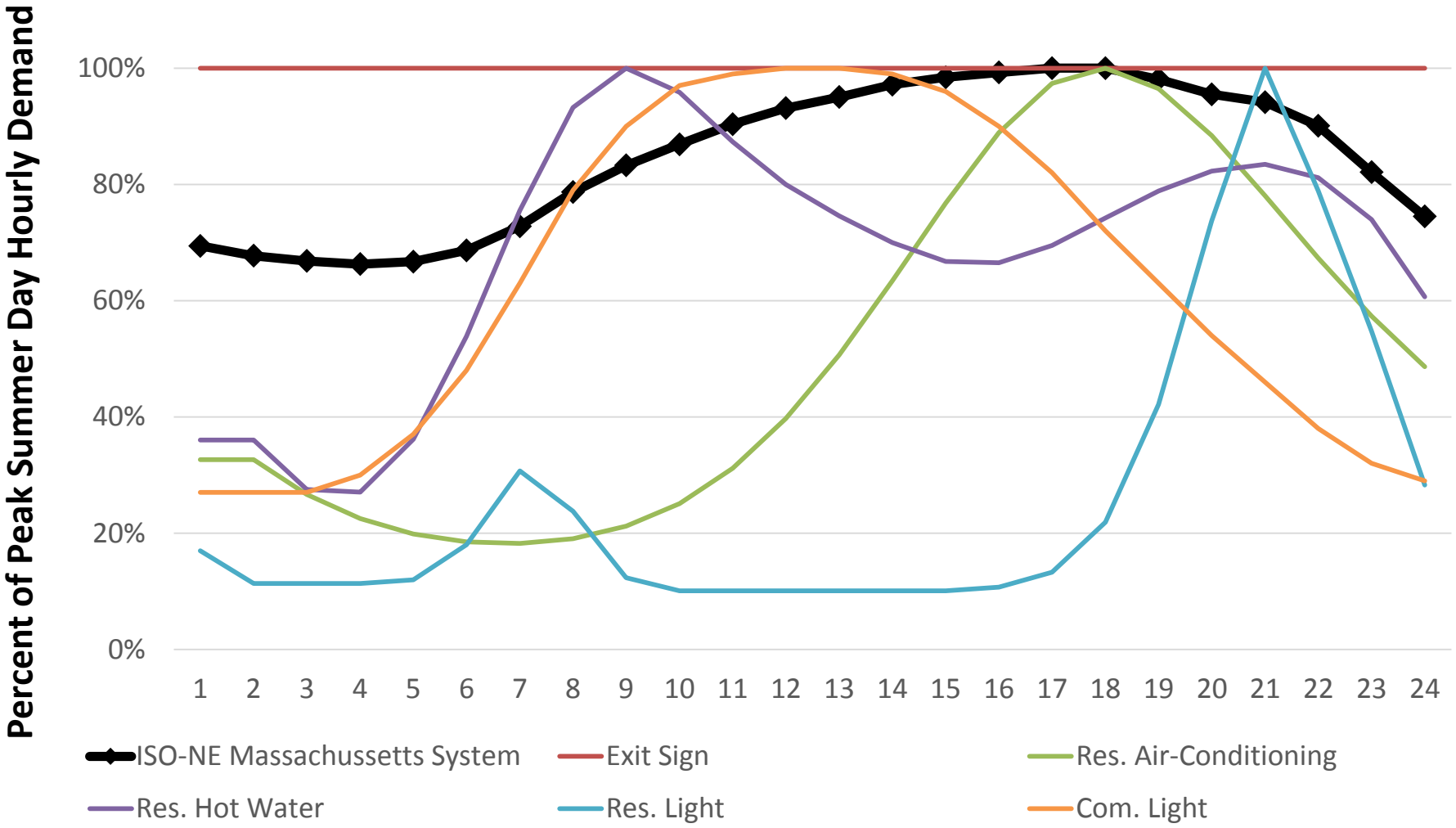


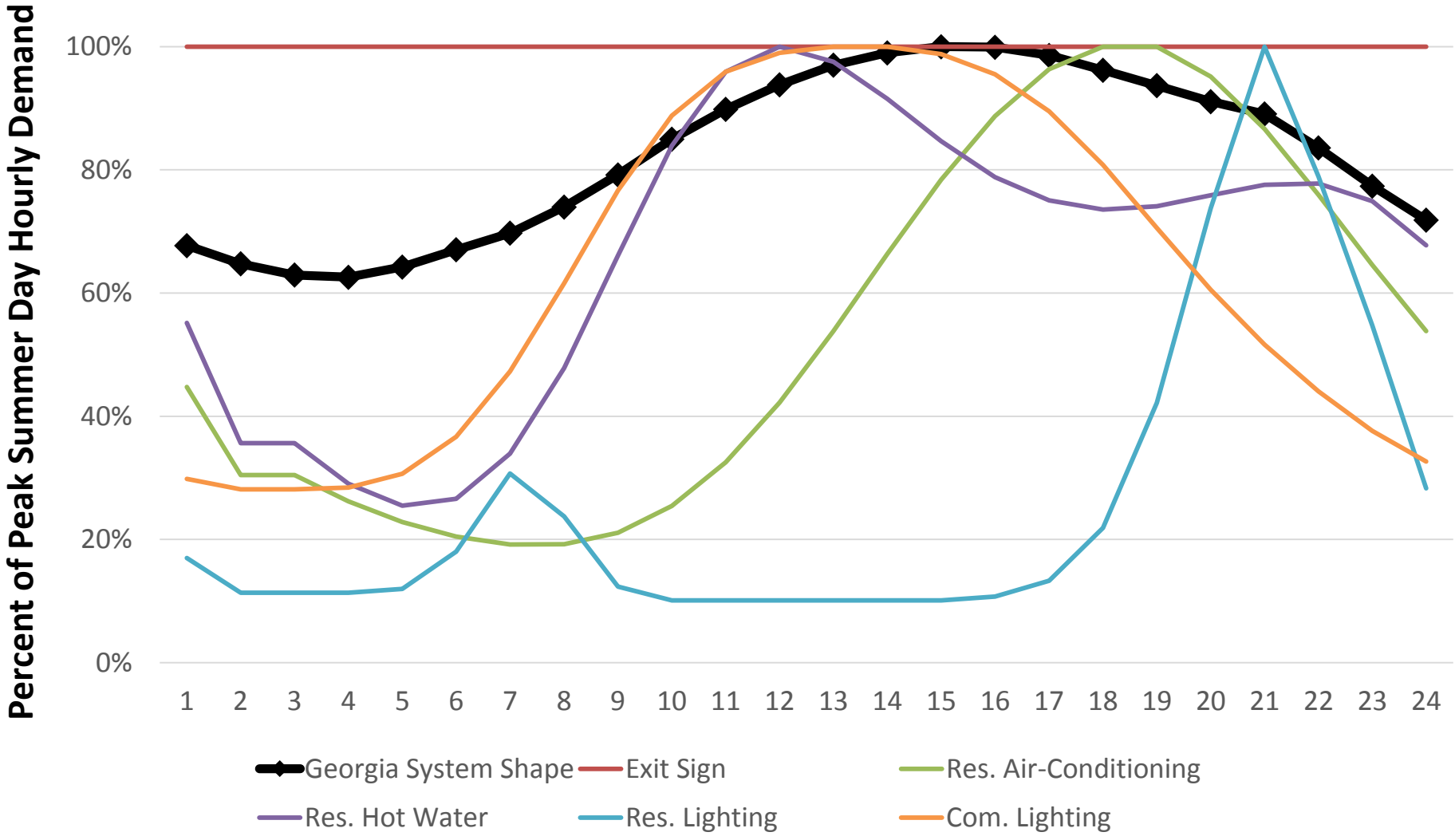
California System Shape and End-Use Load Shapes



Massachusetts System Shape and End-Use Load Shapes



Georgia System Shape and End-Use Load Shapes



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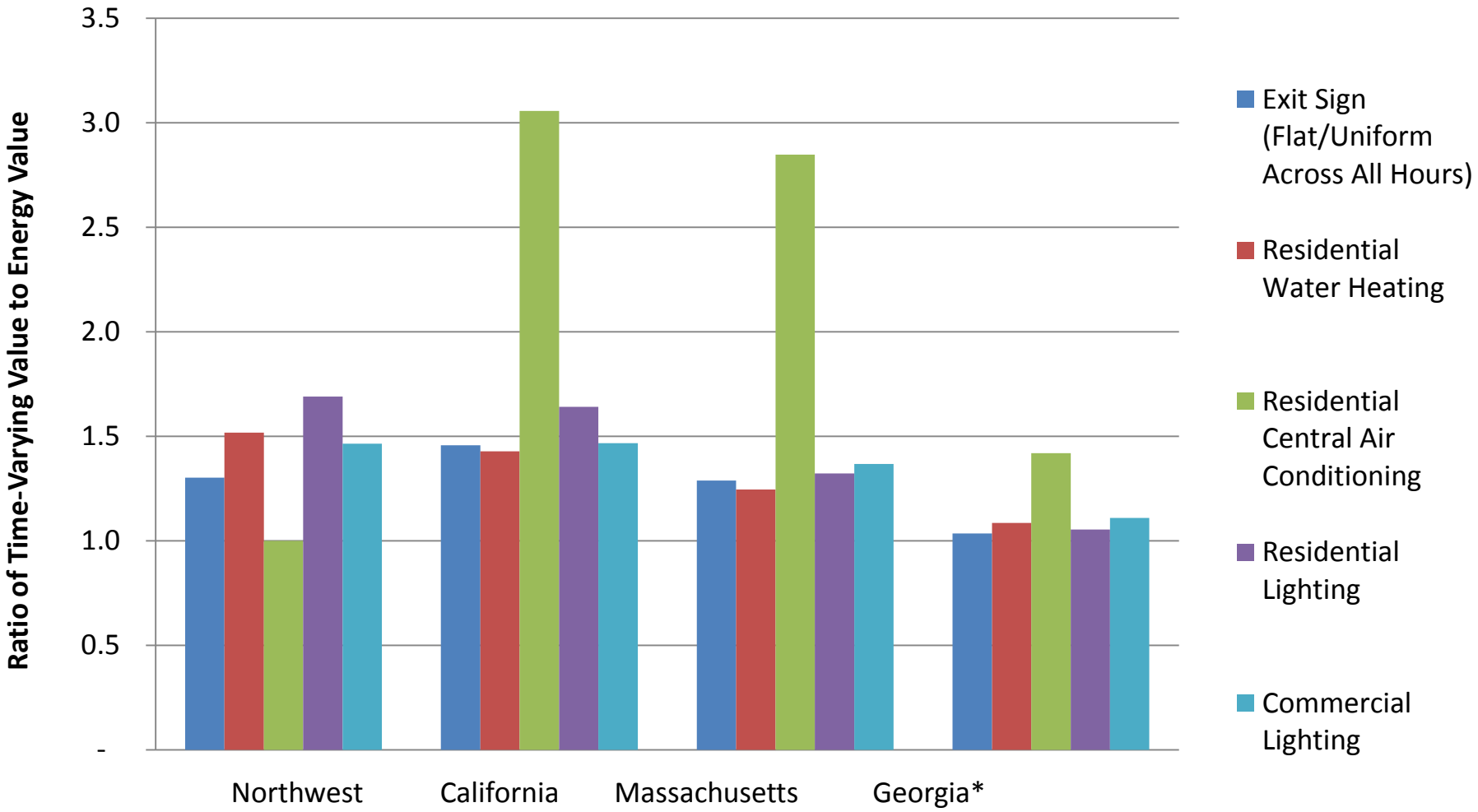

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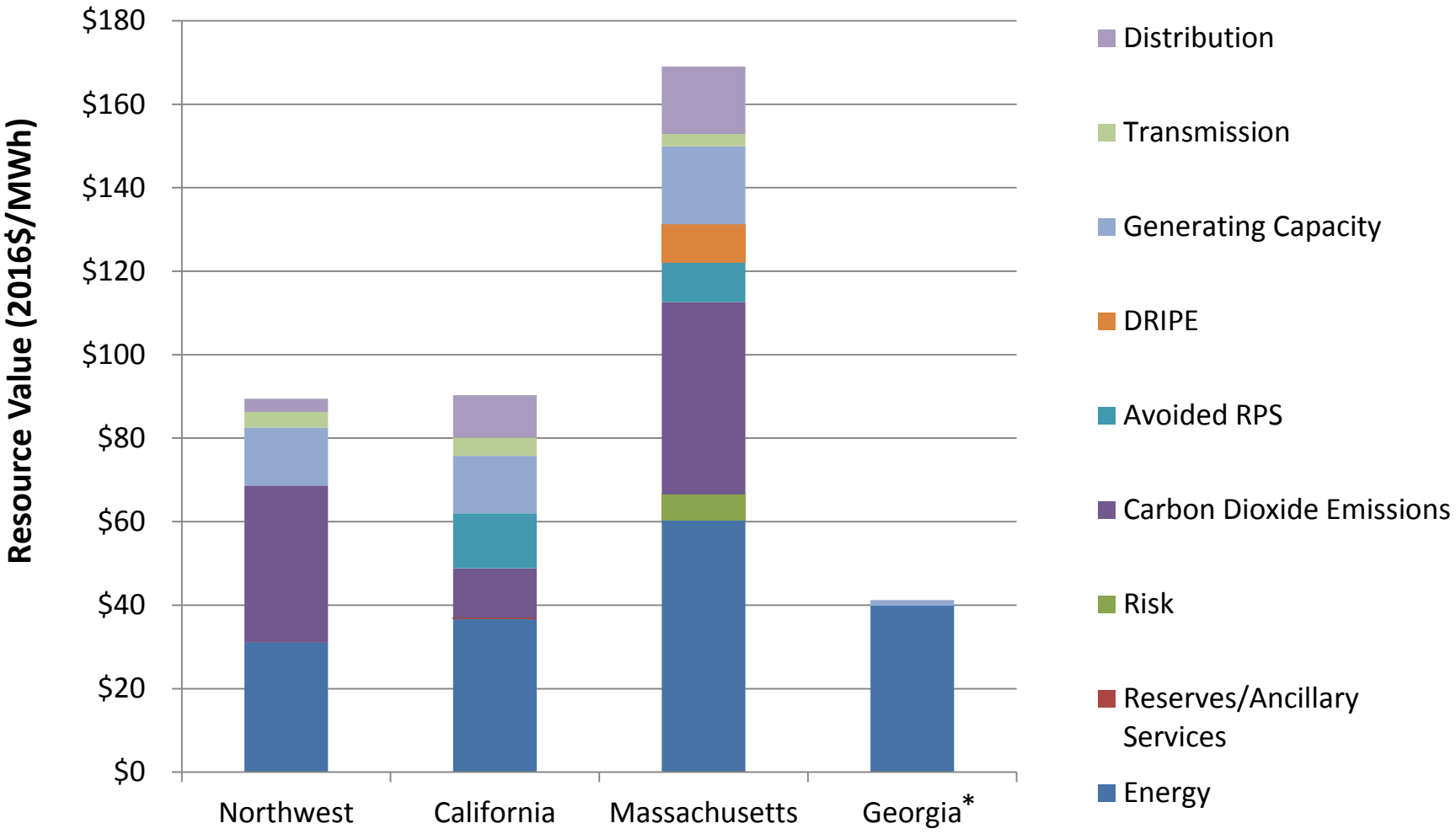
Exit Sign (flat load shape)

Measure 1 of 5



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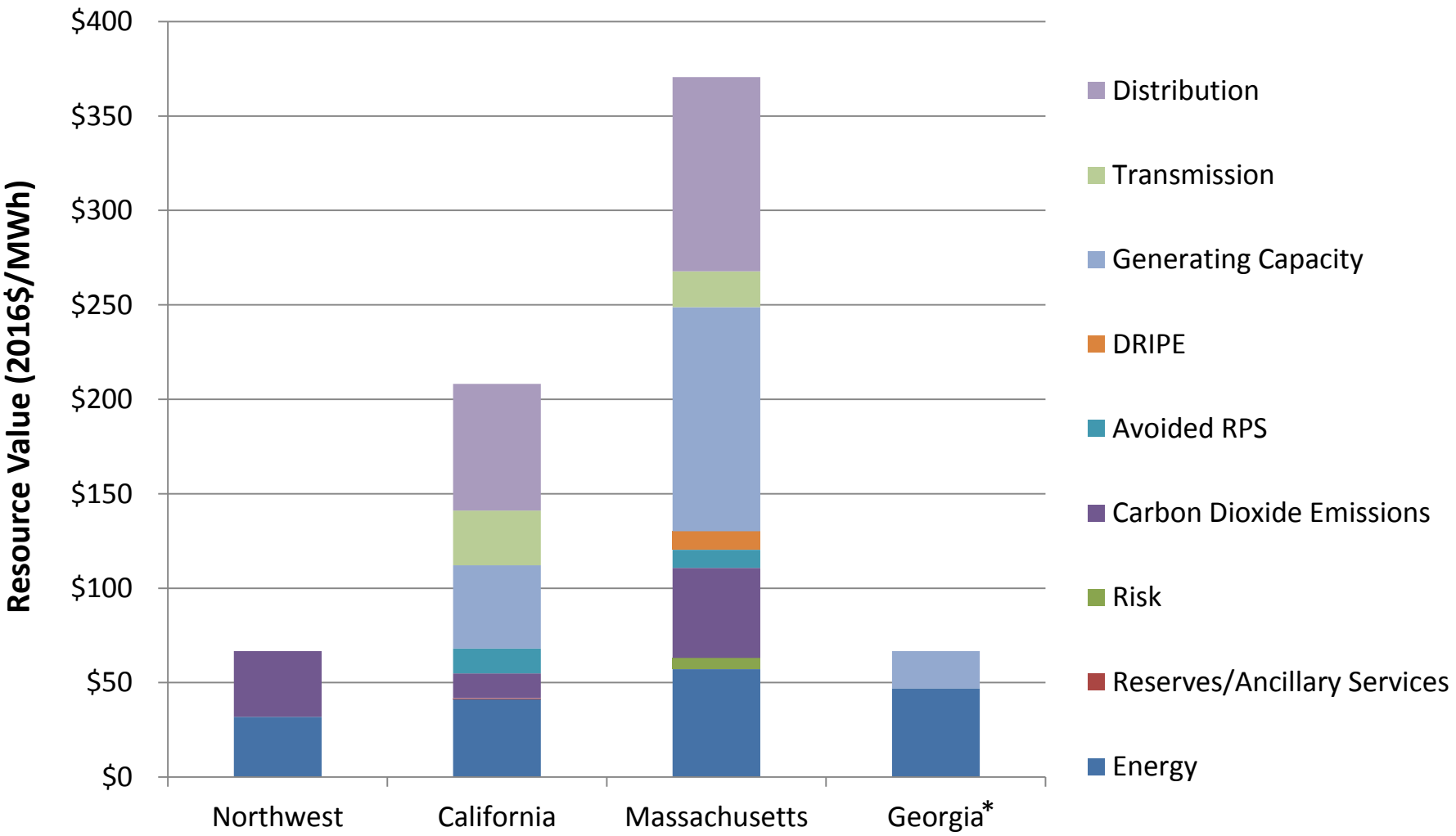
Residential Central Air-Conditioning

Measure 2 of 5



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Residential Hot Water

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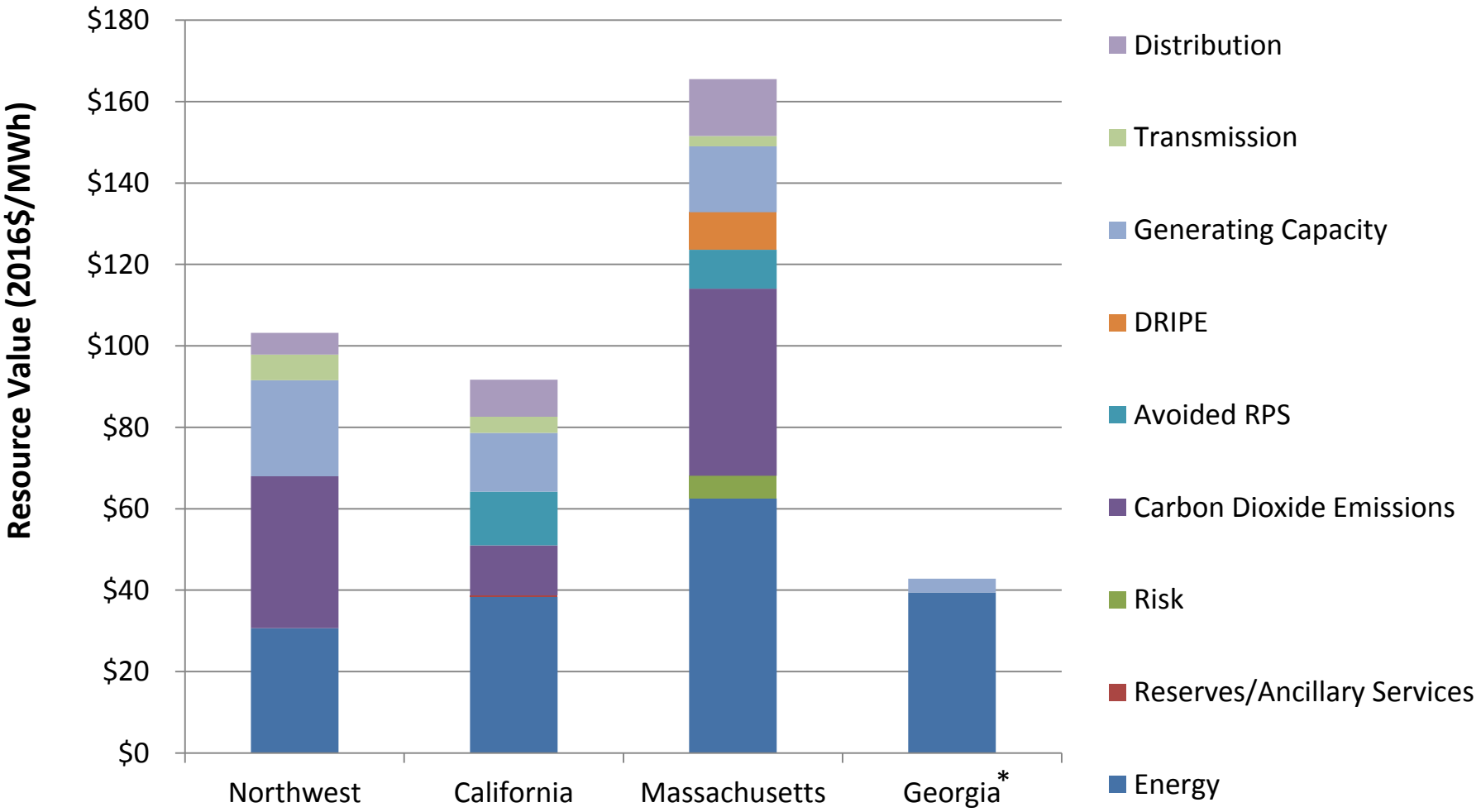

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Residential Lighting

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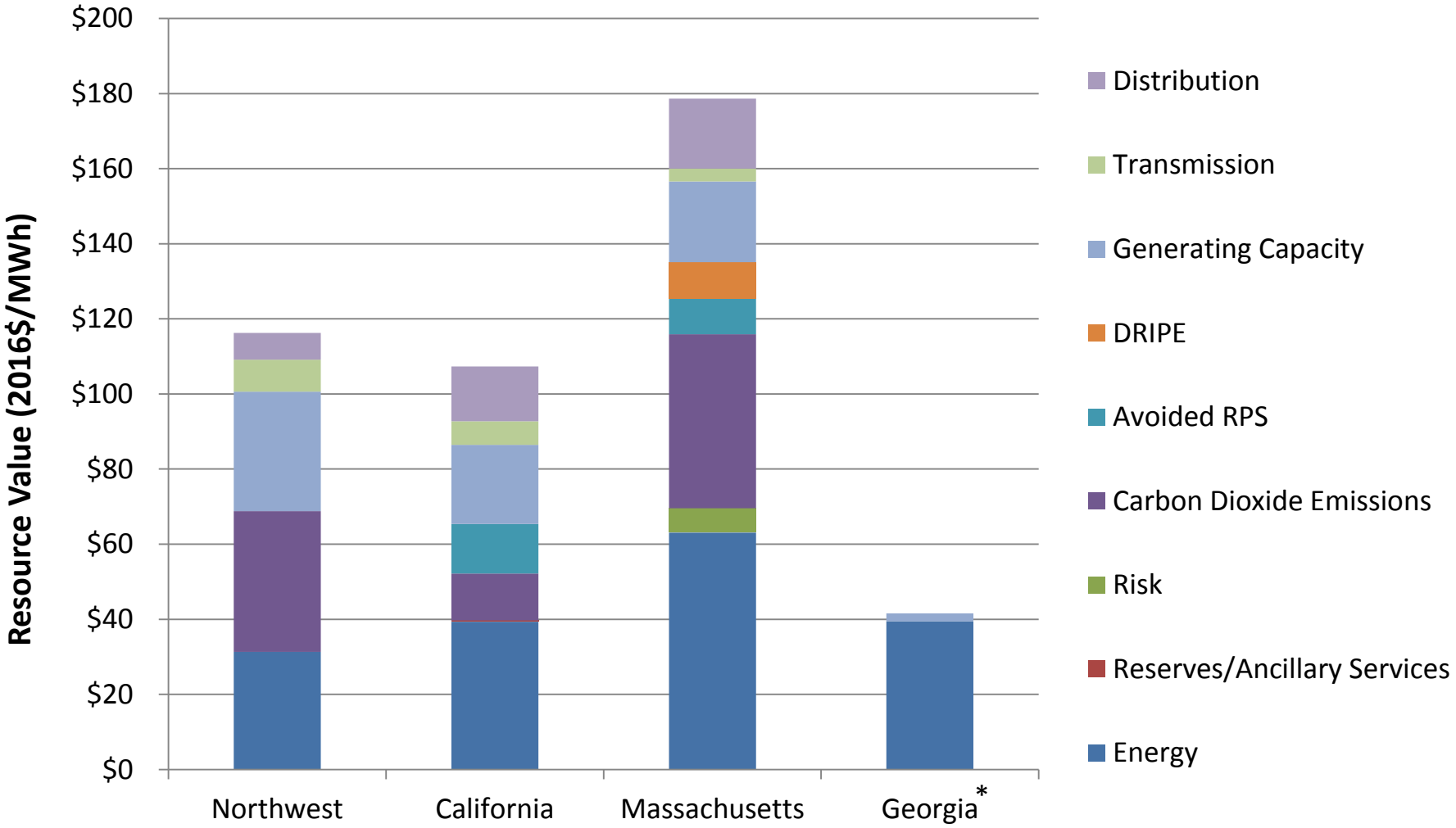

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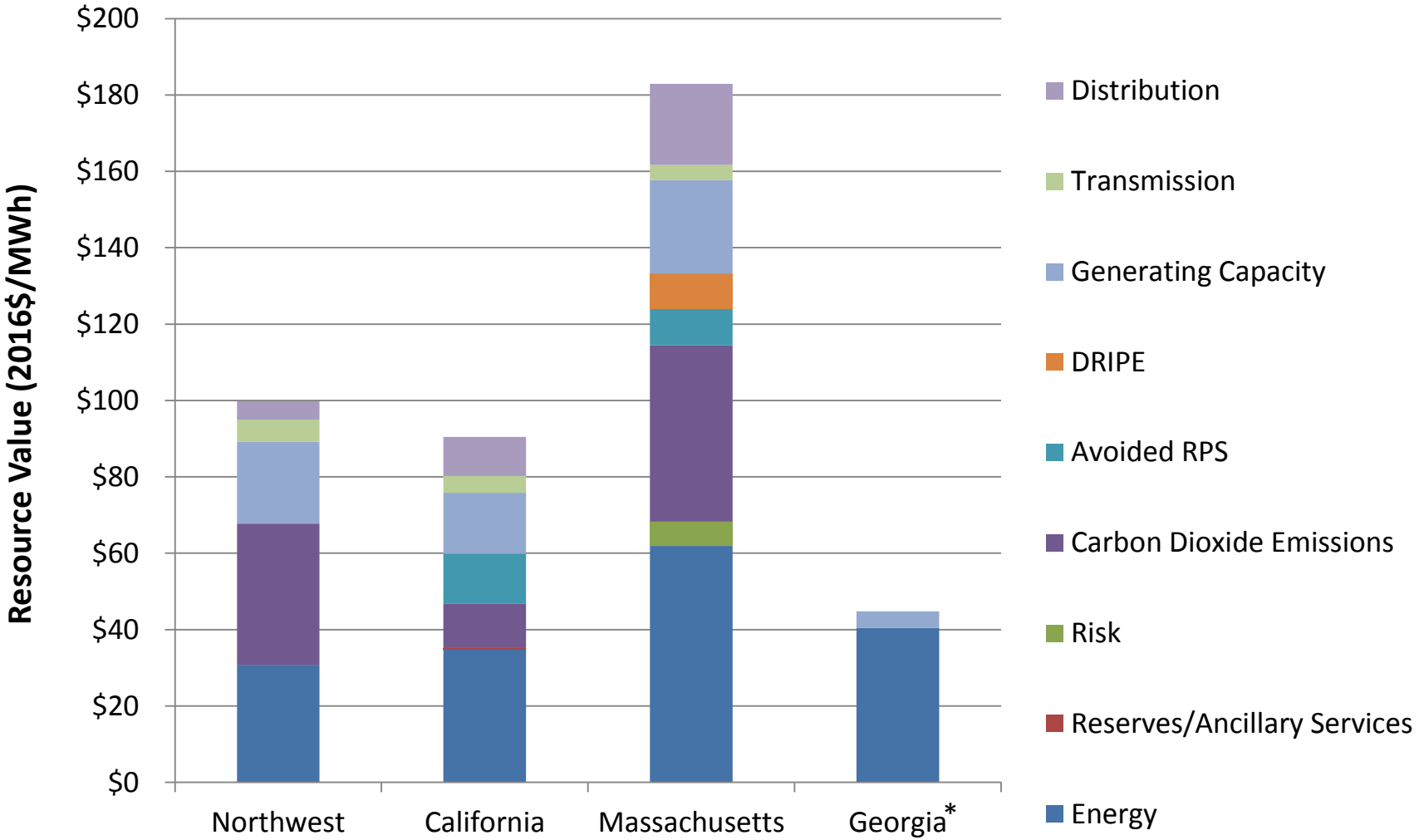
Commercial Lighting

Measure 5 of 5



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Conclusions

- Electric energy efficiency resources save energy and may reduce peak demand.
- The time-varying value of energy efficiency measures varies across the locations studied because of physical and operational characteristics of the individual utility system, the time periods that the savings from measures occur and differences in the value and components of avoided cost considered.
- Across the four locations studied, some of the largest capacity benefits from energy efficiency are derived from the deferral of transmission and distribution system infrastructure upgrades. However, the deferred cost of transmission and distribution infrastructure upgrades also exhibited the greatest range in value of all the components of avoided cost across the locations studied.
- Of the five measures studied, residential air-conditioning has the most significant added value when the total time-varying value is considered in summer peaking systems.

Conclusions (cont'd)

- The increased use of distributed energy resources and the addition of major new electricity consuming end-uses are anticipated to significantly alter the load shape of many utility systems in the future.
- Data used to estimate the impact of energy efficiency measures on electric system peak demands will need to be updated periodically to accurately reflect the value of savings as system load shapes change.
- Publicly available components of electric system costs avoided through energy efficiency are not uniform across states and utilities. Inclusion or exclusion of these components and differences in their value affect estimates of the time-varying value of efficiency.
- Publicly available data on end-use load and energy savings shapes are limited, concentrated regionally, and should be expanded.

Utility, State or Regional Recommendations

- Collect metered data on a variety of end-use load and energy savings shapes for the state or region at least at the hourly level and make the data publicly available in a format that can be readily used in planning processes.
- Account for variations in the calculation of time-varying value of energy savings and avoided costs.
- Periodically update estimates of the impact of energy efficiency measures on utility system peak demands to accurately reflect changing system load shapes.
- Study transferability of end-use load shapes from one climate zone to another climate zone.

Regional or National Recommendations

- Identify best practices for establishing the time-varying value of energy efficiency in integrated resource planning and demand-side management planning to ensure investment in a least-cost, reliable electric system.
- Establish protocols for consistent methods and procedures for developing end-use load shapes and load shapes of efficiency measures.
- Establish common methods for assessing the time-varying value of energy savings, including values that are often missing such as deferred or avoided T&D investments.

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Natalie Mims
namims@lbl.gov
510-486-7584

Tom Eckman
teckman49@gmail.com
503-803-5047

Chuck Goldman
cagoldman@lbl.gov
510-486-4637

Lisa Schwartz
lcschwartz@lbl.gov
510-486-6315

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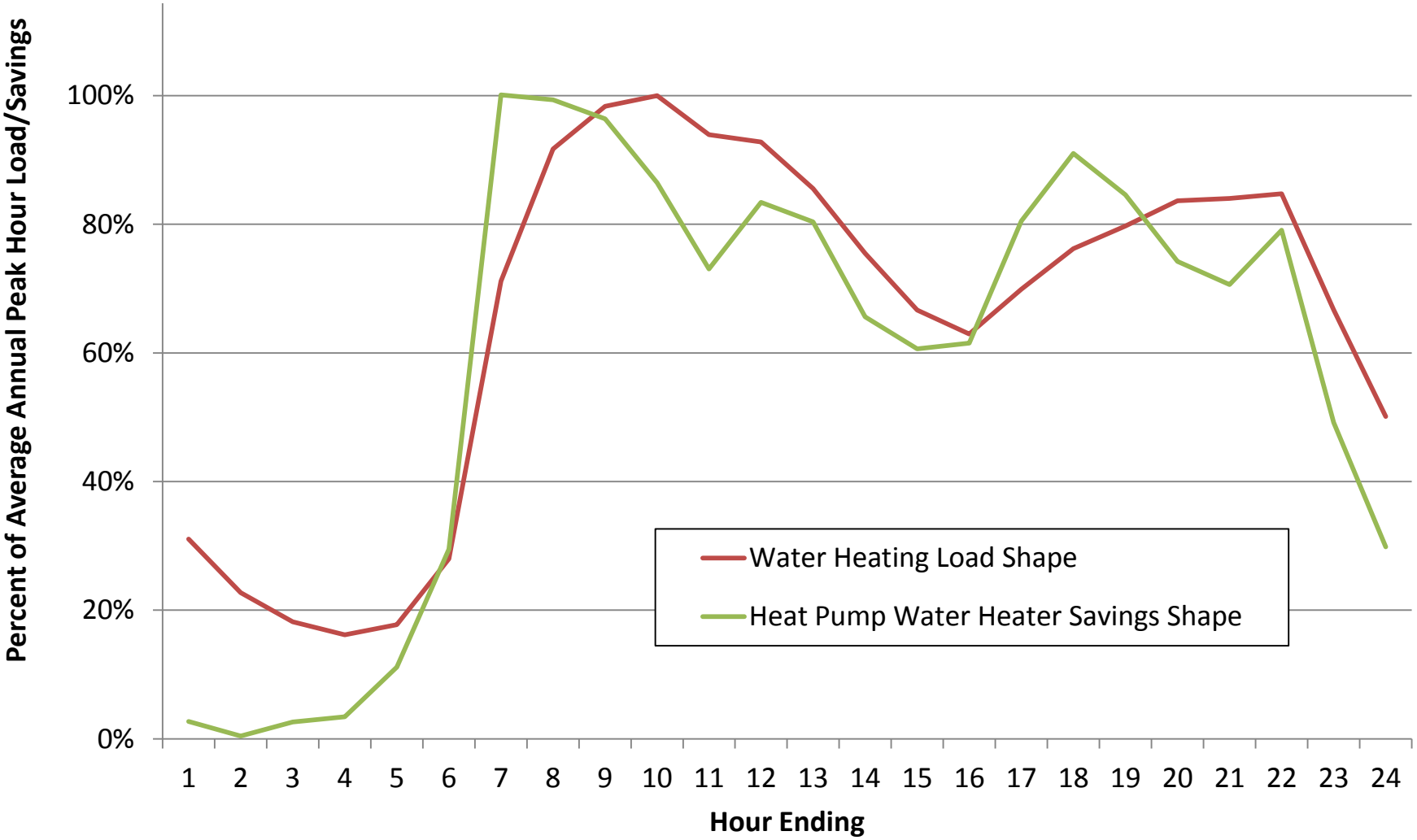

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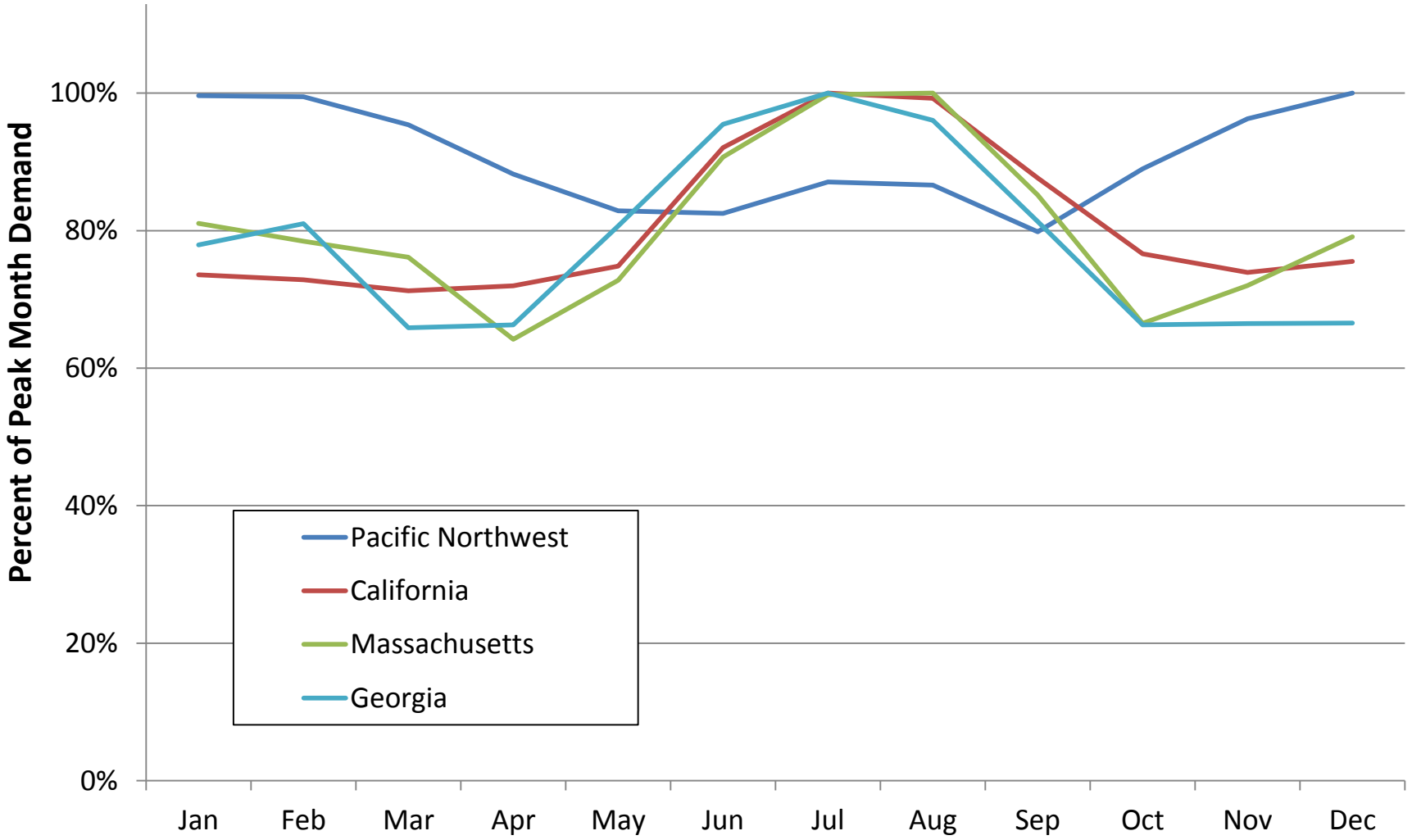

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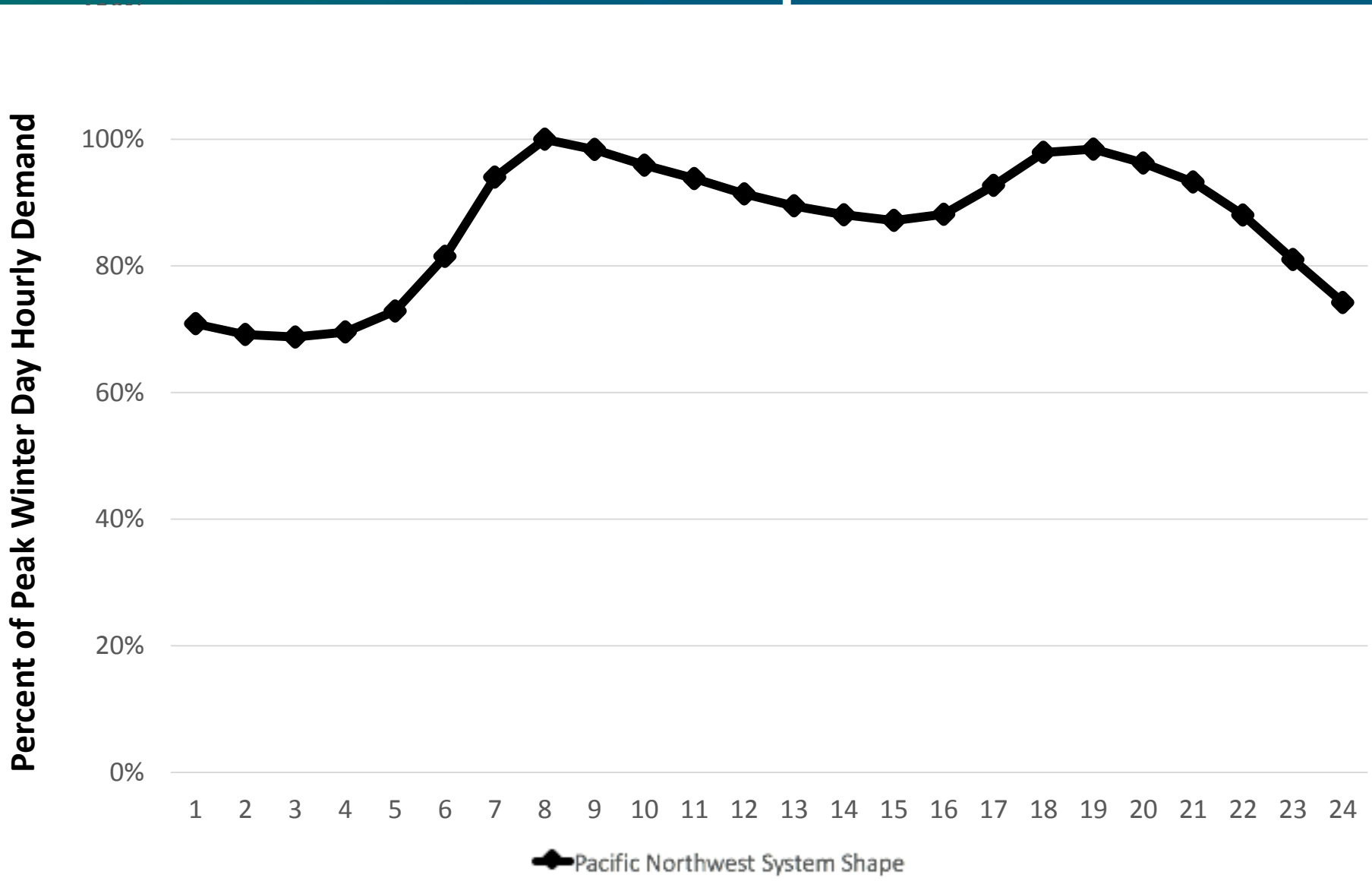

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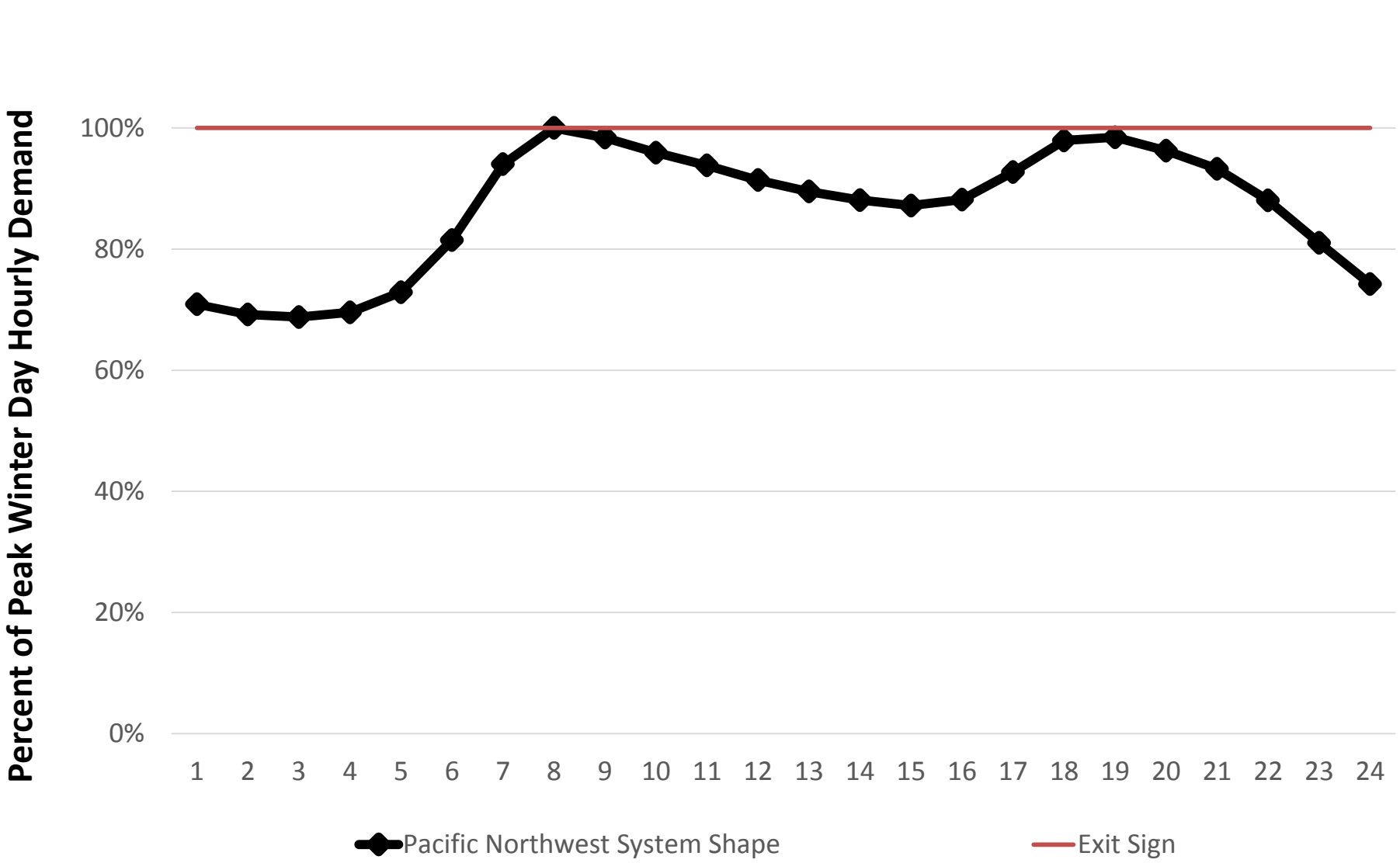

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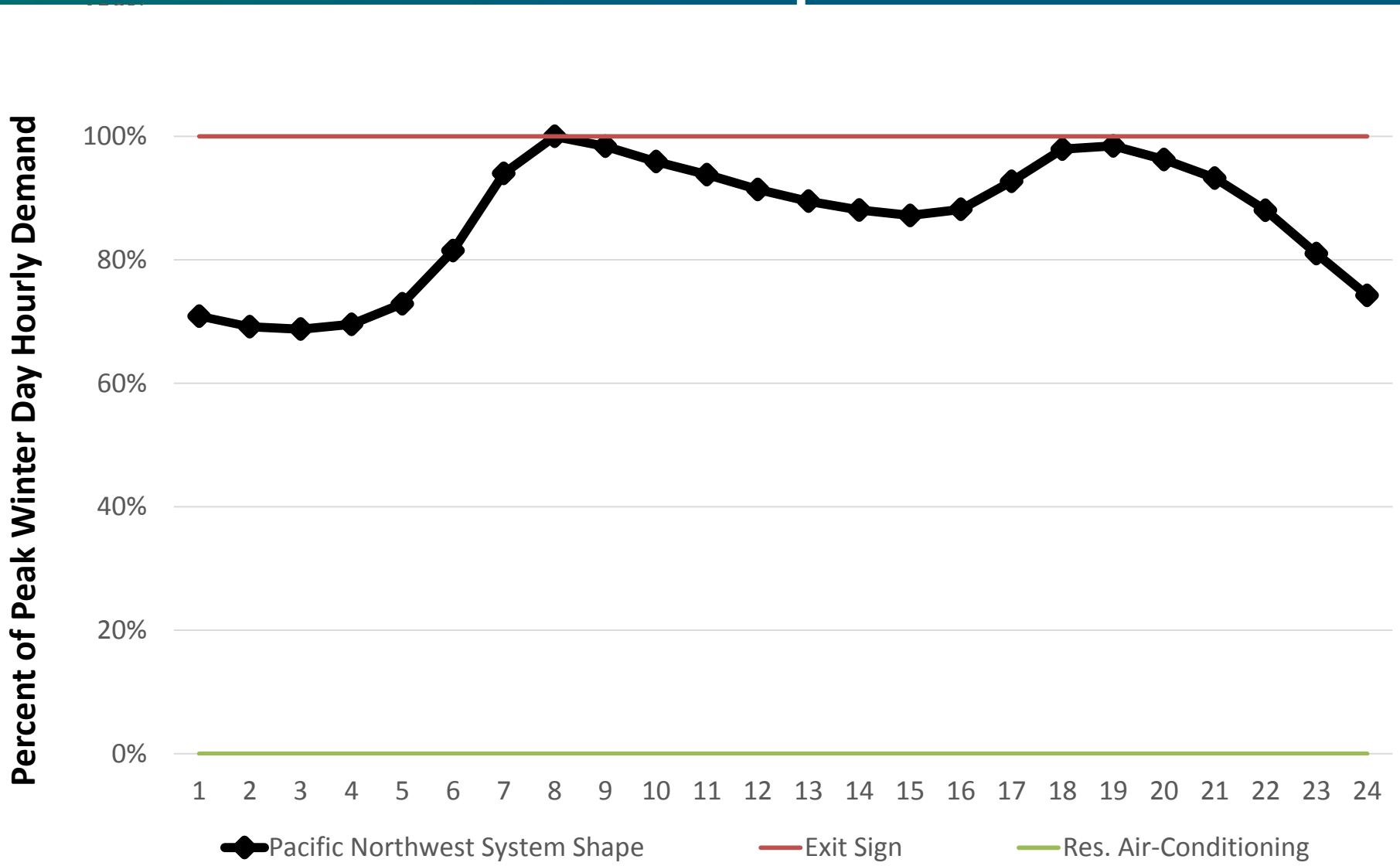

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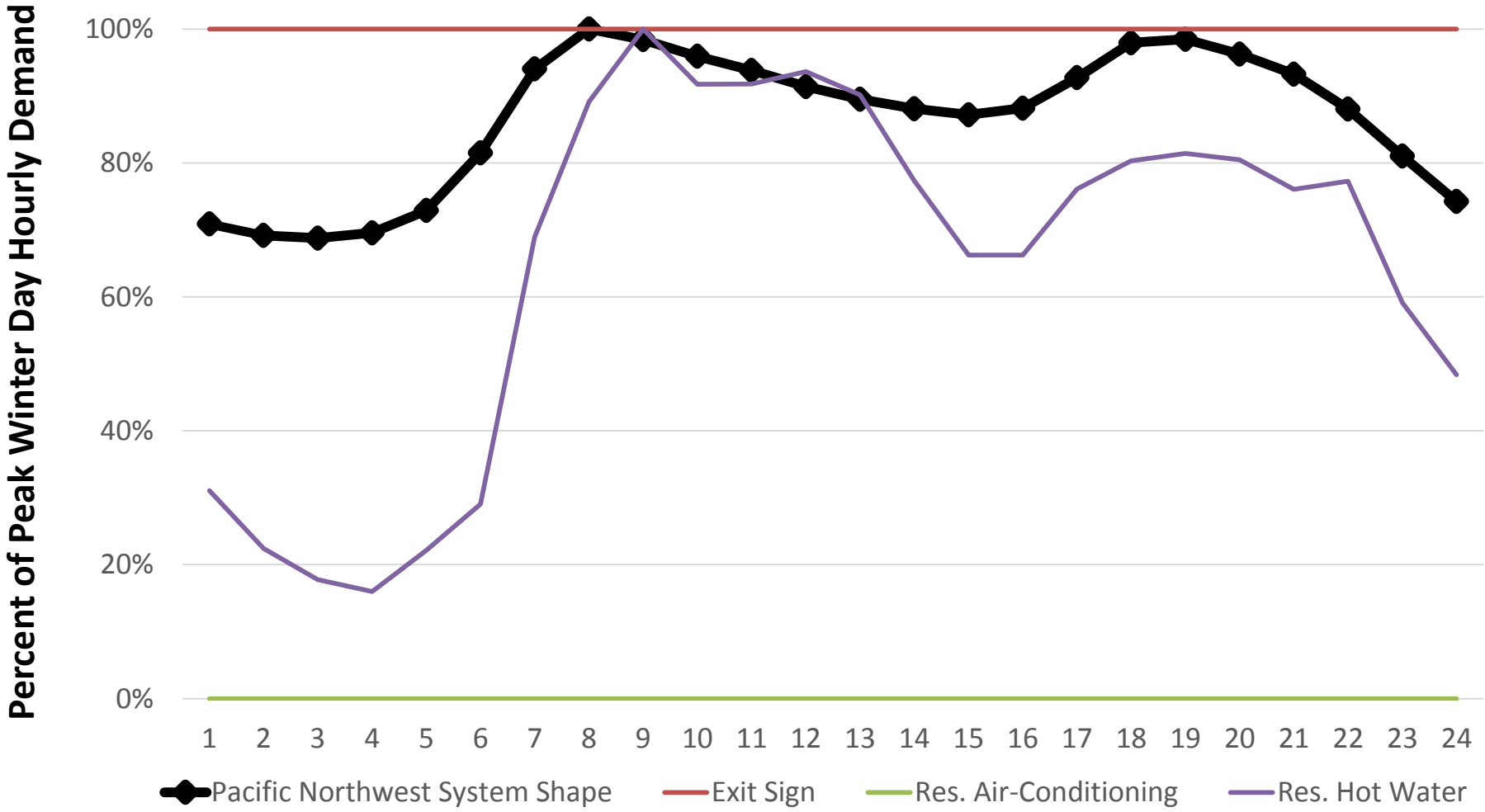

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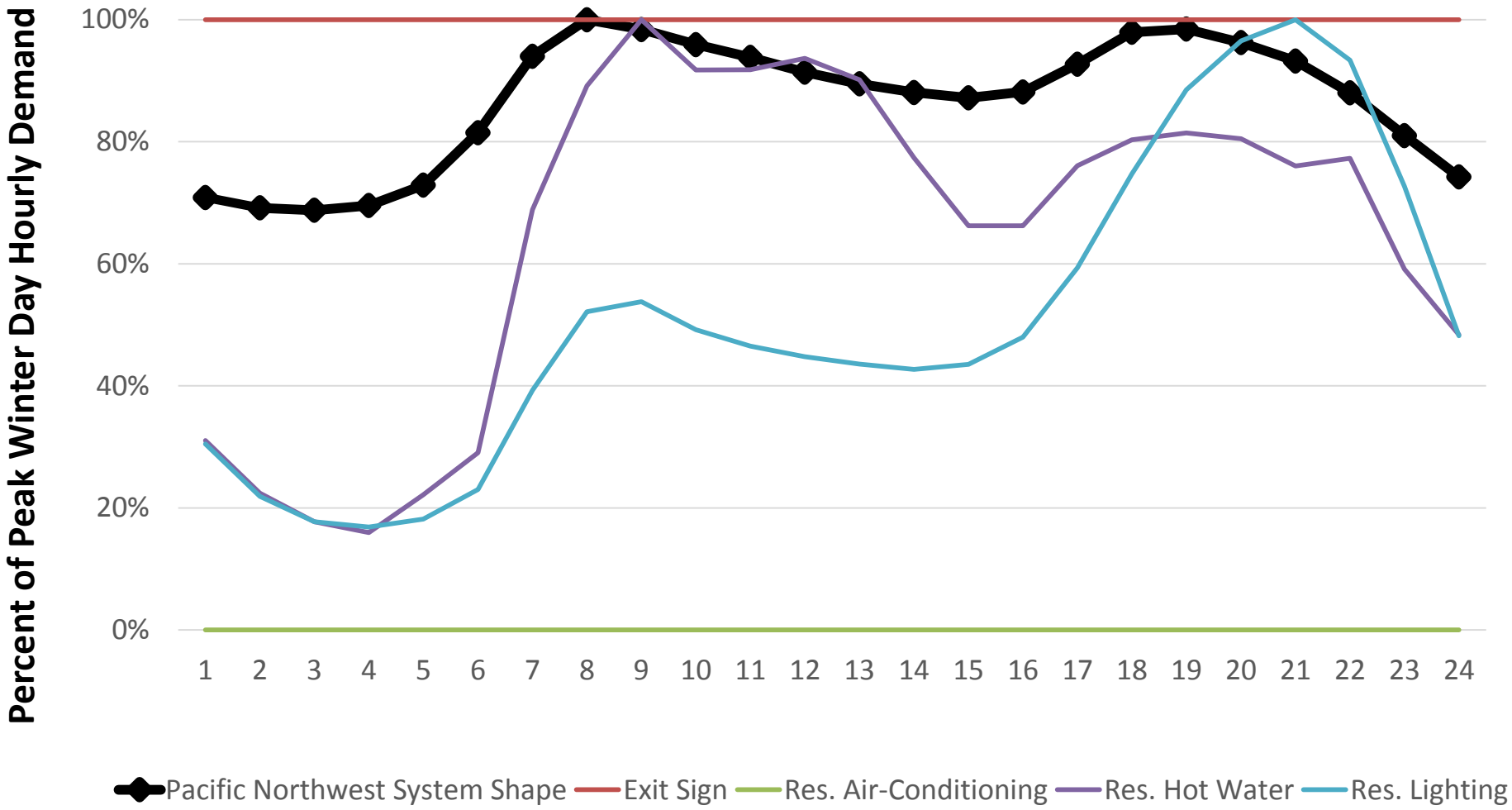

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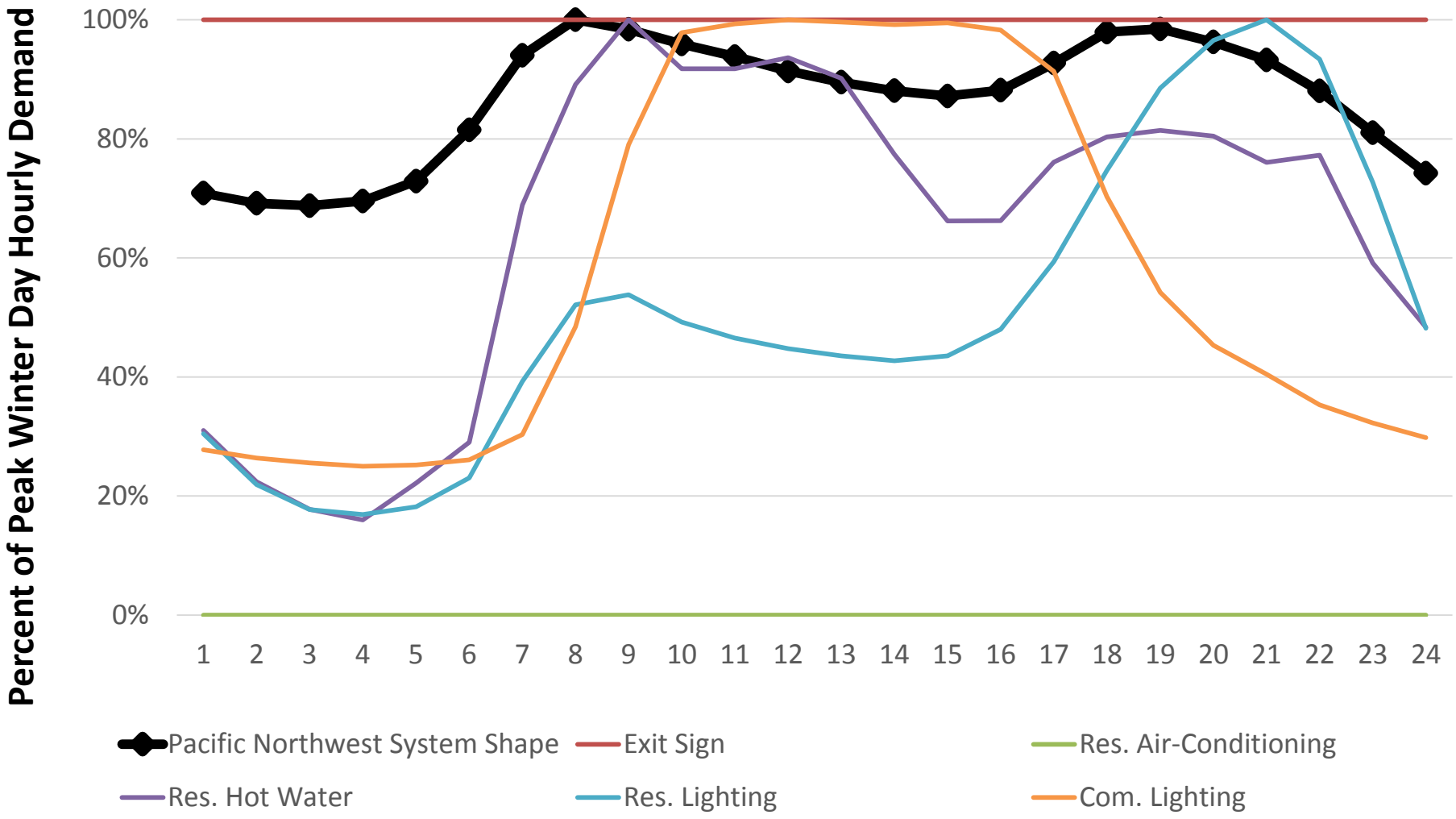

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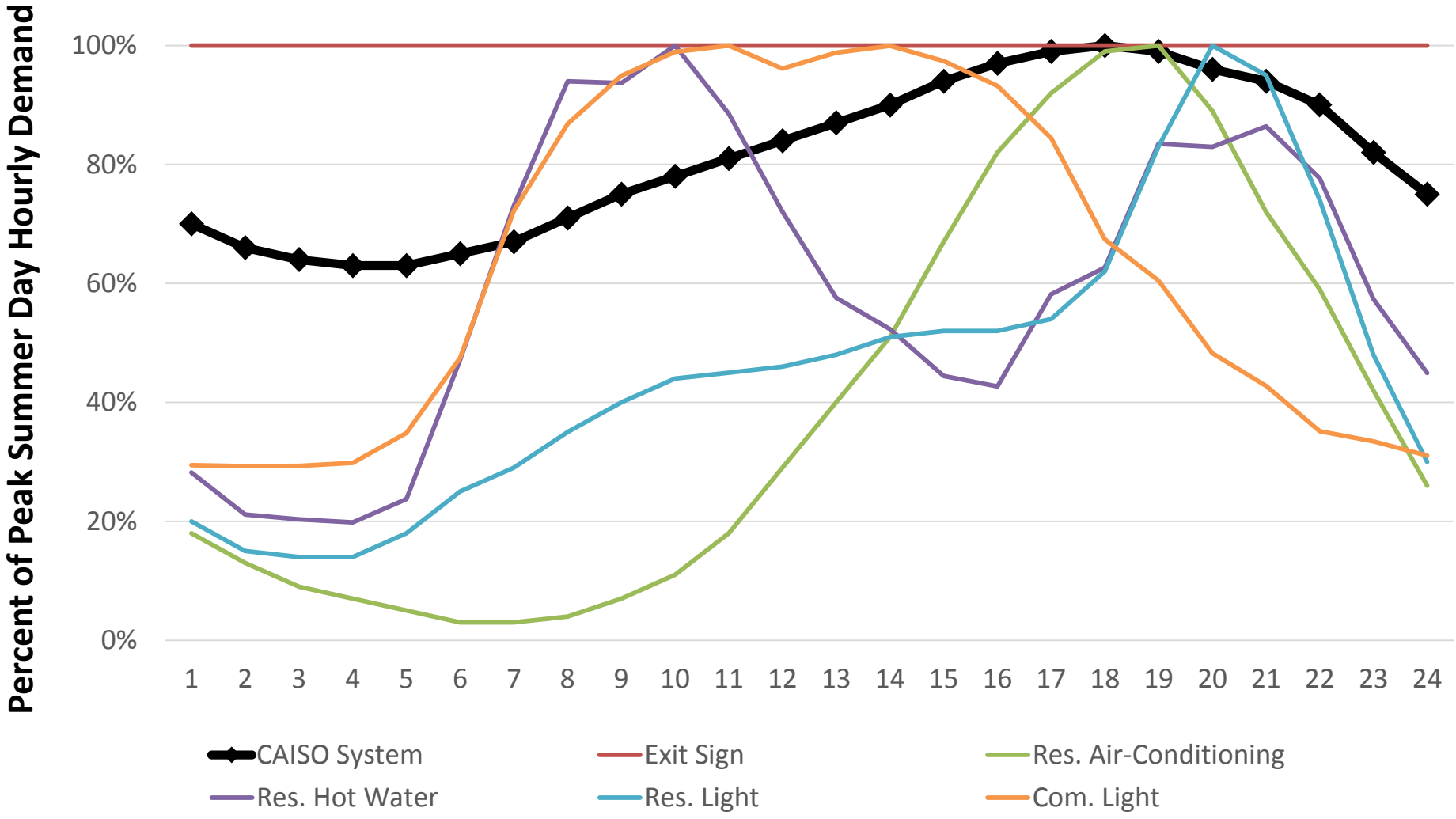
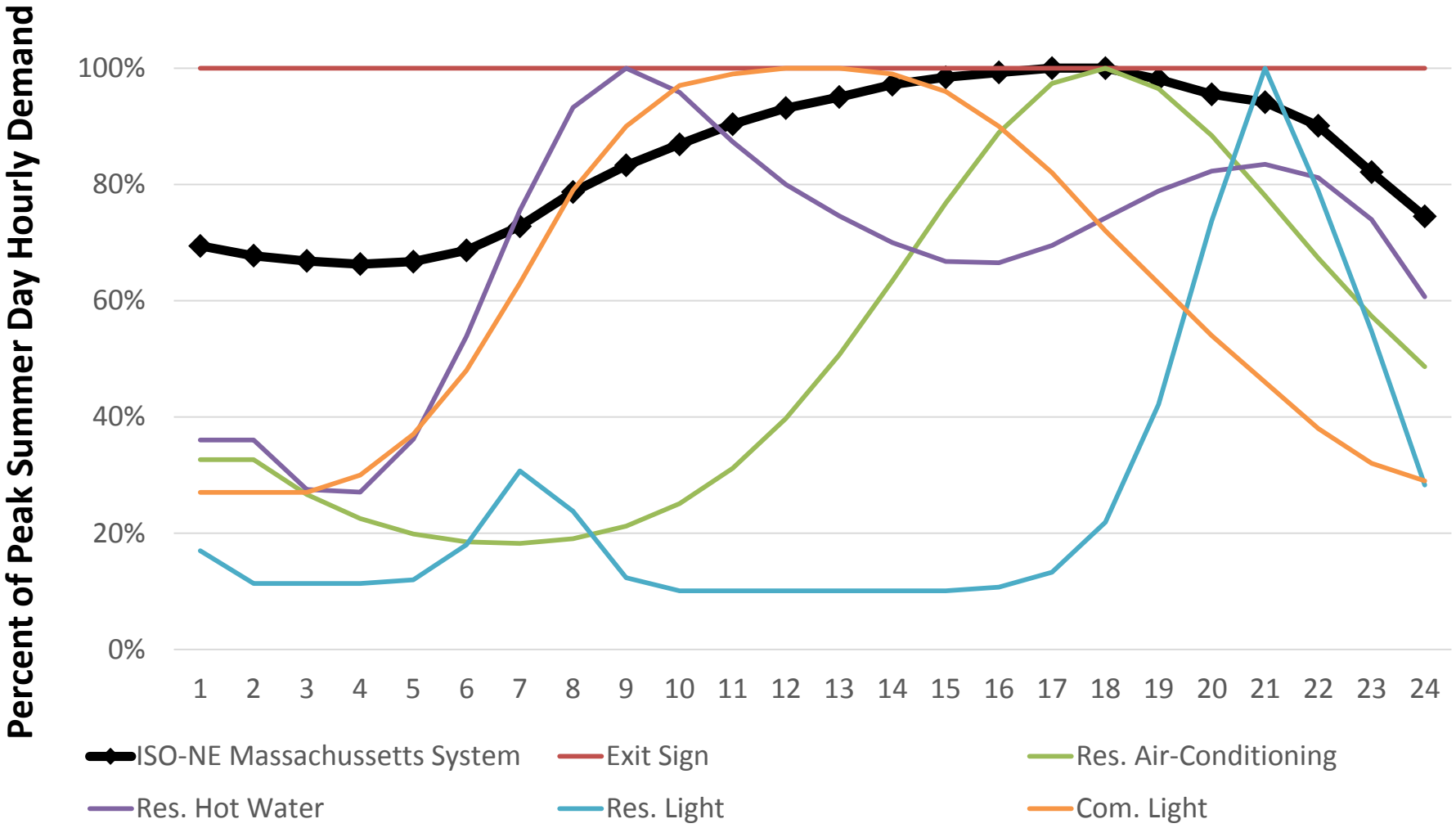
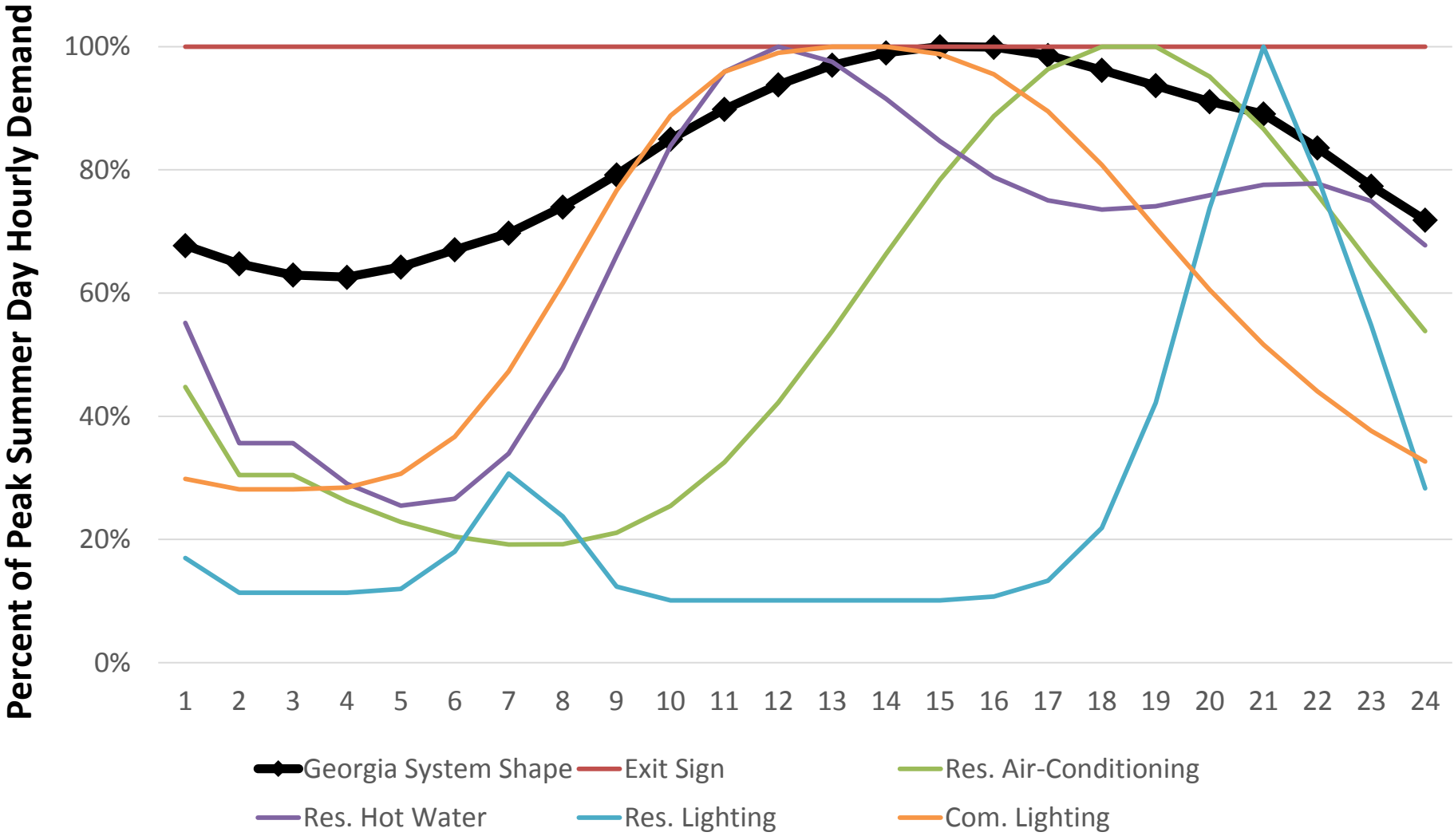


Massachusetts System Shape and End-Use Load Shapes



Georgia System Shape and End-Use Load Shapes



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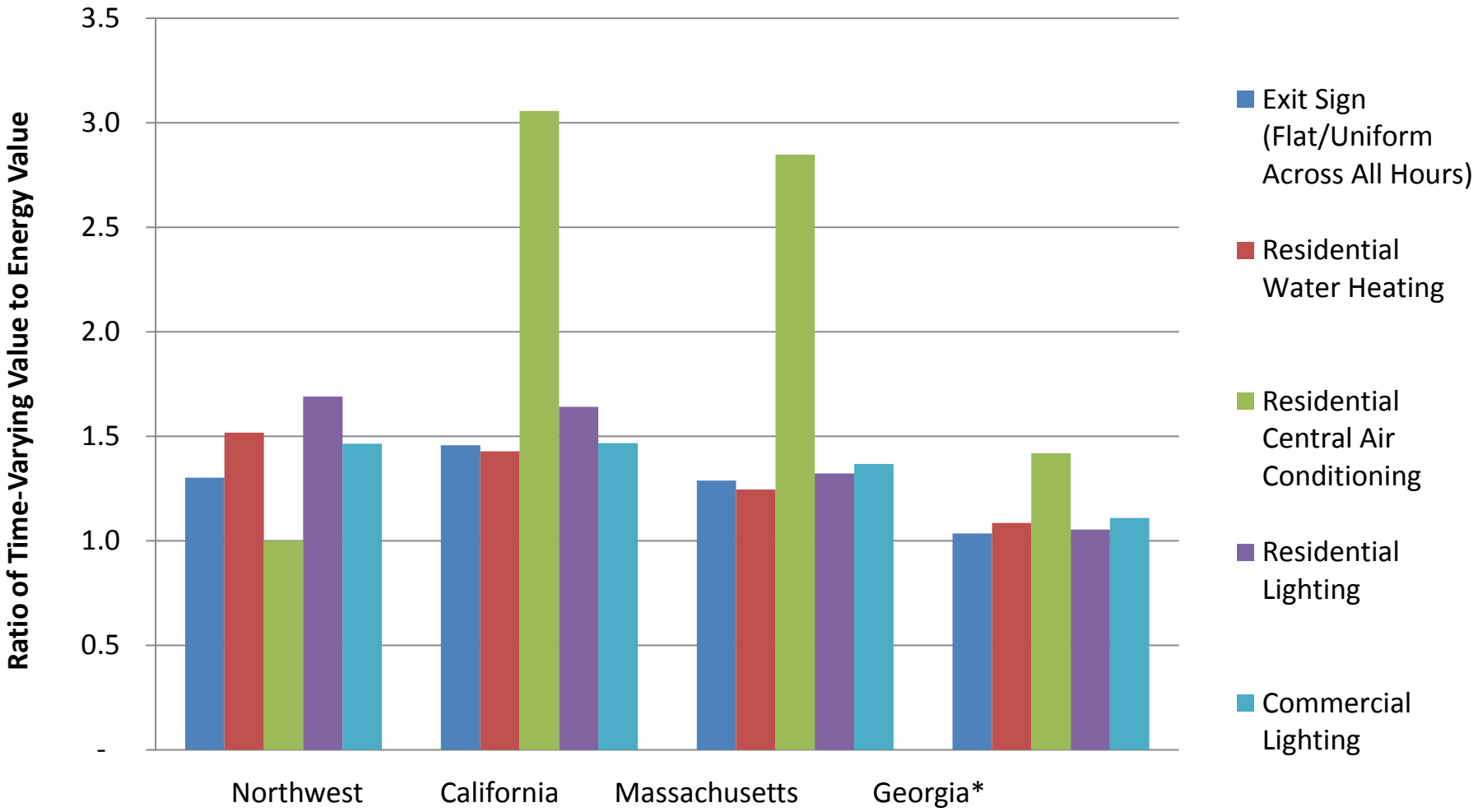

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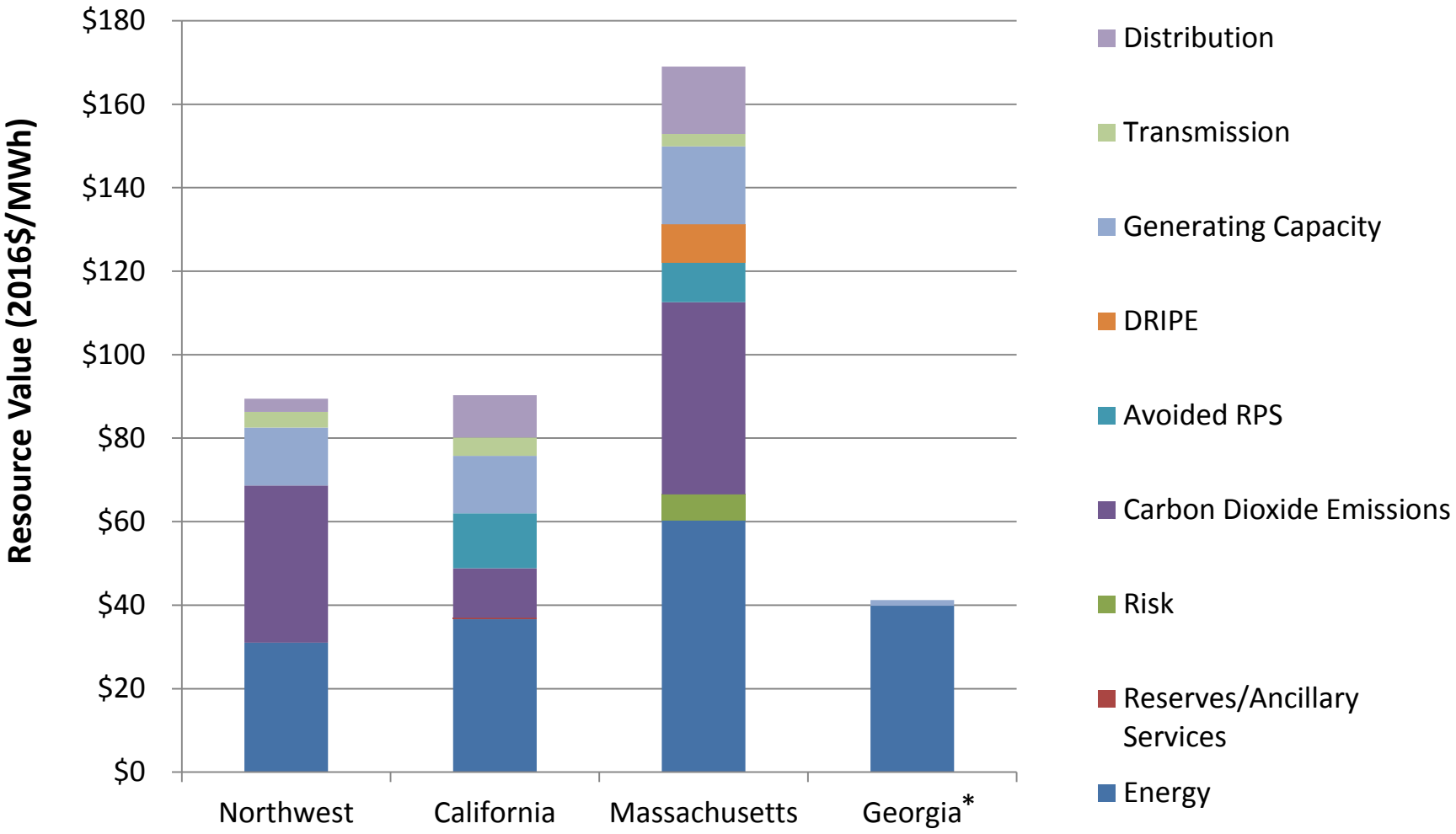
Exit Sign (flat load shape)

Measure 1 of 5



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Residential Central Air-Conditioning

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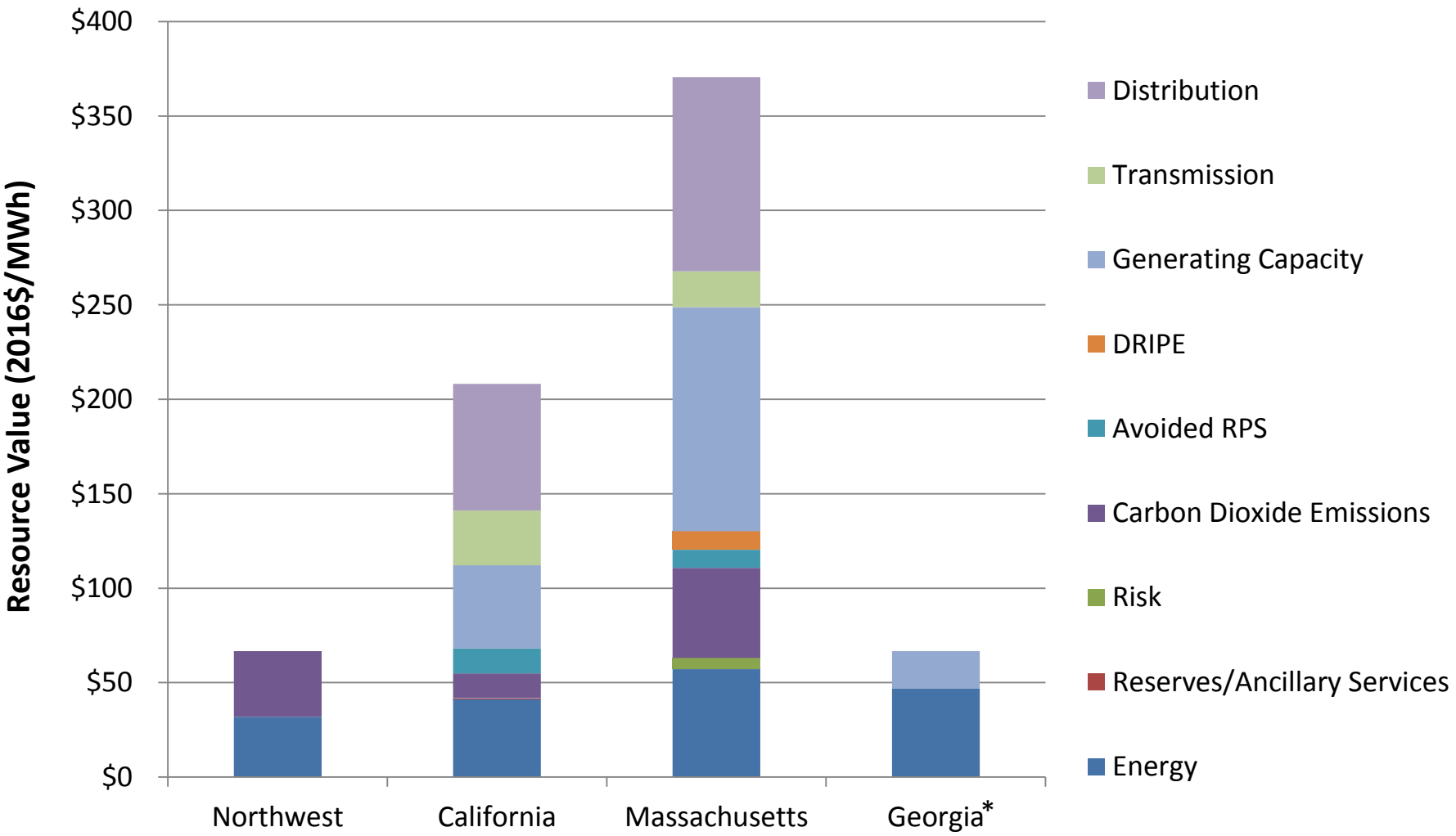

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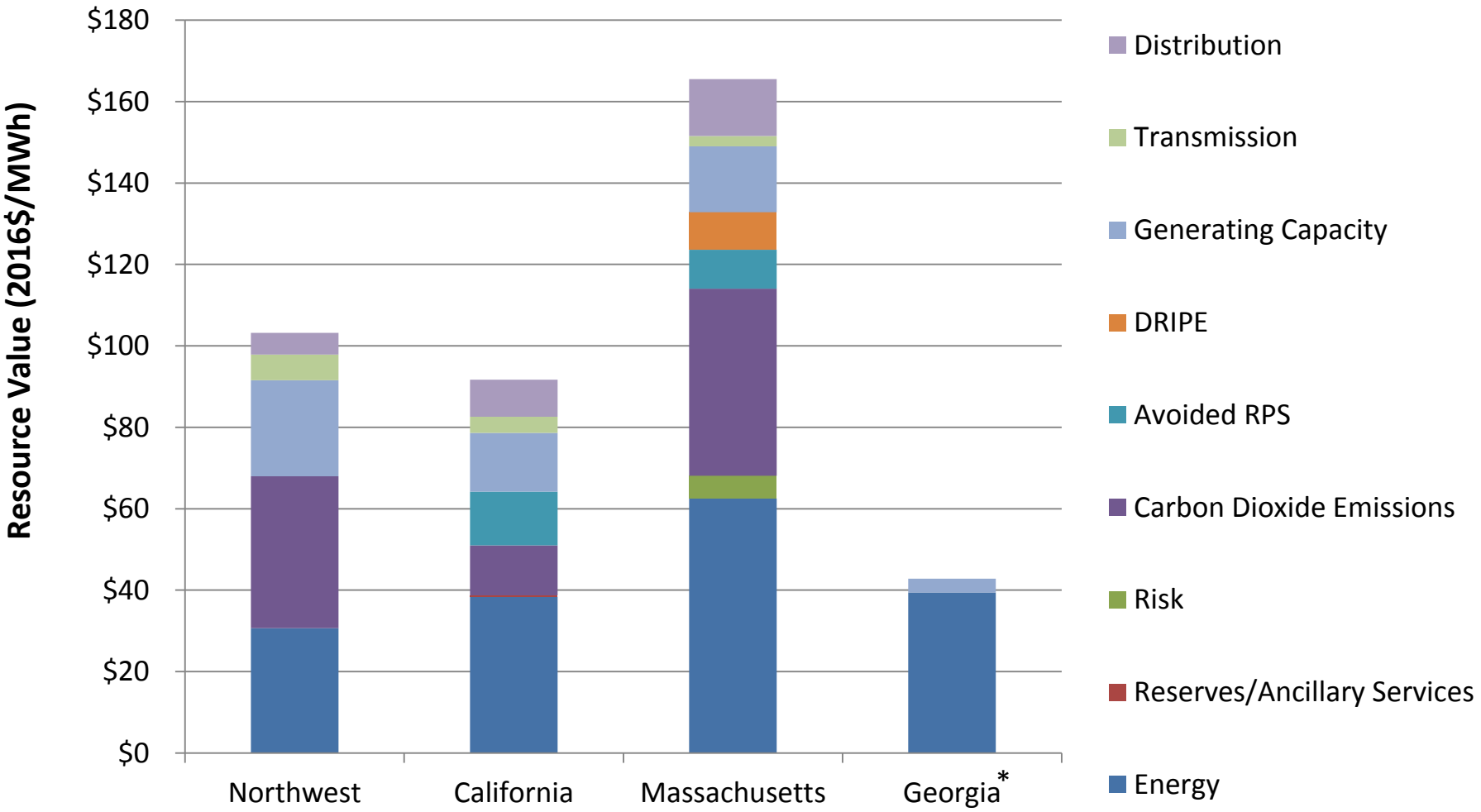

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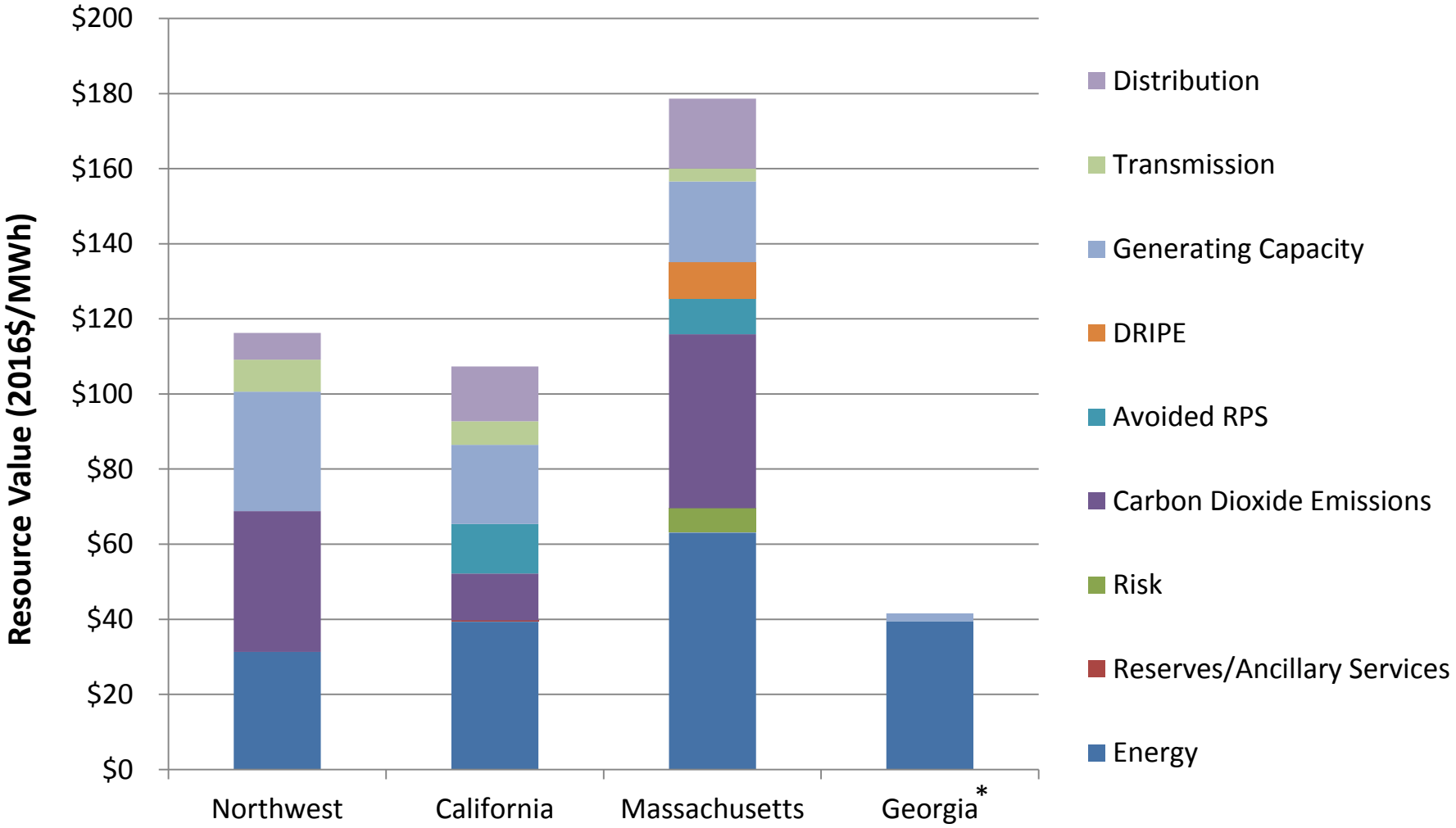
Residential Lighting

Measure 4 of 5



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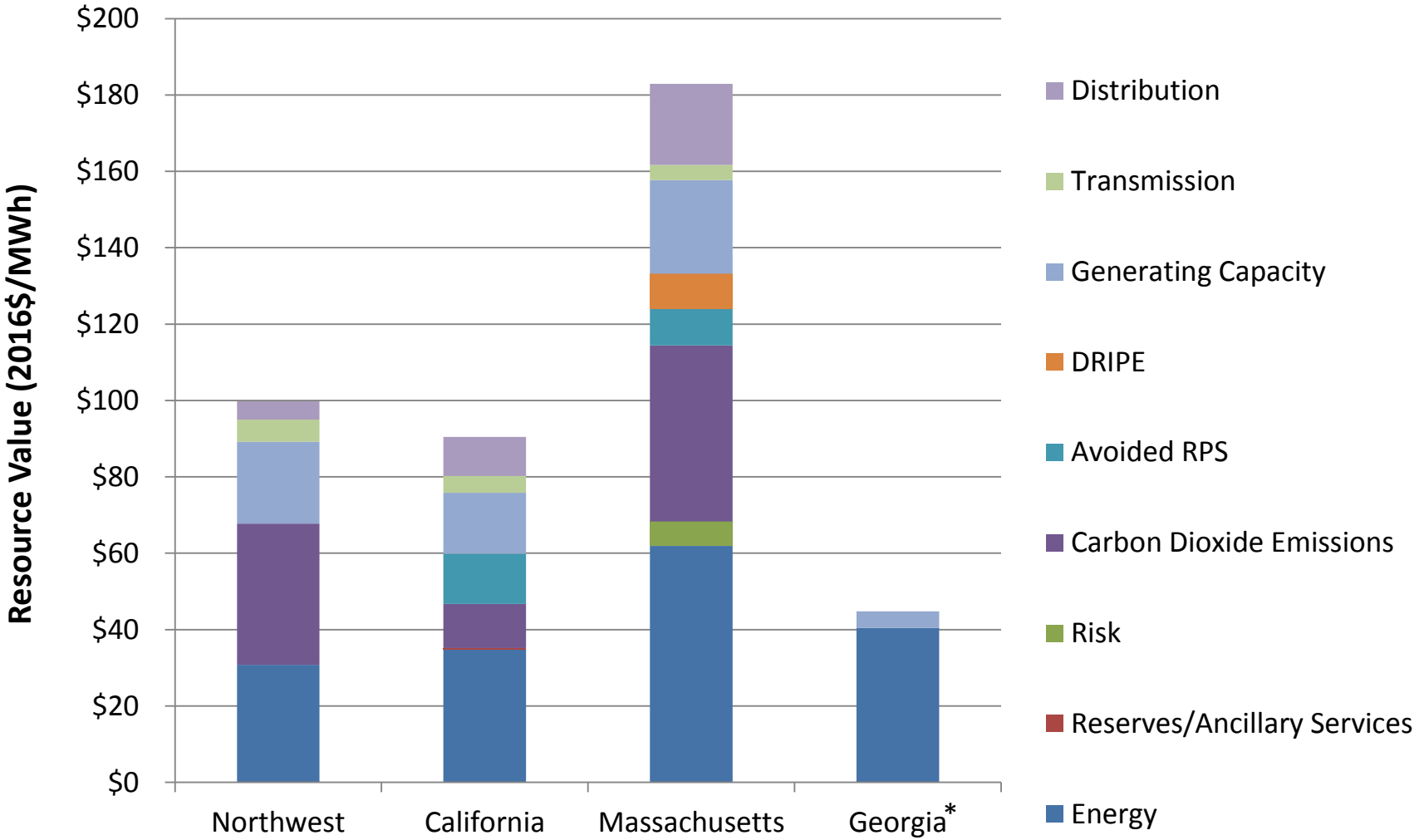

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- The increased use of distributed energy resources and the addition of major new electricity consuming end-uses are anticipated to significantly alter the load shape of many utility systems in the future.
- Data used to estimate the impact of energy efficiency measures on electric system peak demands will need to be updated periodically to accurately reflect the value of savings as system load shapes change.
- Publicly available components of electric system costs avoided through energy efficiency are not uniform across states and utilities. Inclusion or exclusion of these components and differences in their value affect estimates of the time-varying value of efficiency.
- Publicly available data on end-use load and energy savings shapes are limited, concentrated regionally, and should be expanded.

Utility, State or Regional Recommendations

- Collect metered data on a variety of end-use load and energy savings shapes for the state or region at least at the hourly level and make the data publicly available in a format that can be readily used in planning processes.
- Account for variations in the calculation of time-varying value of energy savings and avoided costs.
- Periodically update estimates of the impact of energy efficiency measures on utility system peak demands to accurately reflect changing system load shapes.
- Study transferability of end-use load shapes from one climate zone to another climate zone.

Regional or National Recommendations

- Identify best practices for establishing the time-varying value of energy efficiency in integrated resource planning and demand-side management planning to ensure investment in a least-cost, reliable electric system.
- Establish protocols for consistent methods and procedures for developing end-use load shapes and load shapes of efficiency measures.
- Establish common methods for assessing the time-varying value of energy savings, including values that are often missing such as deferred or avoided T&D investments.

Energy Technologies Area Lawrence Berkeley National Laboratory

Natalie Mims
namims@lbl.gov
510-486-7584

Tom Eckman
teckman49@gmail.com
503-803-5047

Chuck Goldman
cagoldman@lbl.gov
510-486-4637

Lisa Schwartz
lcschwartz@lbl.gov
510-486-6315

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