Energy Technologies Area   Lawrence Berkeley National Laboratory

Time-Varying Value of Energy Efficiency

ACEEE Energy Efficiency as a Resource

David Nemtzow (DOE/BTO)

Natalie Mims (LBNL)

November 1, 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.

“Time is on my side”…or is it?

Why should we care about time-sensitive valuation of energy-efficiency?

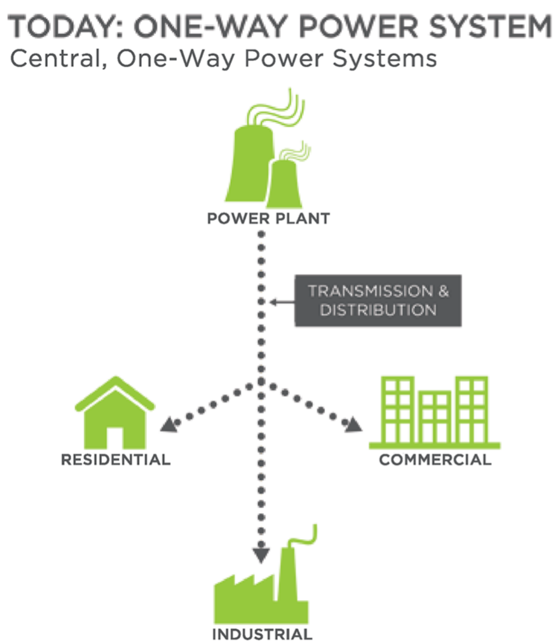
1. **Cost of generating electricity varies by time (esp. at peaks)**
   - Fuel/resource type
   - Powerplant fleet/heat rate
2. **As does cost of delivering electricity**
   - T&D infrastructure/cost
   - T&D congestion
3. **As do environmental impacts, other factors**
   - Emissions vary by fuel, heat rate, T&D congestion, etc.
   - Risk, DRIPE, etc.
4. **EE measures have their own “load” curve**
   - Exit signs vs. air conditioners

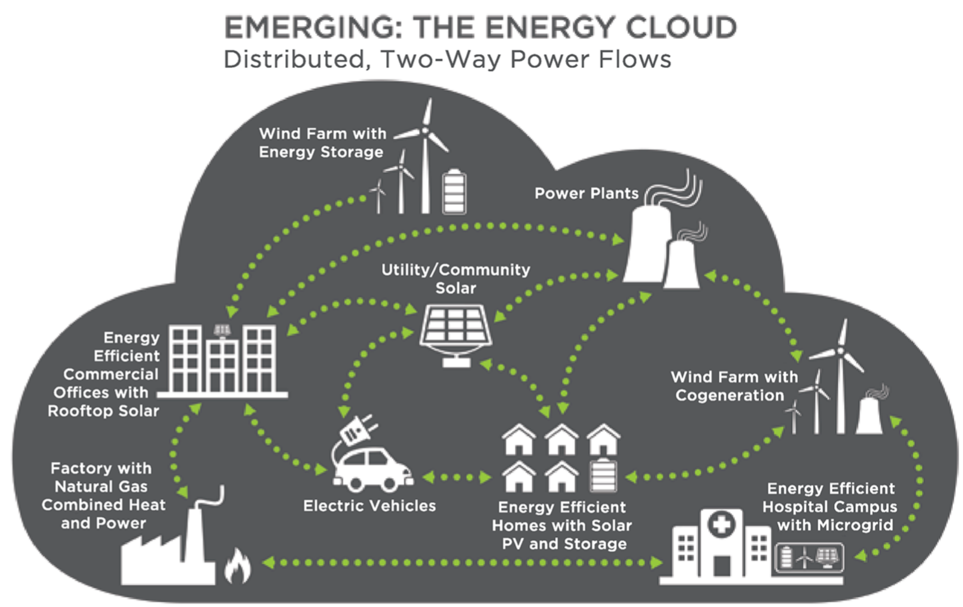
TSV Overview, con't

But?...

1. **Isn't locational-sensitive valuation also key?**
   - Yes, we also care about it & it's directly connected to TSV but not today's topic
2. **Won't dynamic/ToU/RTP rates solve this?**
   - Maybe
   - Regardless, they're barely implemented for most customers
   - There are plenty of other actions that can be taken to "TSV up"
3. **Isn't the duck curve changing everything?**
   - Yes, in some places. But not (yet?) in most
   - Duck-curving doesn't change underlying importance of TSV, just arithmetic
4. **What about connectivity/IoT?**
   - Very relevant. Certainly helpful, but also challenging
5. **Ok, I'm sold but isn't this (too?) hard?**
   - No! Stay tuned

Moving Towards the Grid of the Future





BTO Grid-integrated Efficient Buildings Research

- Interoperability
- Sensing and measurement
- Grid services valuation
- Time-sensitive valuation
- Machine Learning
- Transactive homes, buildings, and campuses
- Buildings, equipment as *virtual storage*

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)

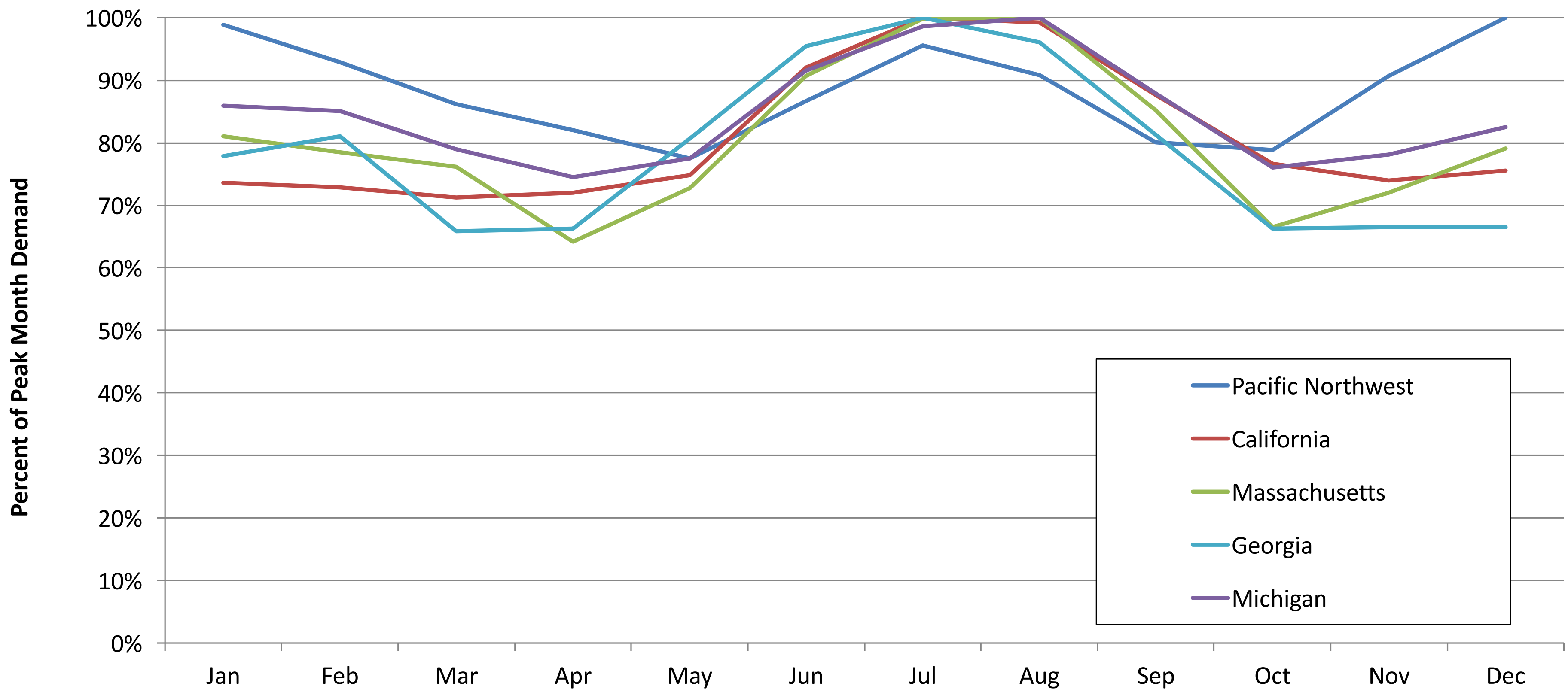
Study Approach

- 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 5 locations:

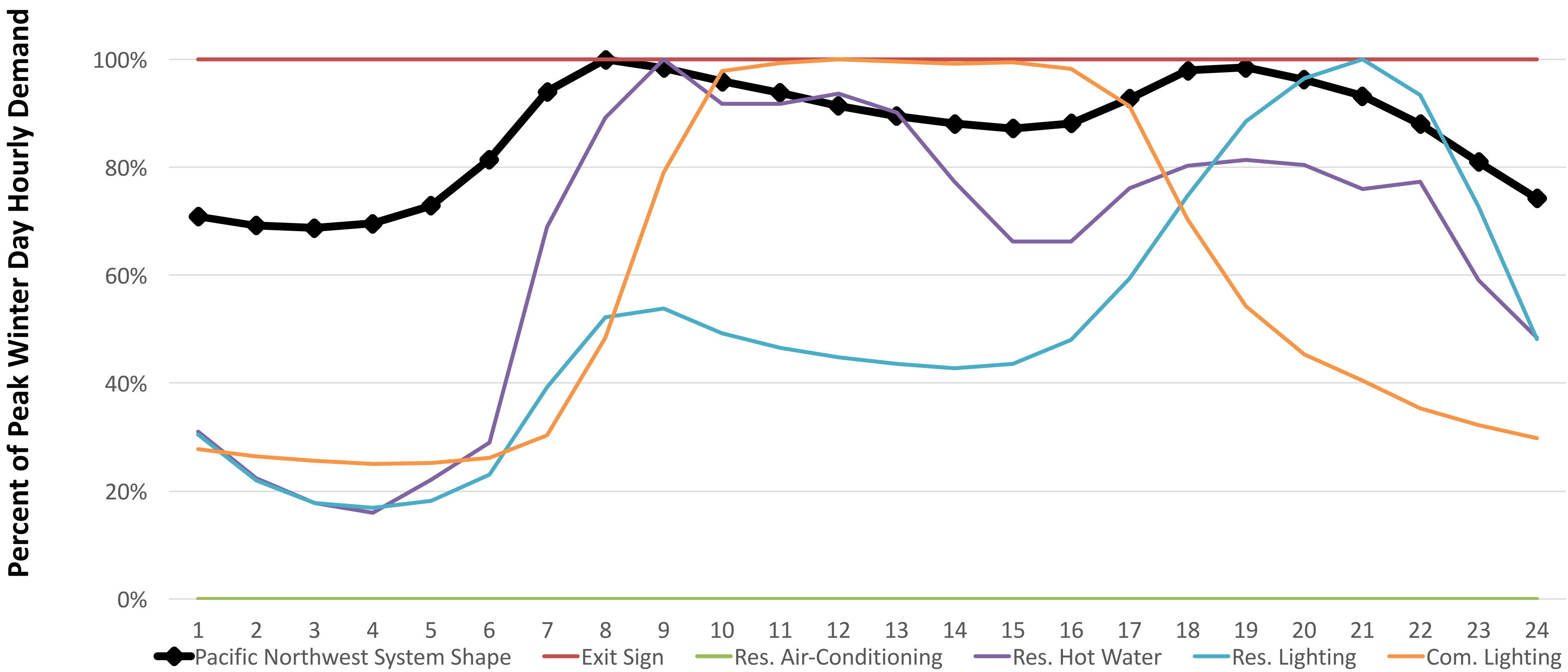
Measures	*State/Region*
Exit sign (Flat load shape)	Pacific Northwest
Commercial lighting	California
Residential lighting	Massachusetts
Residential water heater	Georgia
Residential air conditioning	Michigan

- 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.

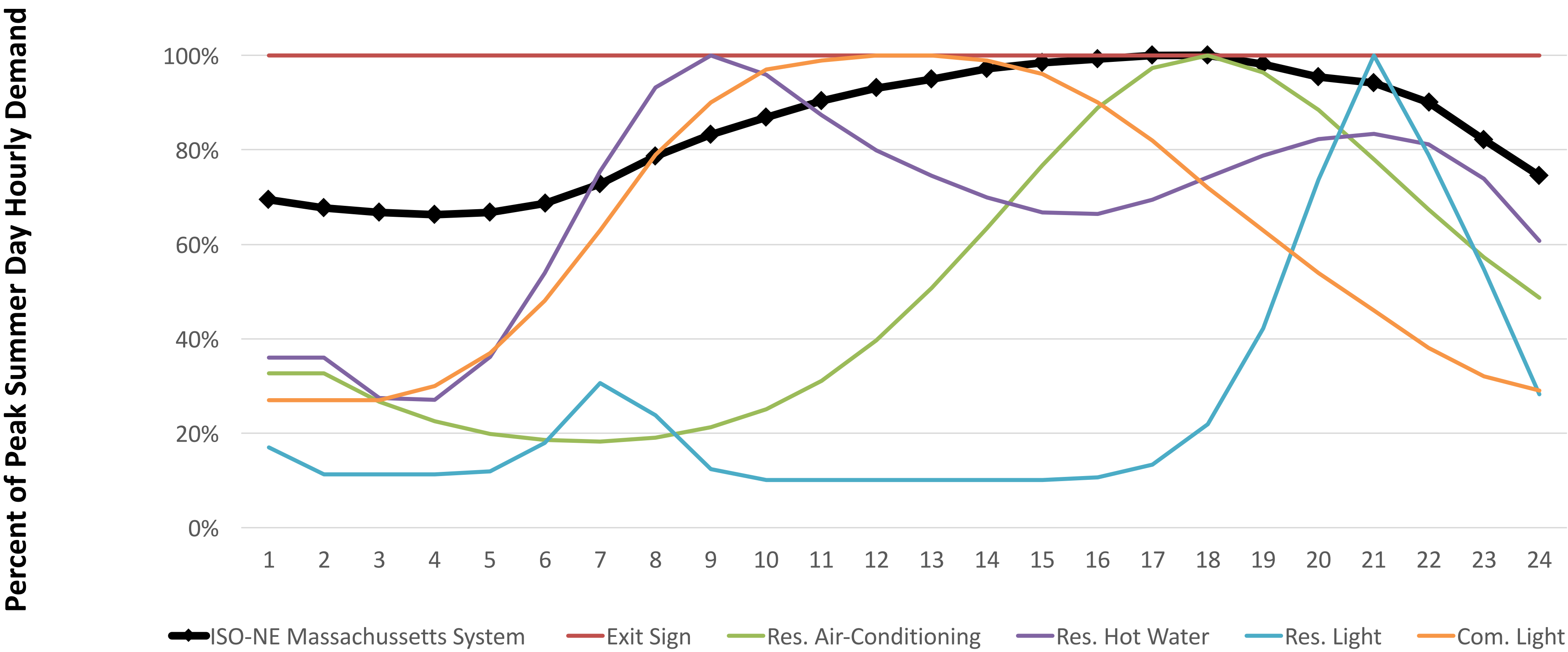
2016 System Load Shapes



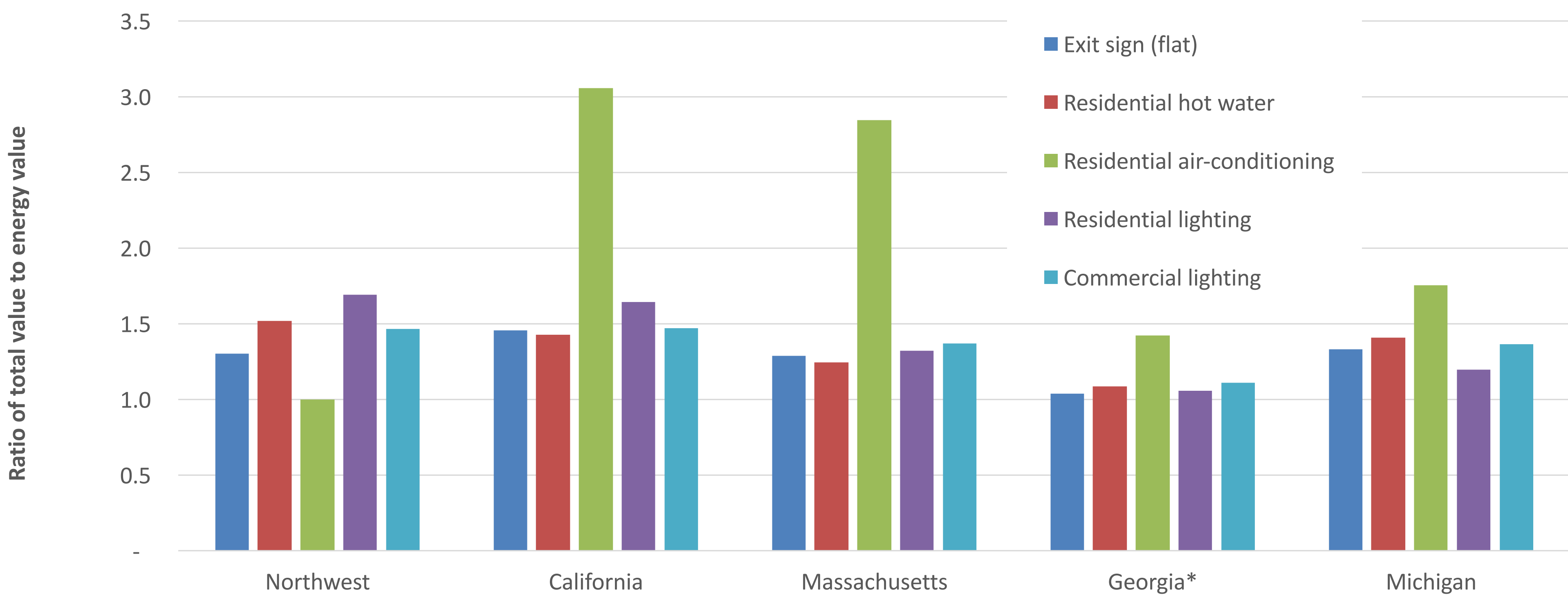
Pacific Northwest System Shapes and End-Use Load Shapes



Massachusetts System Shape and End-Use Load Shapes



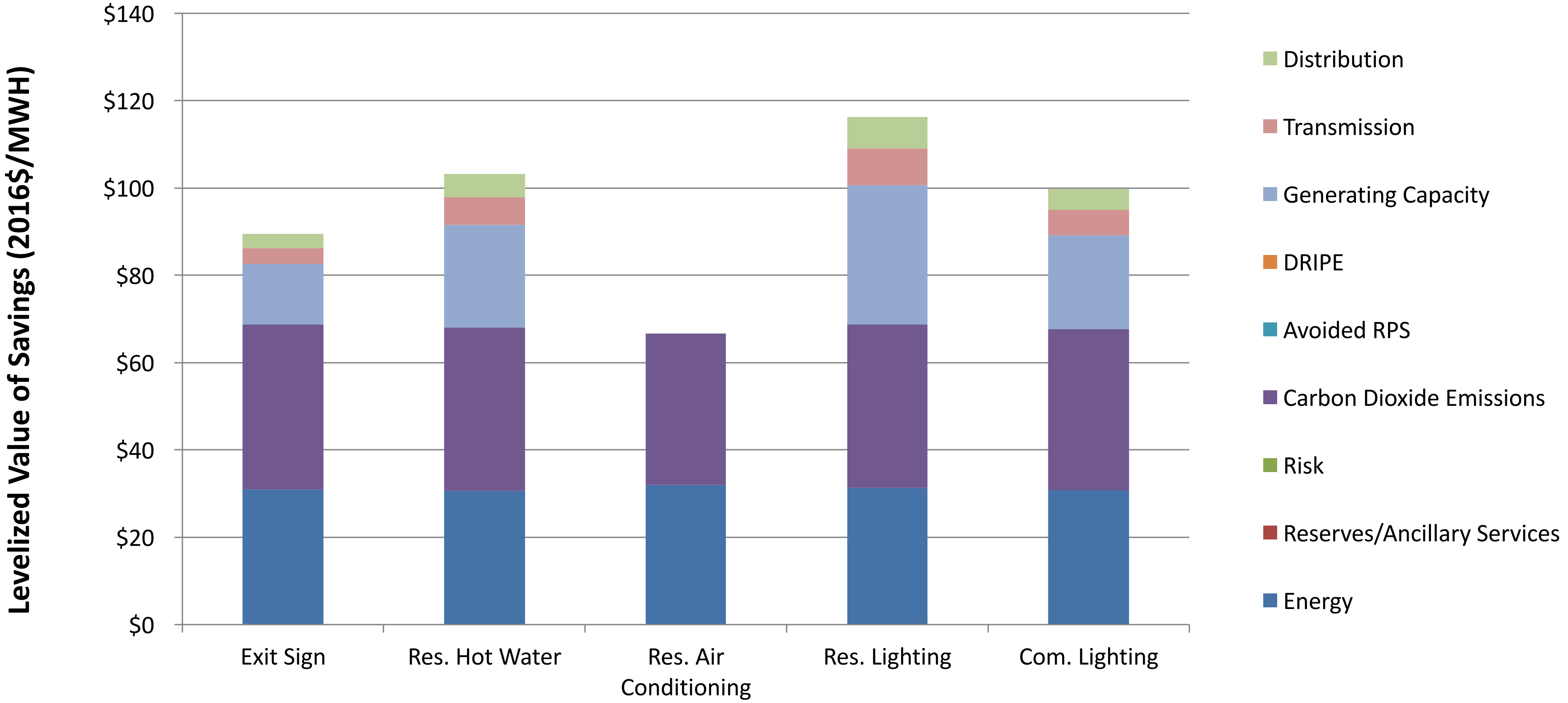
Comparing Total Utility System Value to Energy Value



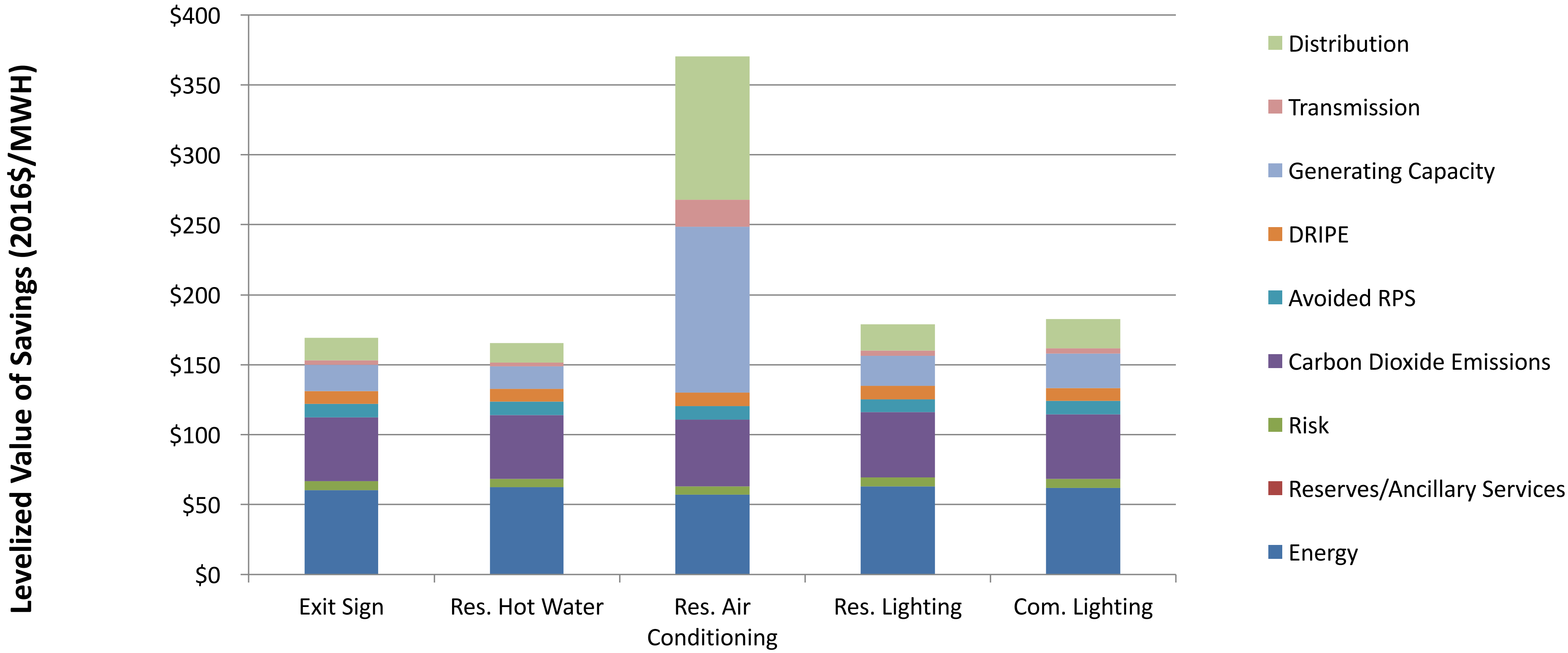
Notes: The flat load shape is an exit sign. Energy value includes: energy, risk, carbon dioxide emissions, avoided RPS and DRIPE, as applicable. Total time-varying value includes all energy values and capacity, transmission, distribution and spinning reserves. Ratios are calculated by dividing total time-varying values by energy-only values.

* In Georgia, where publicly available data did not include avoided transmission and distribution system values, the time-varying value of efficiency appears much lower for all measures evaluated. Avoided transmission and distribution costs are included in Georgia Power's energy efficiency evaluations, but are not a part of the publicly available PURPA avoided cost filing.

Northwest Time-Varying Value by Load Shape

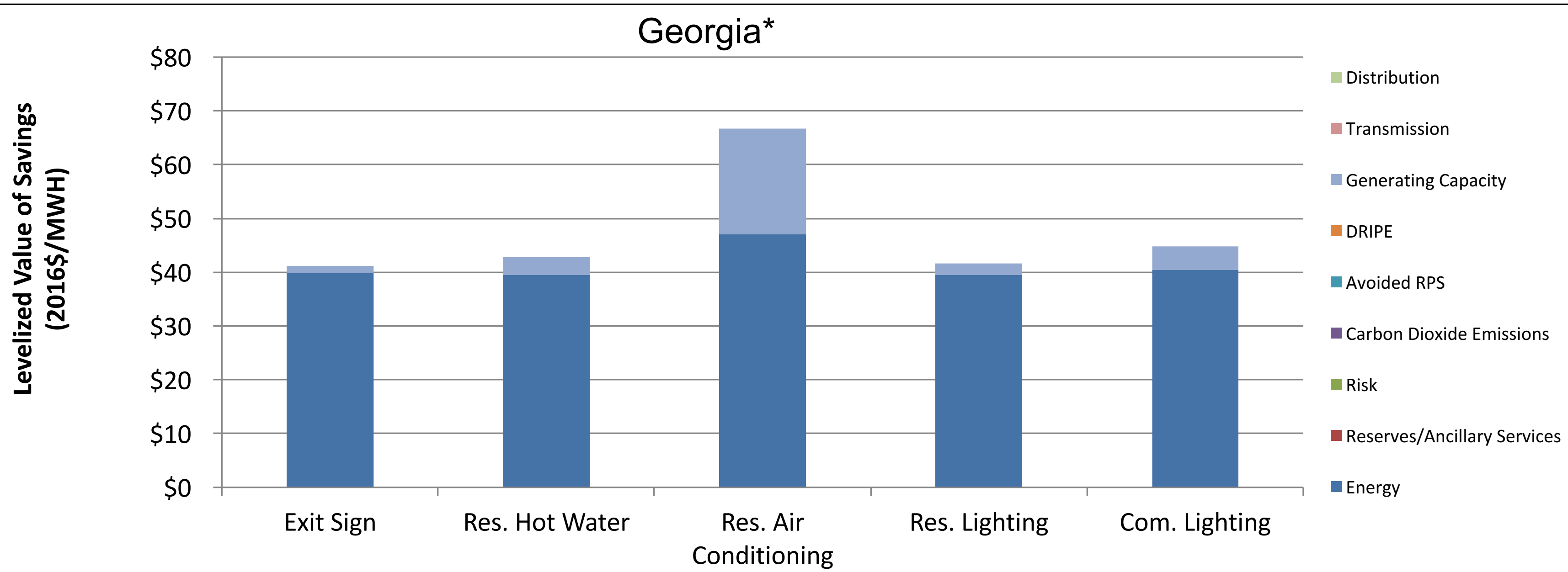


Massachusetts Time-Varying Value by Load Shape



Why All Avoided Cost Values Matter

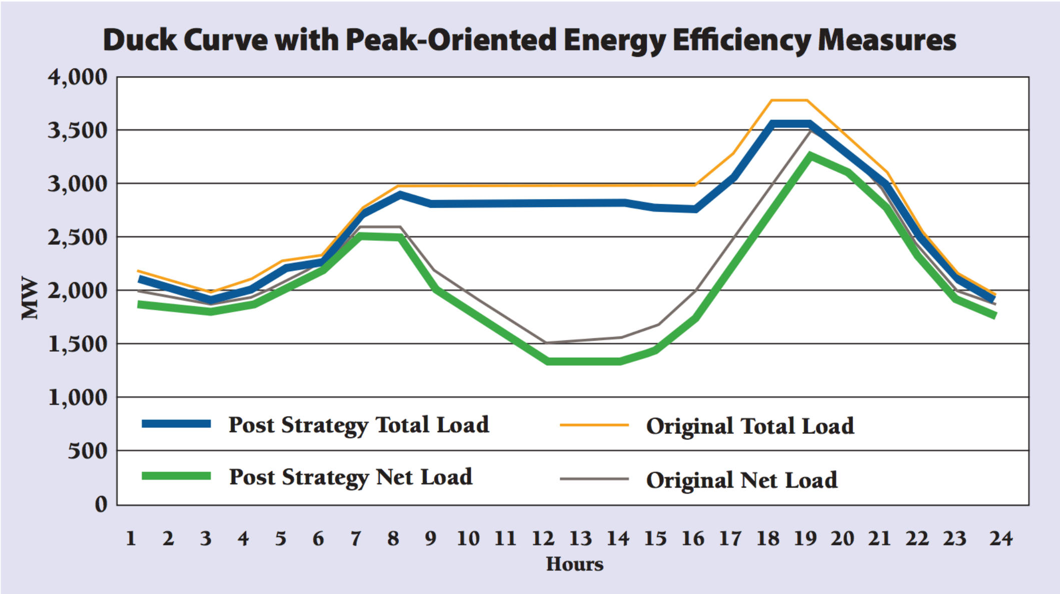
- The time-varying value of energy efficiency measures varies across the locations studied because of physical and operational characteristics of the individual utility system, the time periods that the savings from measures occur and differences in the value and components of avoided cost considered.
- 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.



* In Georgia, where publicly available data did not include avoided transmission and distribution system values, the time-varying value of efficiency appears much lower for all measures evaluated. Avoided transmission and distribution costs are included in Georgia Power's energy efficiency evaluations, but are not a part of the publicly available PURPA avoided cost filing

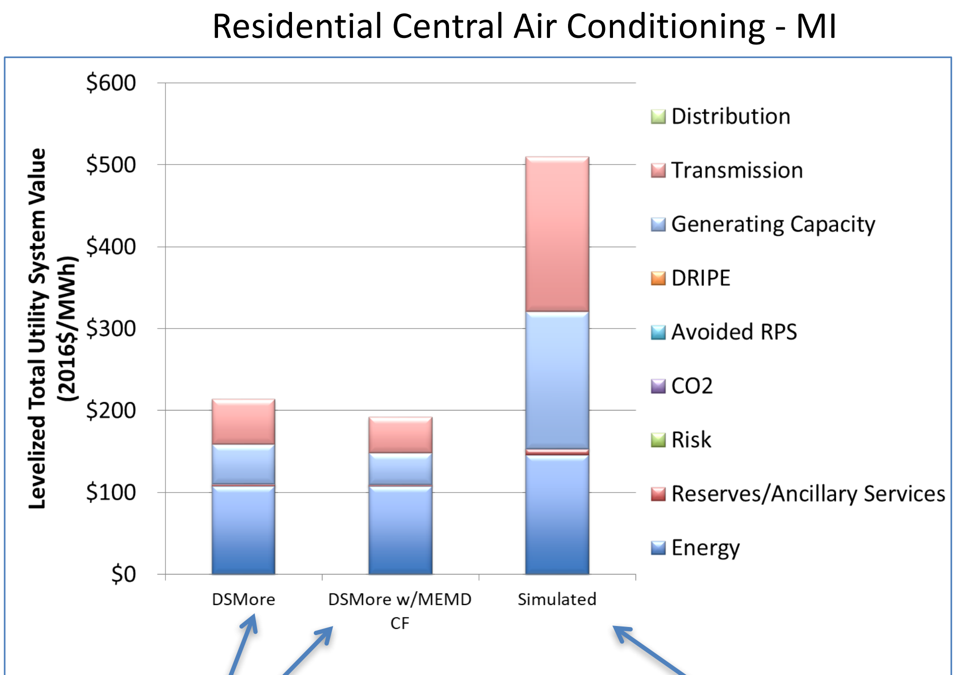
Why Changing System Shapes Matter

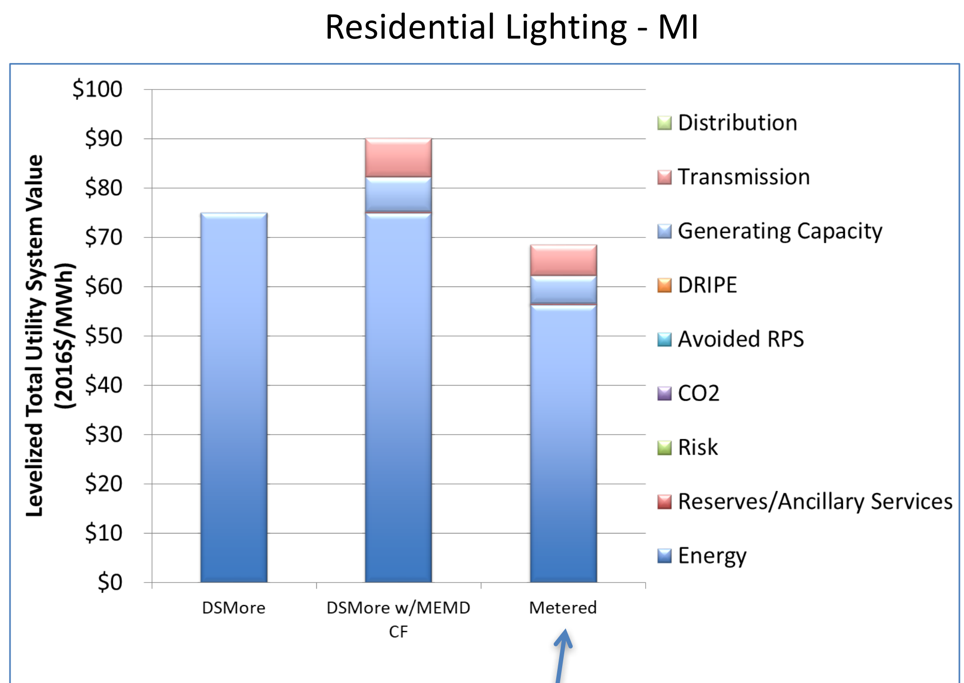
- The increased use of distributed energy resources and the addition of major new electricity consuming end-uses are anticipated to significantly alter the load shape of many utility systems in the future.
- Data used to estimate the impact of energy efficiency measures on electric system peak demands will need to be updated periodically to accurately reflect the value of savings as system load shapes change.



Source:
[Teaching the Duck to Fly, Jim Lazar]

Why Accurate Load Shapes Matter





Load Shapes Not Based on Metered Data

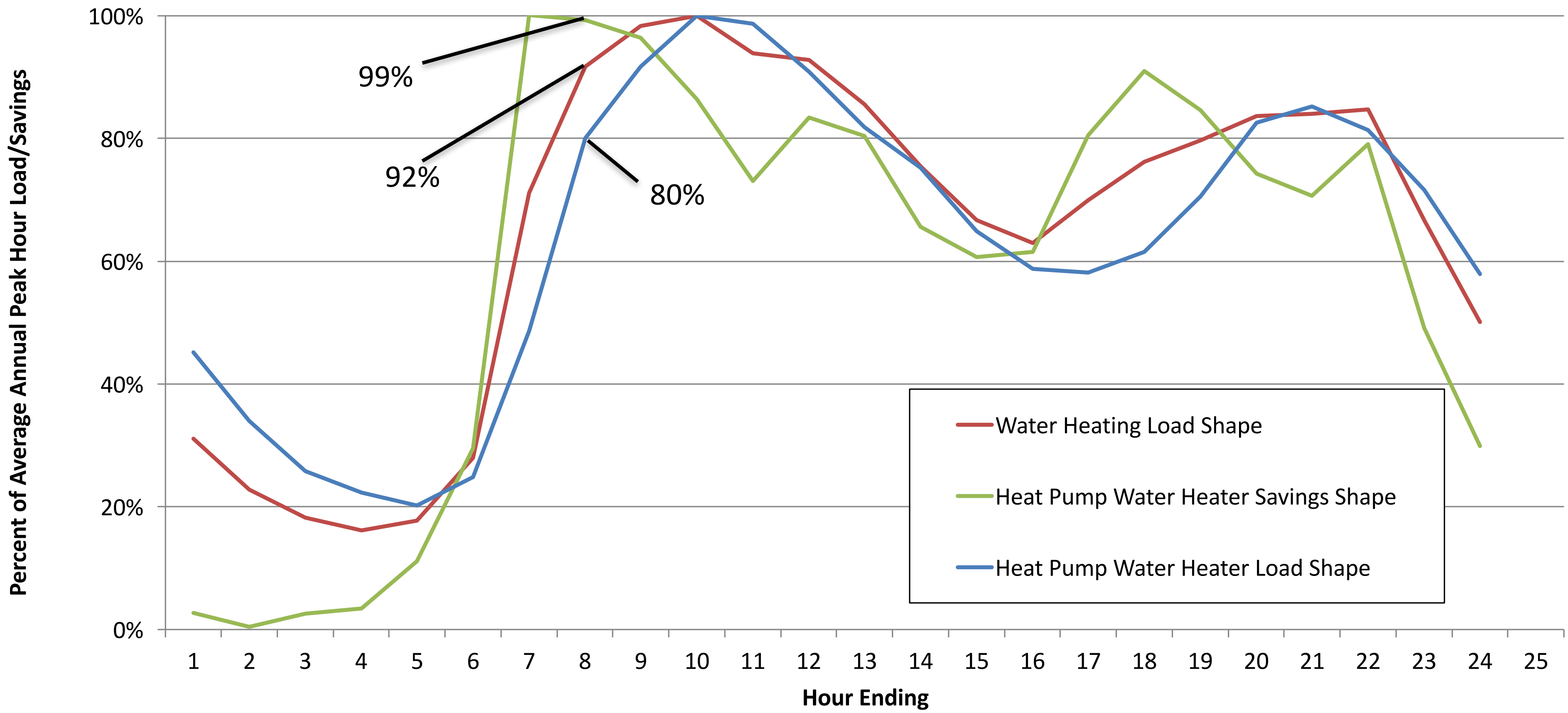
Simulated Load Shapes May Not Represent "Diversified Loads"

Statistically Representative Metered Data Provides More Accurate Representation

Why Savings Shapes Matter (1)

- 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.

Why Savings Shapes Matter (2)



Utility, State or Regional Recommendations on Approach

- 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 on Approach

- 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.

Potential areas for TSV consideration (1)

These are interesting potential areas; we are not endorsing anything here besides think it through. Period.

- Dynamic rates
- Utility regulation
  - Incentives/rebates
  - EERS avoided costs
  - IRP
  - distribution planning
  - financial incentives for IOUs
  - Etc.!
- Utility programs

Potential areas for TSV consideration (2)

(we are still not endorsing anything here besides think it through)

- Governmental actions
  - Labeling, e.g. Energystar
  - R&D
  - Appliance standards
  - Building codes
  - Procurement
- More data and analysis collection!

Questions?

Natalie Mims

namims@lbl.gov

510-486-7584

Visit our website at:
http://emp.lbl.gov/

Follow the Electricity Markets & Policy Group on Twitter @BerkeleyLabEMP

David Nemtzow

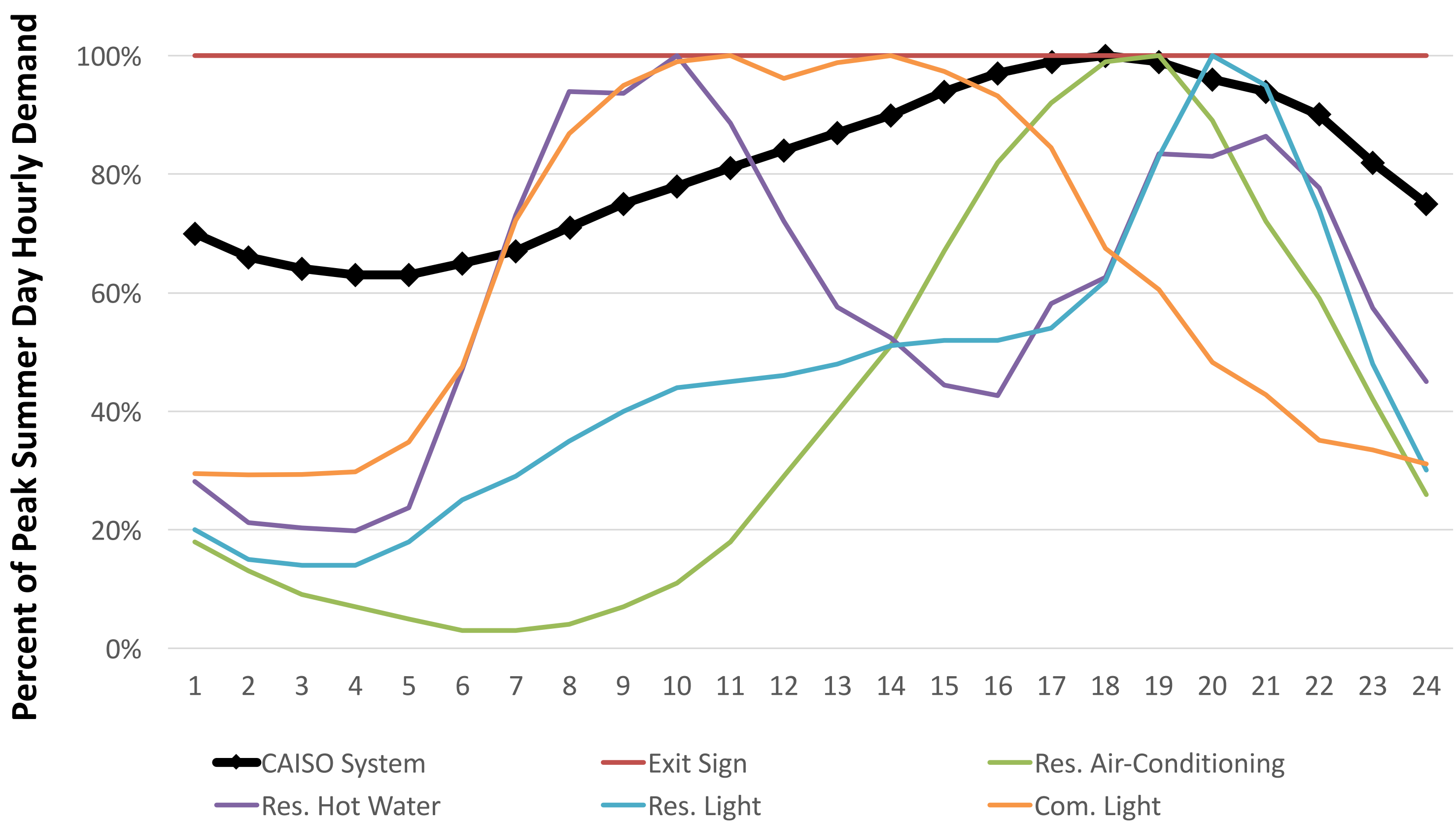
David.Nemtzow@ee.doe.gov

202-586-2480

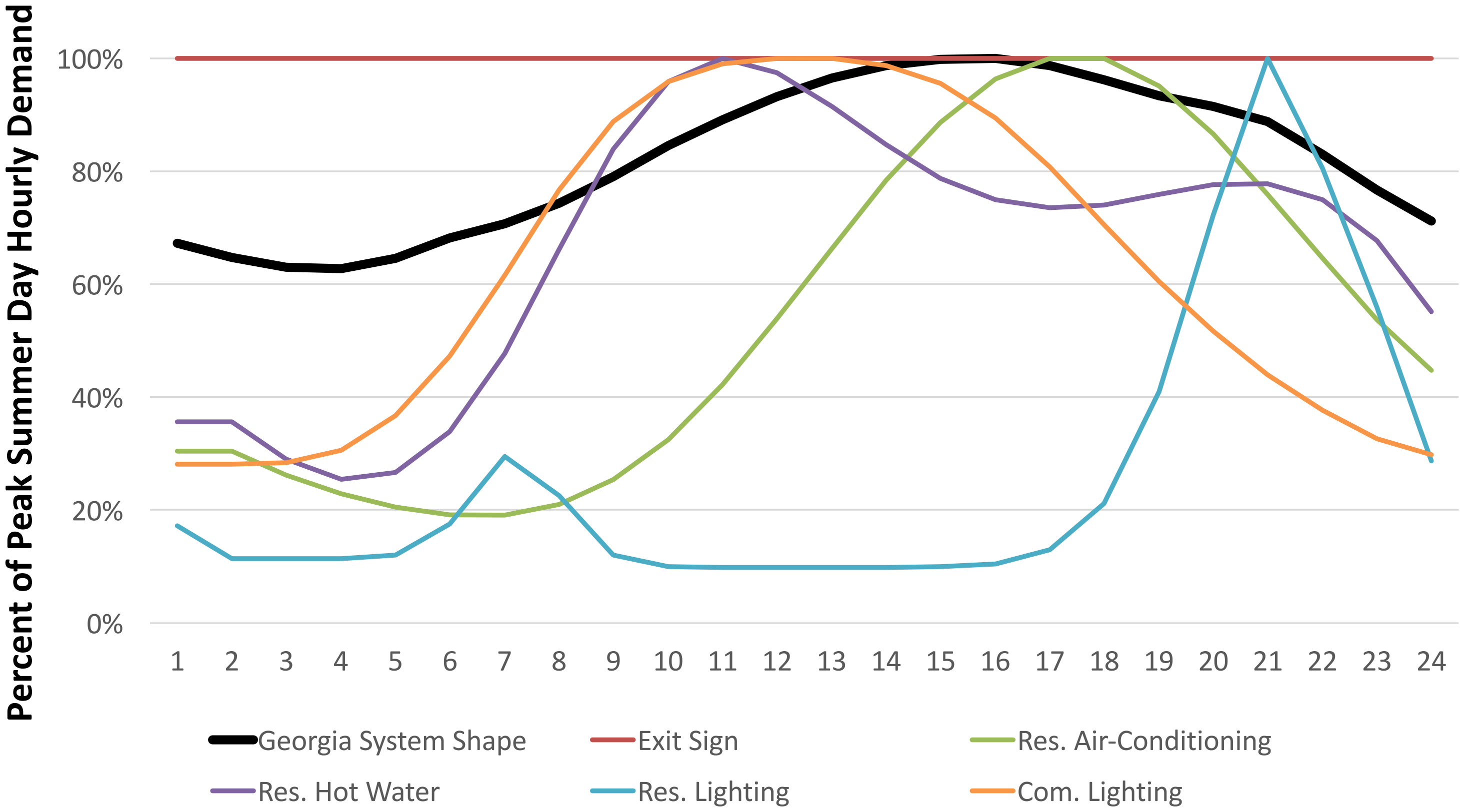
Visit our website at:
https://energy.gov/eere/buildings/building-technologies-office

Additional Slides

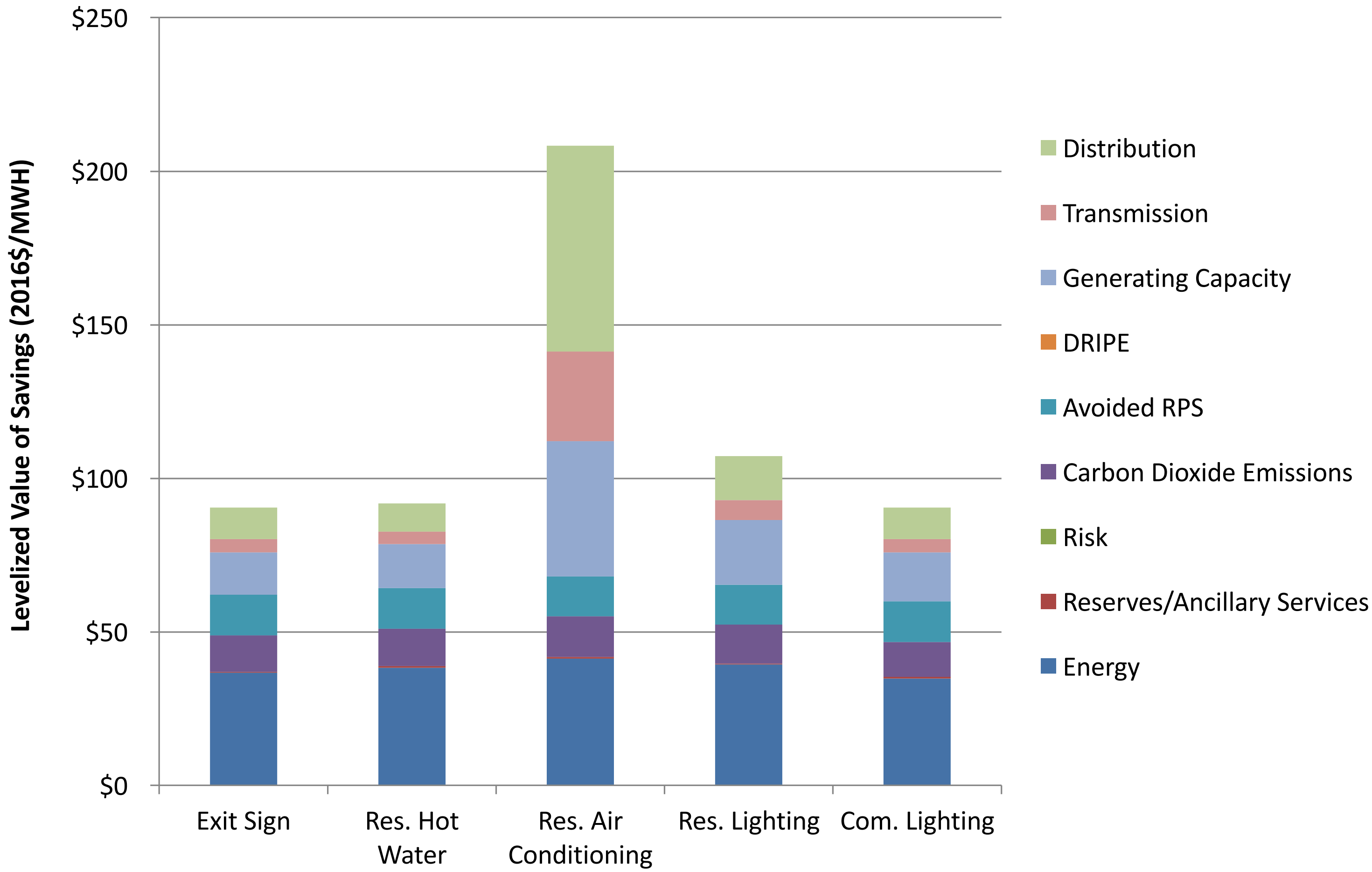
California System Shape and End-Use Load Shapes



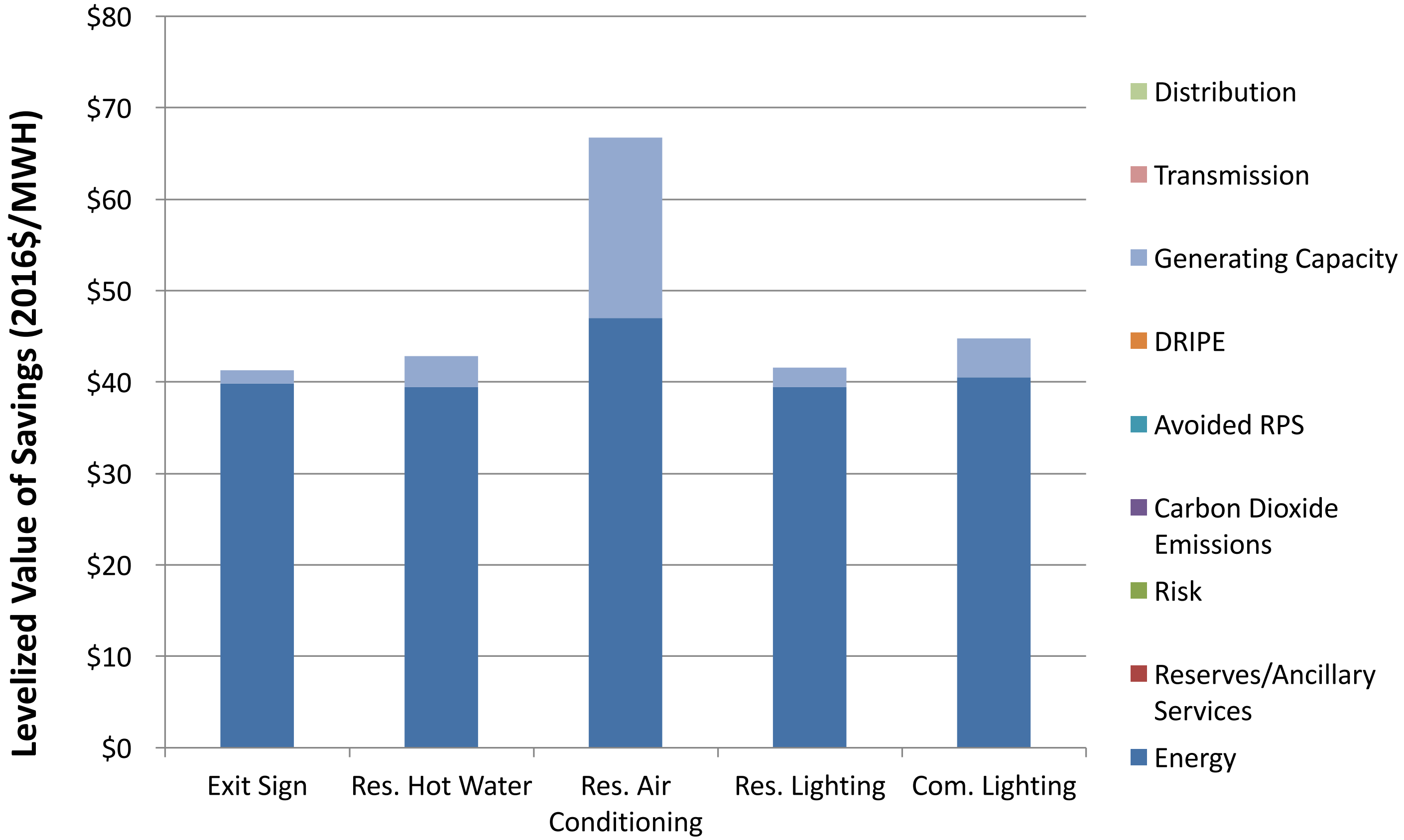
Georgia System Shape and End-Use Load Shapes



California Time-Varying Value by Load Shape



Georgia* Time-Varying Value by Load Shape



* In Georgia, where publicly available data did not include avoided transmission and distribution system values, the time-varying value of efficiency appears much lower for all measures evaluated. Avoided transmission and distribution costs are included in Georgia Power's energy efficiency evaluations, but are not a part of the publicly available PURPA avoided cost filing

Michigan Time-Varying Value by Load Shape