Using the Whole Toolbox: Integrating Demand-Side Potential Studies

Presented at the 2017 ACEEE National Conference on Energy Efficiency as a Resource

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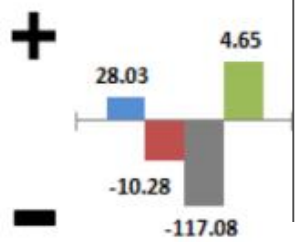
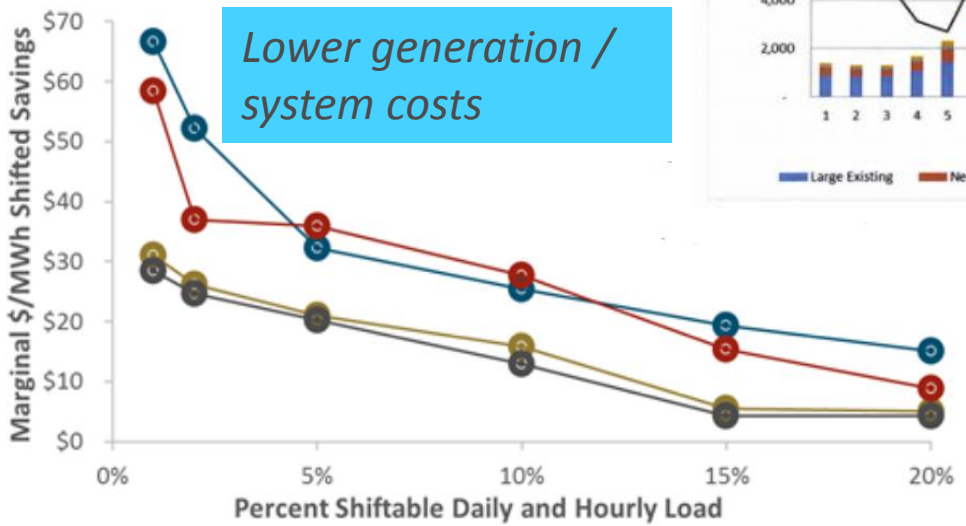
Planning electric EE investments in isolation carries growing opportunity costs.

Electricity system planners and policymakers have an interest in understanding the potential *integrated* impacts of distributed electricity resources (EE, DR, DG, Storage), based on a variety of desired outcomes:

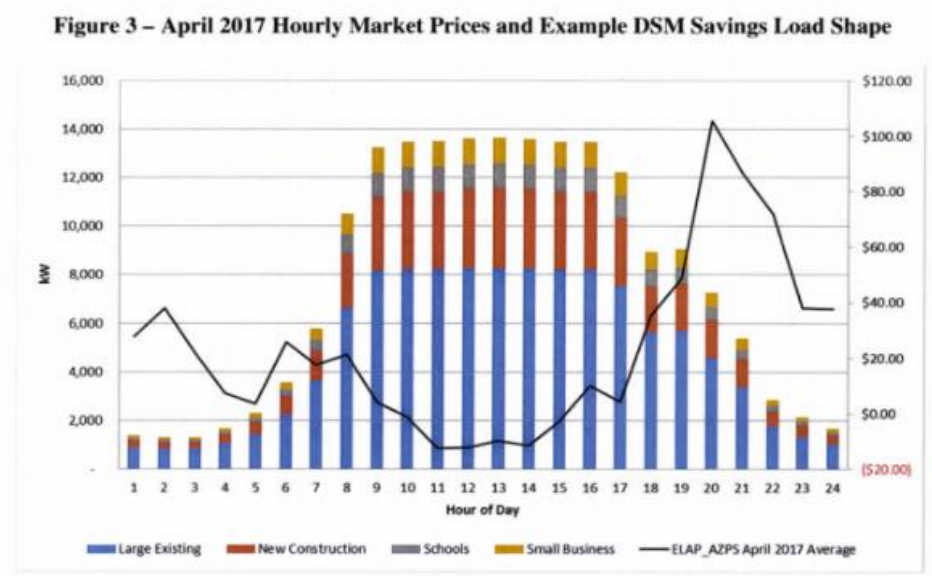
Metric	Reference Case Value
Generation Capital Cost	$90.97 Billion
Transmission Capital Cost	$28.56 Billion
CO2 Production	329.37 Million Metric Tons
Weighted Average LCOE (No CO2) of All Generation (2011-2032)	$46.74 per MWh



Lower transmission costs, emissions



Lower generation / system costs

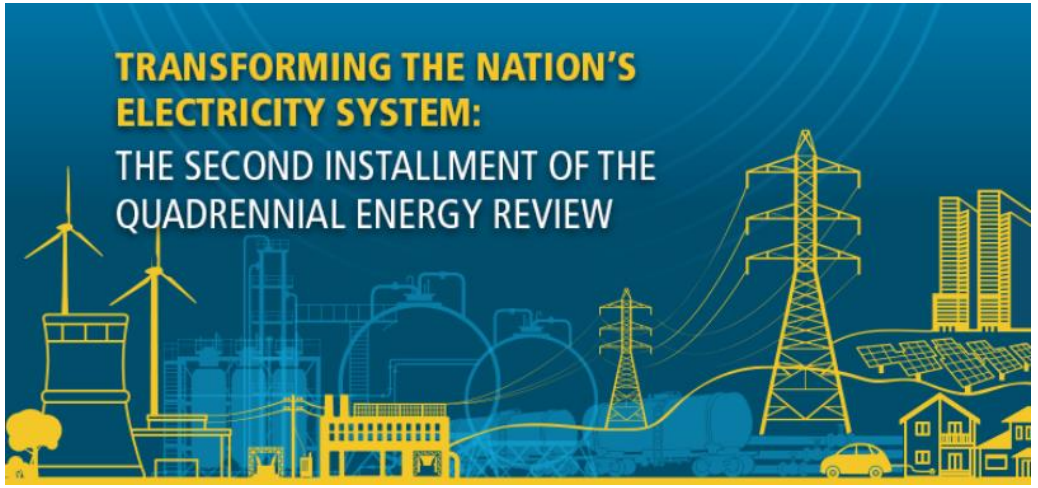


Integration of VERs

Figure 37: Marginal savings to the CAISO system per MWh shifted.

QER Discussion of an Integrated Demand-Side Resources Potential Study

***"Conduct an analysis of the potential for deployment of demand side (energy efficiency, DR, DG, storage) technologies**. While numerous studies have indicated significant cost-effective potential from energy efficiency investments, there is an incomplete patchwork of different energy efficiency potential studies and other distributed resources at the utility or state level that use a variety of different methodologies. These studies, which typically consider only energy efficiency, do not take into account the potential to integrate energy efficiency investments with other consumer options, such as DR, DG, and onsite storage—technologies to which consumers have growing access. DOE, with input from EPA, should conduct a national demand-side resources potential study with sufficient geographic resolution to more effectively value and integrate DERs into state and national electricity policy, while meeting environmental goals."*



Current EPSA Work in Integrated DER potential

DOE's Energy Policy and Systems Analysis has two analysis projects on this topic:

1) With Lawrence Berkley National Laboratory: Scope **a national, integrated DER potential study**

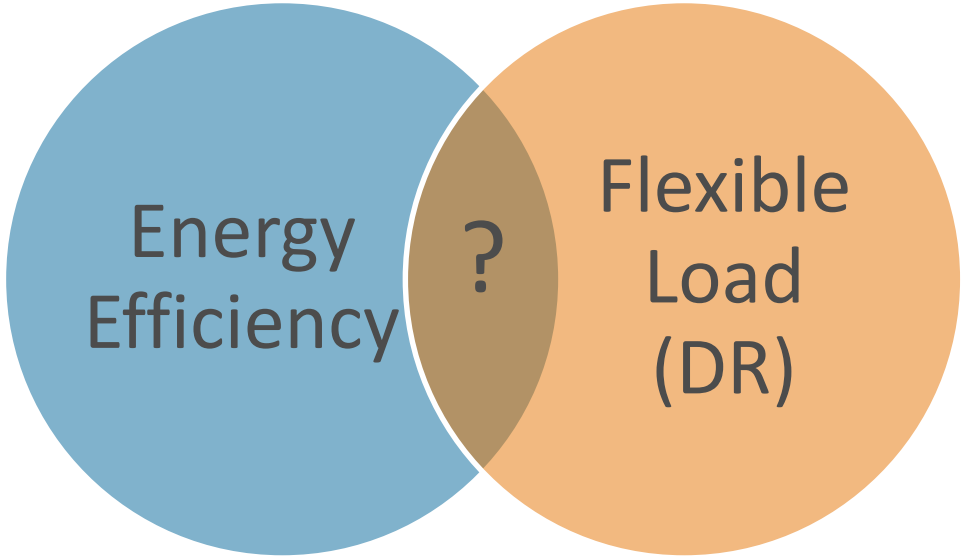
- Describe the concept, value, approach options, data requirements, and cost range of a national integrated demand-side potential study, and relevant analytical considerations
- Discuss tradeoffs between various approaches from both a state and national perspective with respect to granularity, cost, accuracy and data requirements
- Produce guide for states interested in pursuing their own iDER potential study, including tools for considering interactive effects between technologies/strategies (anticipated publication June 2018)

2) With Evolved Energy Research and the National Renewable Energy Laboratory: Perform foundational, illustrative analysis to produce **national and regional integrated supply curves for energy efficiency and demand response** (flexible load).

- Preliminary results complete; Presentation of final results by end of 2017

Evolved Energy Analysis: Study research questions

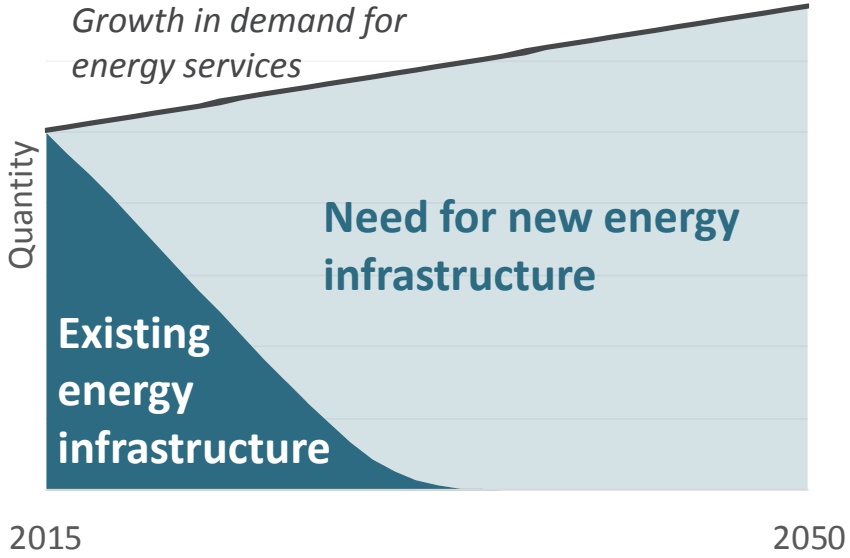
- How do **energy efficiency** measures **interact** with **flexible load** measures?
  - How does this interaction change by technology?
  - How does the interaction vary by region?
- To investigate this question, our team has investigated 25 different buildings technologies
- This investigation is one part of an expanded set of questions regarding the interactions between multiple DER types (storage, PV, EE, etc.)



Research tool: EnergyPATHWAYS model

- EnergyPATHWAYS is a bottom-up energy sector model with stock-level accounting of all consuming, producing, delivering, and converting energy infrastructure. Released under an MIT License.
- The U.S. model is populated with data from the National Energy Modeling System (NEMS), EIA, & NREL, among many other sources
- Highly granular electricity dispatch with bottom-up creation of load profiles and 8760-hourly dispatch with flexible loads

Energy Infrastructure Illustration



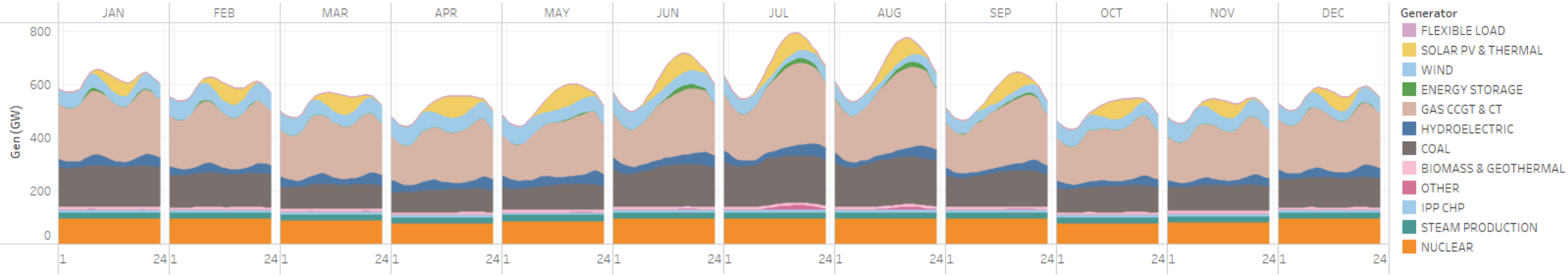
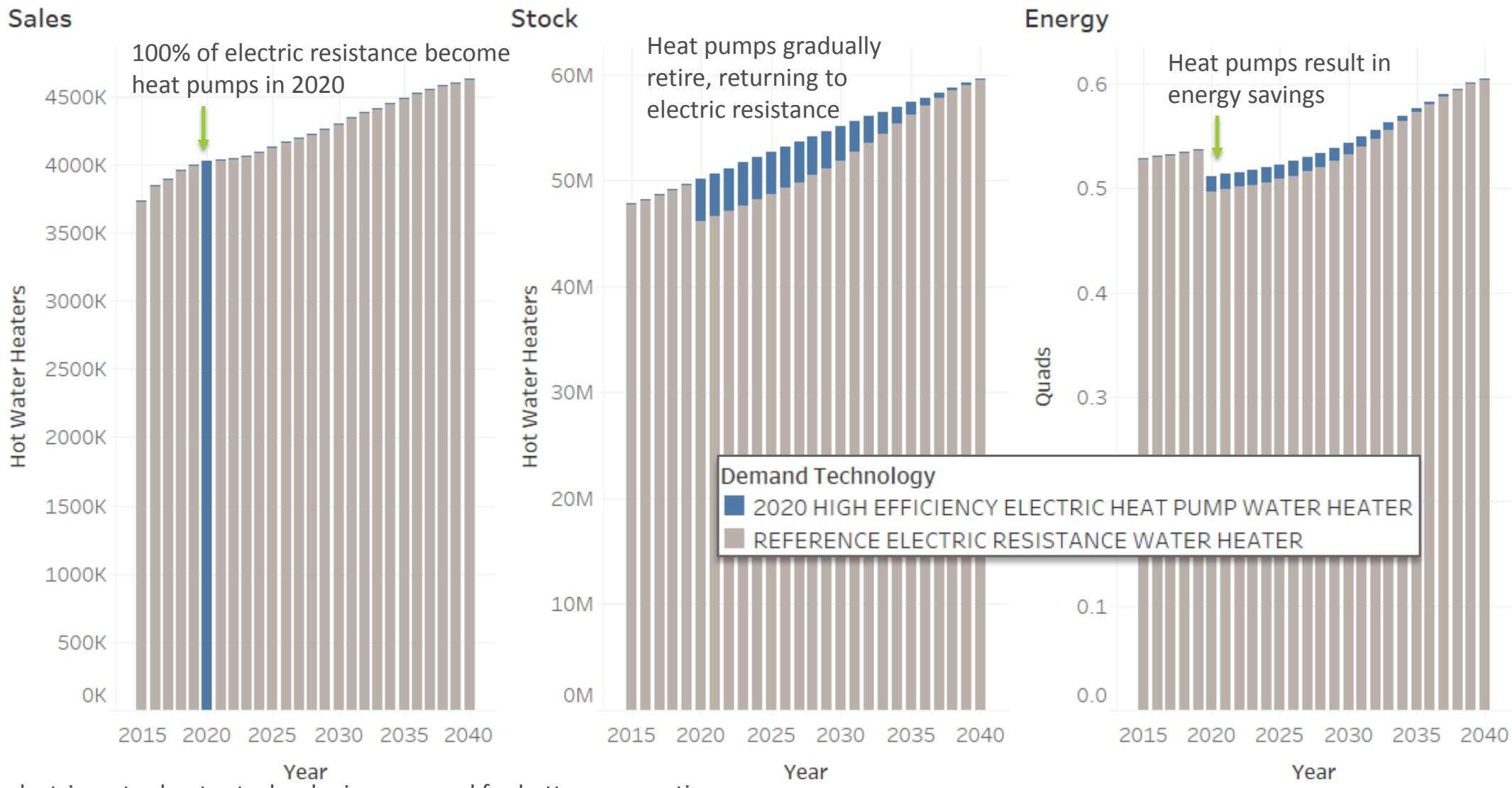


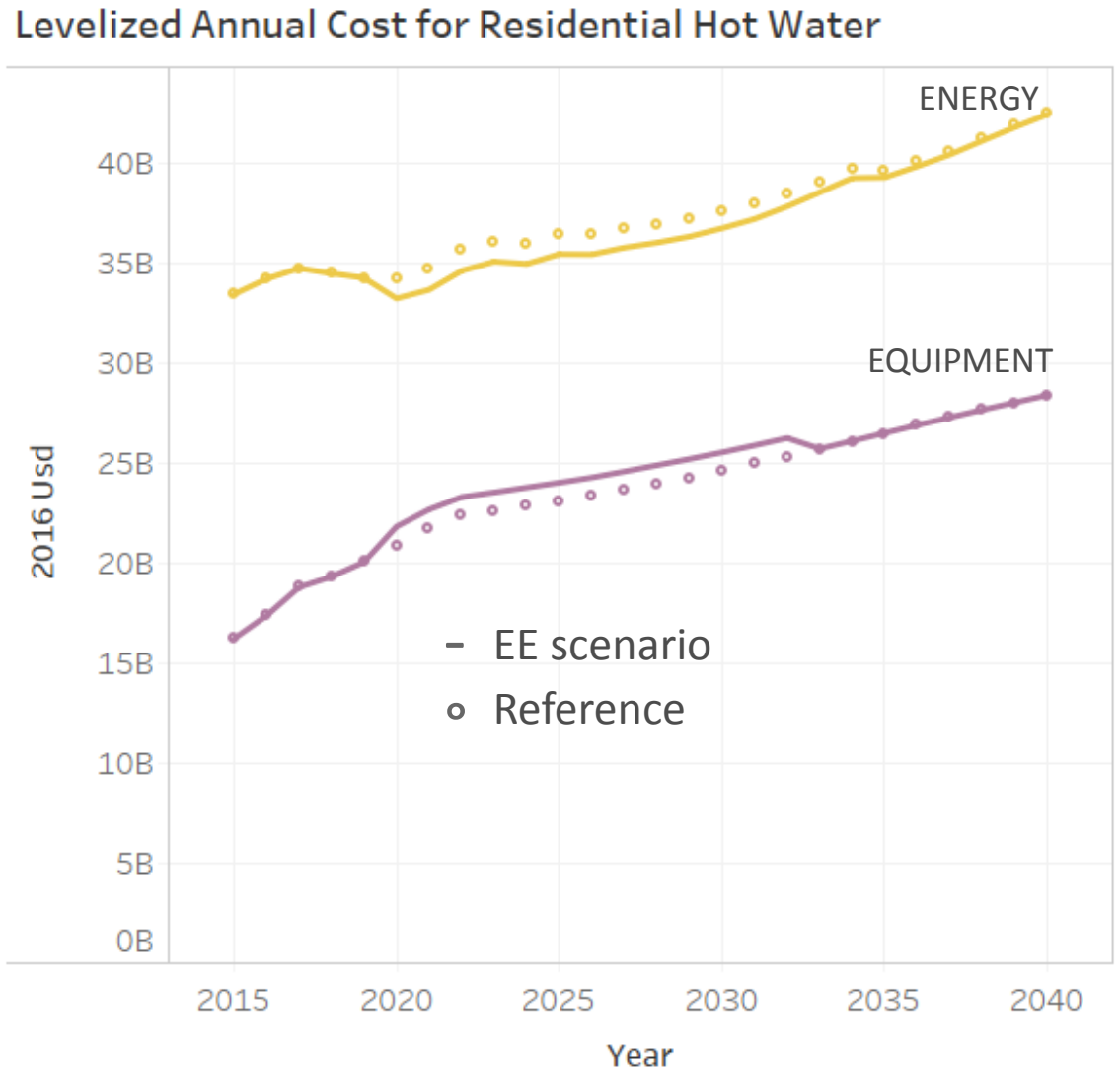
Illustration of a modeled energy efficiency measure



Note: non-electric water heater technologies removed for better perspective

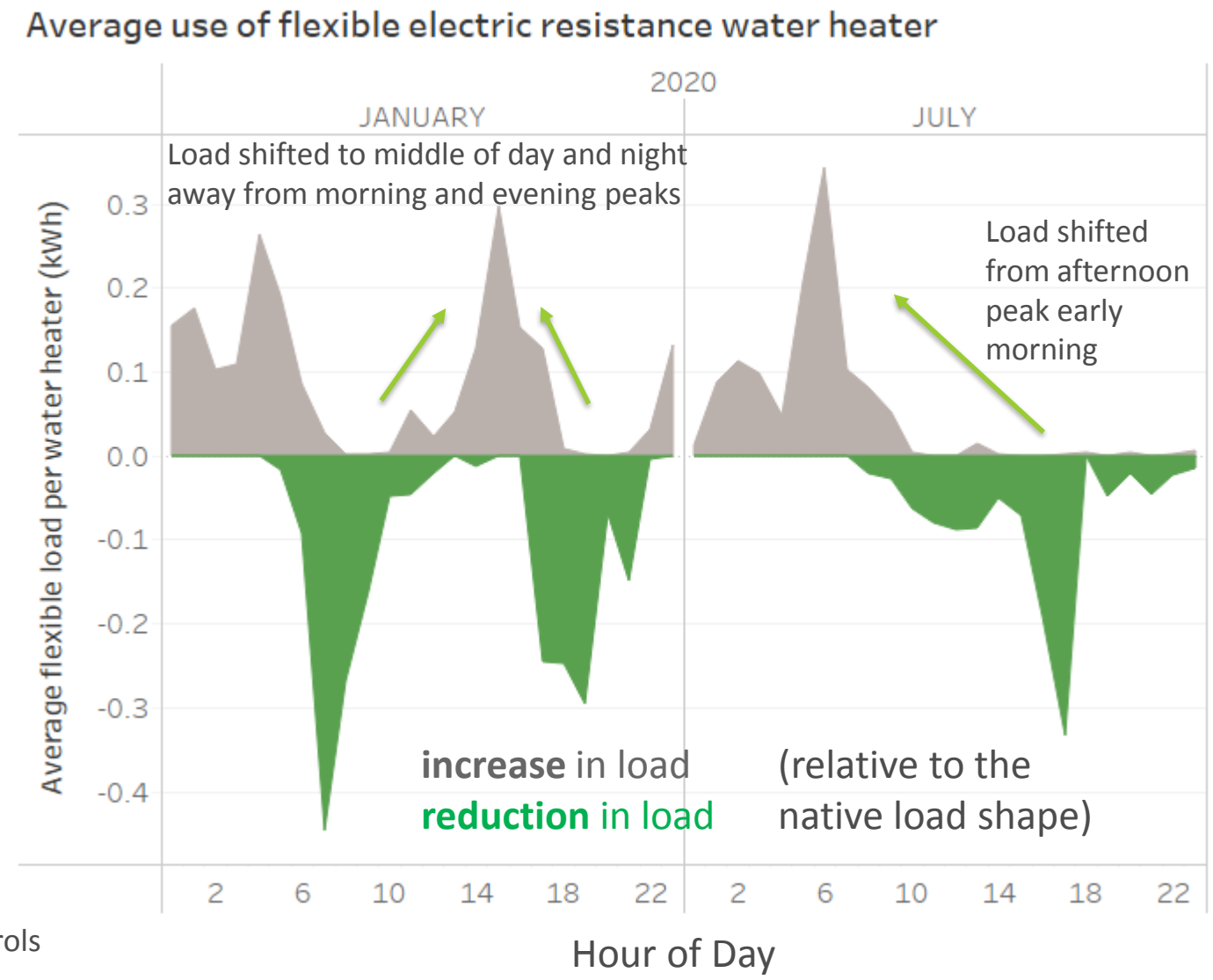
Illustration of a modeled energy efficiency measure continued

- The heat pump hot-water heaters resulted in higher equipment costs, amortized over the equipment book-life
- But.. energy costs are reduced relative to the reference scenario and remain lower for as long as our 2020 vintage stock is active
- The ultimate cost effectiveness of the measure is determined by the present value in 2020



Understanding cost savings from flexible load

- Advanced automated load shifting (flexible load)
  - Each technology has characteristics for the number of hours load can be delayed or advanced in time and what percent of load is allowed to be flexible [1]
  - Total energy consumption does not change
- Costs of flexible load are for enabling technology [2]
- Benefits come from reduced capital and operational expenses in electricity system



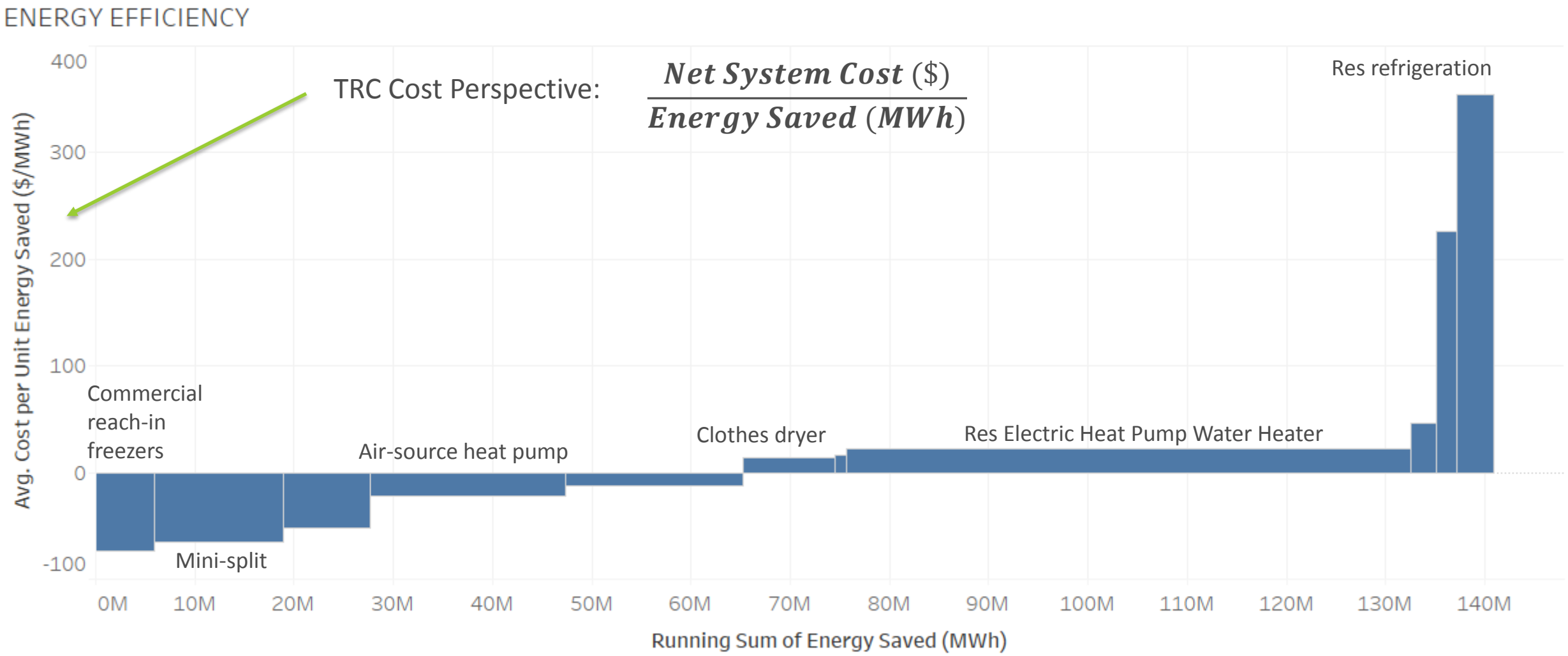
[1] https://drrc.lbl.gov/sites/default/files/lbnl-6417e.pdf
[2] https://emp.lbl.gov/publications/demand-response-advanced-controls

Results caveats

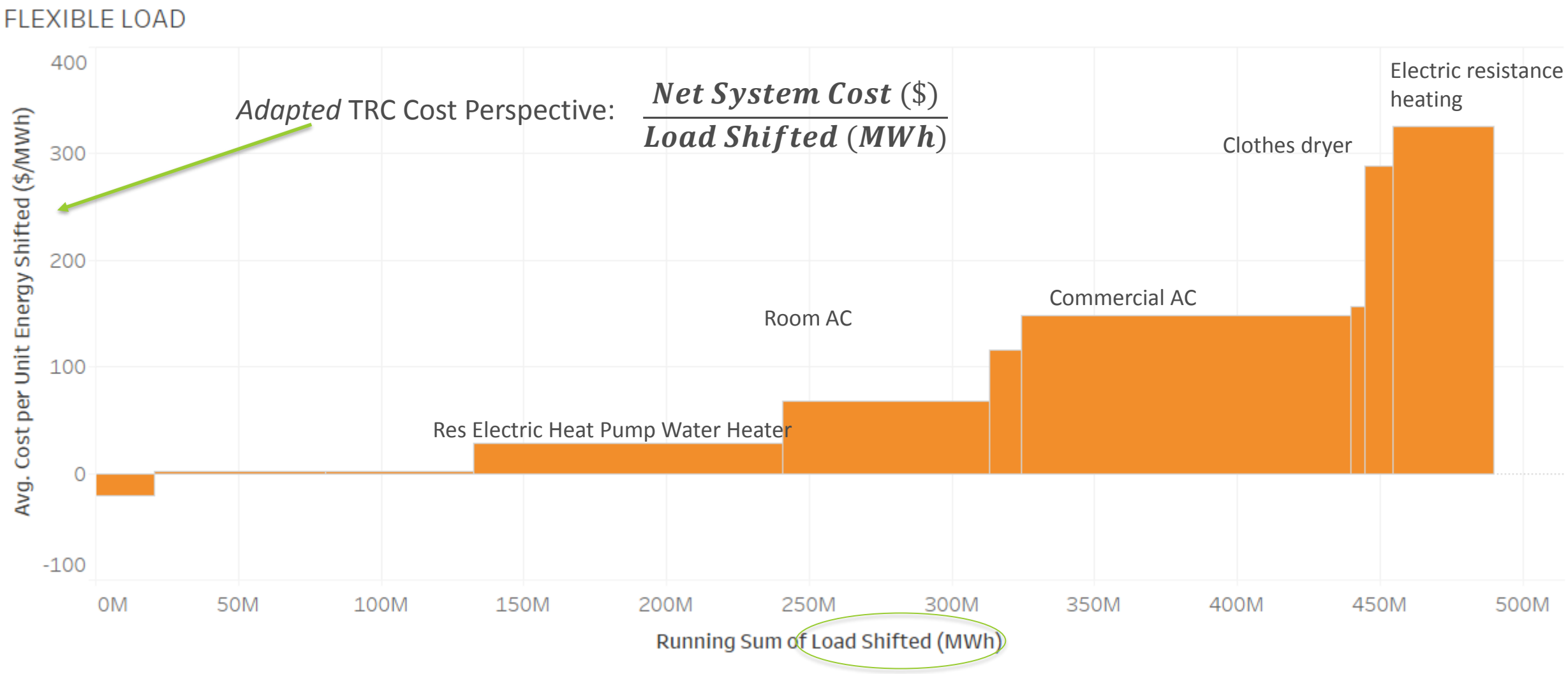
- Results represent a technical potential for natural equipment replacement in 2020
  - 100% of retiring target technologies were replaced with the new technology
  - Once the new technology retired, it was switched back to the original technology
- Technologies with flexible load enabled have 100% participation
  - Flexible load is dispatched centrally with perfect foresight
- Each measure is evaluated independently from all others
  - This will overstate the sum of the value across all measures because it ignores diminishing returns
  - Work in the near future will assess measures in sequence
- Costs are assessed from a TRC perspective (total resource cost test)
  - Allocational issues not investigated nor are the rates needed to induce the desired flexible load behavior from customers
- Future costs & technology performance are based on best available info, but large uncertainty exists [1]
  - Supply curves by their nature are highly dependent on the system context
- Coarse model geography washes sub-regional differences (resolution is the nine U.S. census divisions)
  - Value of EE and DR will vary significantly within these regions

[1] Technology costs and performance are taken from the National Energy Modeling System (NEMS)

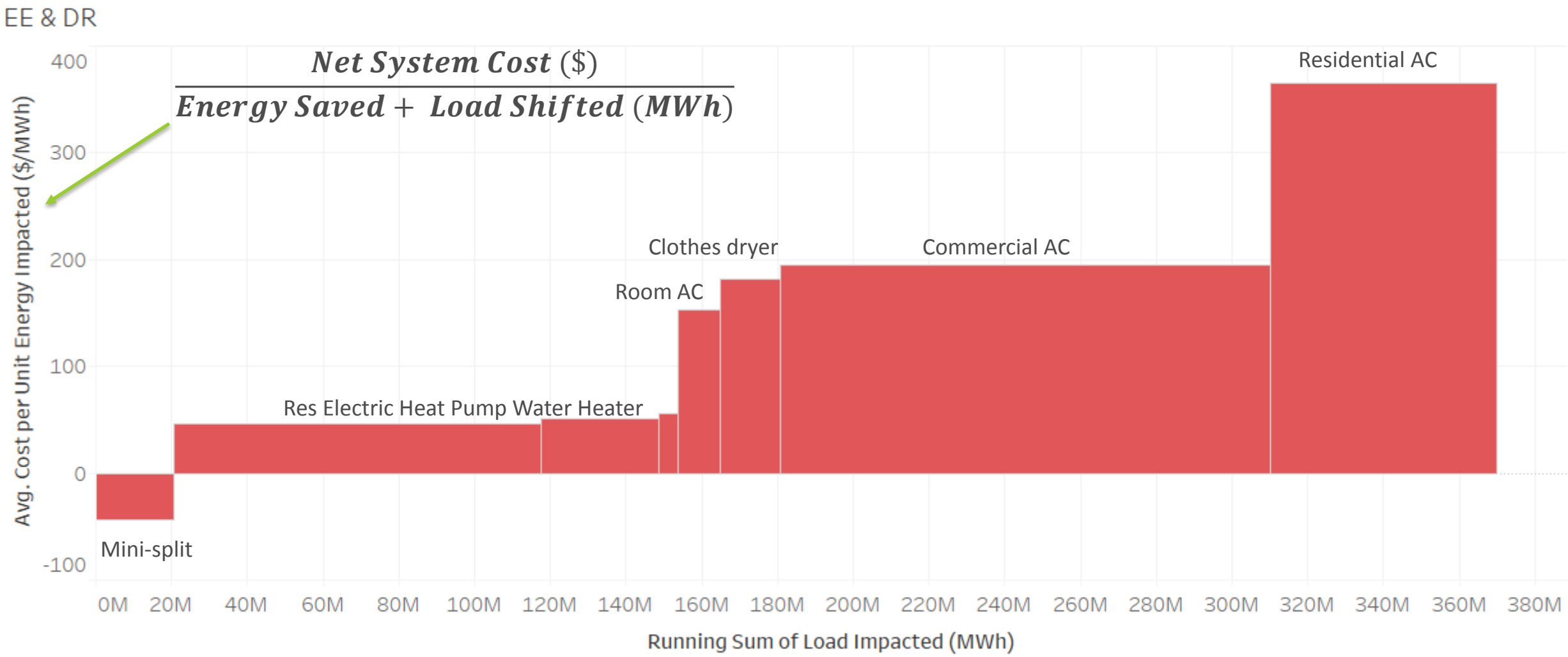
Energy efficiency supply curve



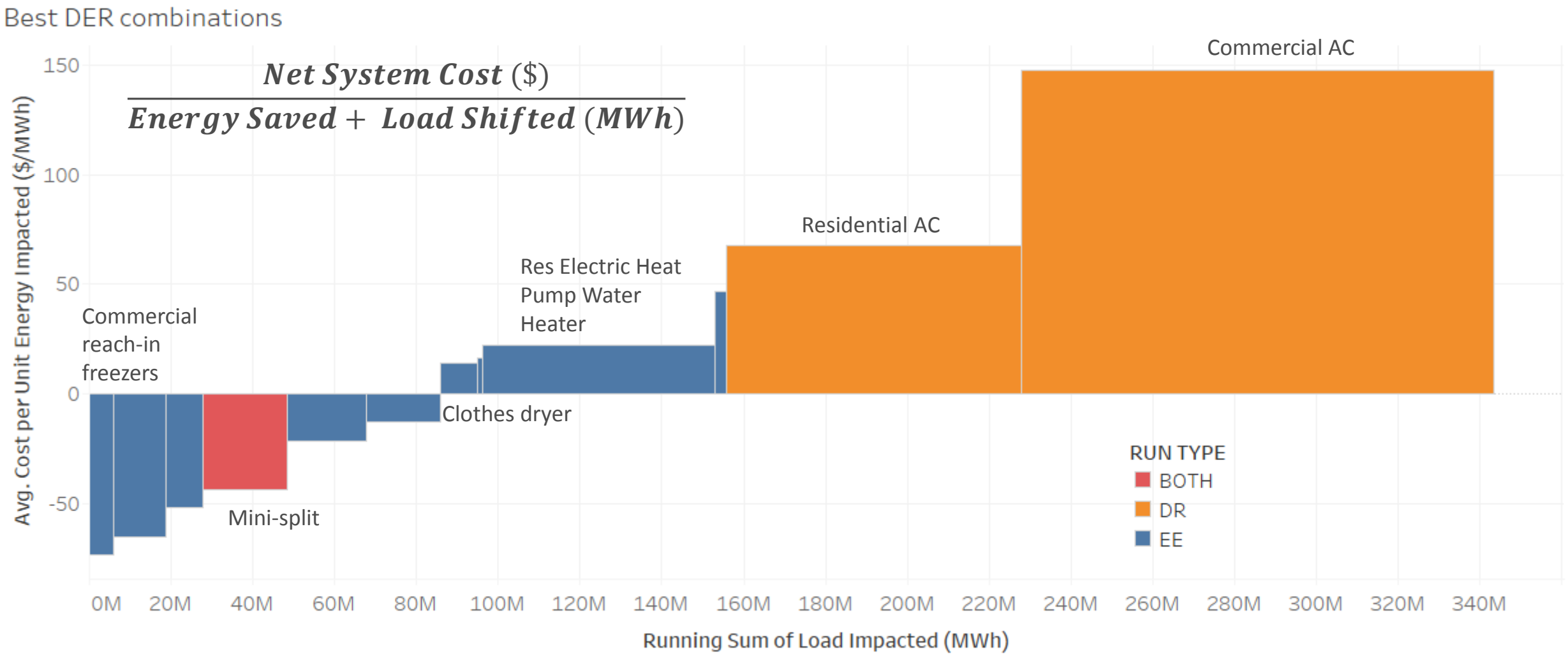
Flexible load supply curve



Energy efficiency plus flexible load supply curve

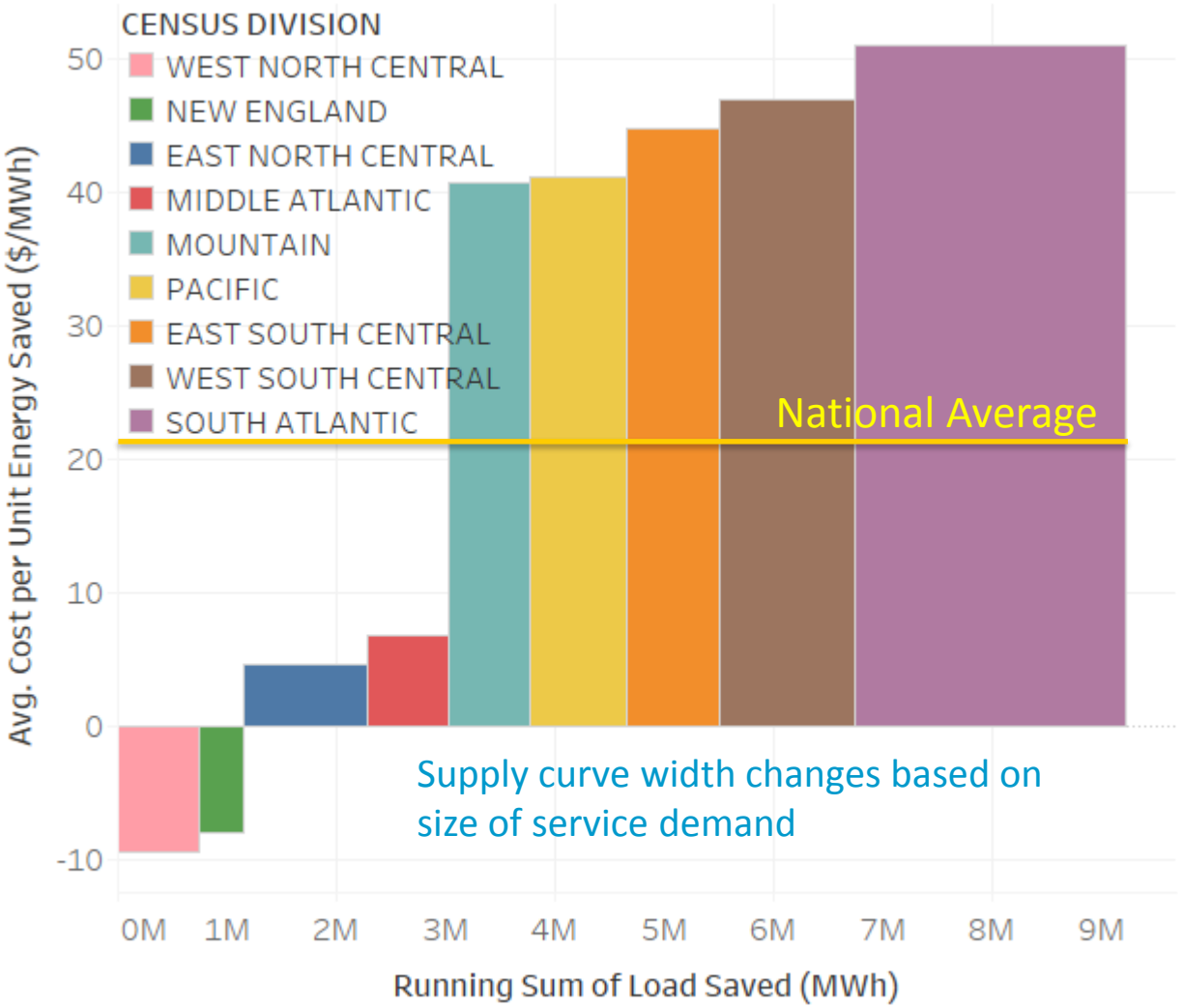


Combined supply curve – "highest value" option for each end-use



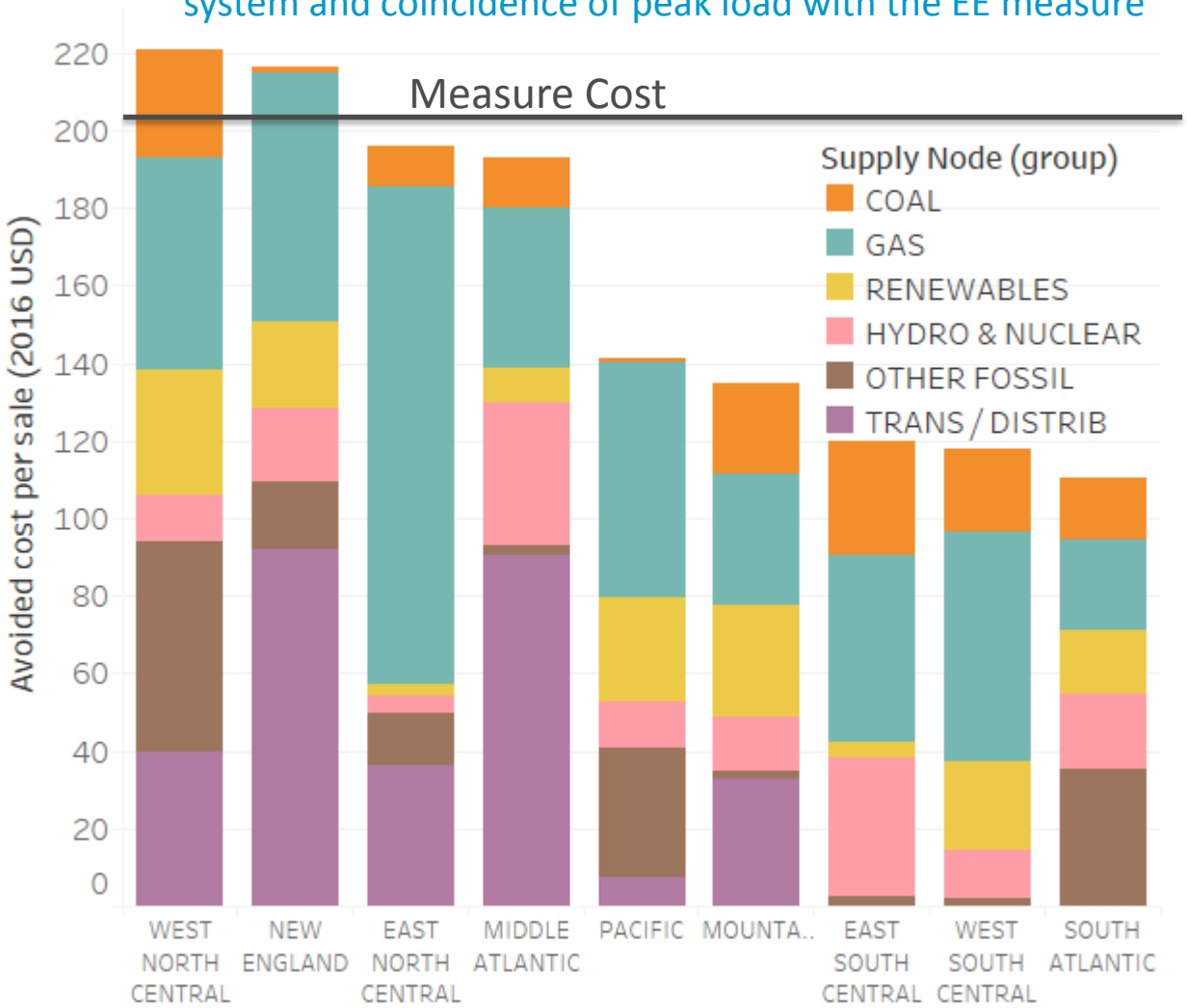
DER combinations chosen with the highest total value (area of each box)

Understanding regional differences (high efficiency dryer example – EE only)



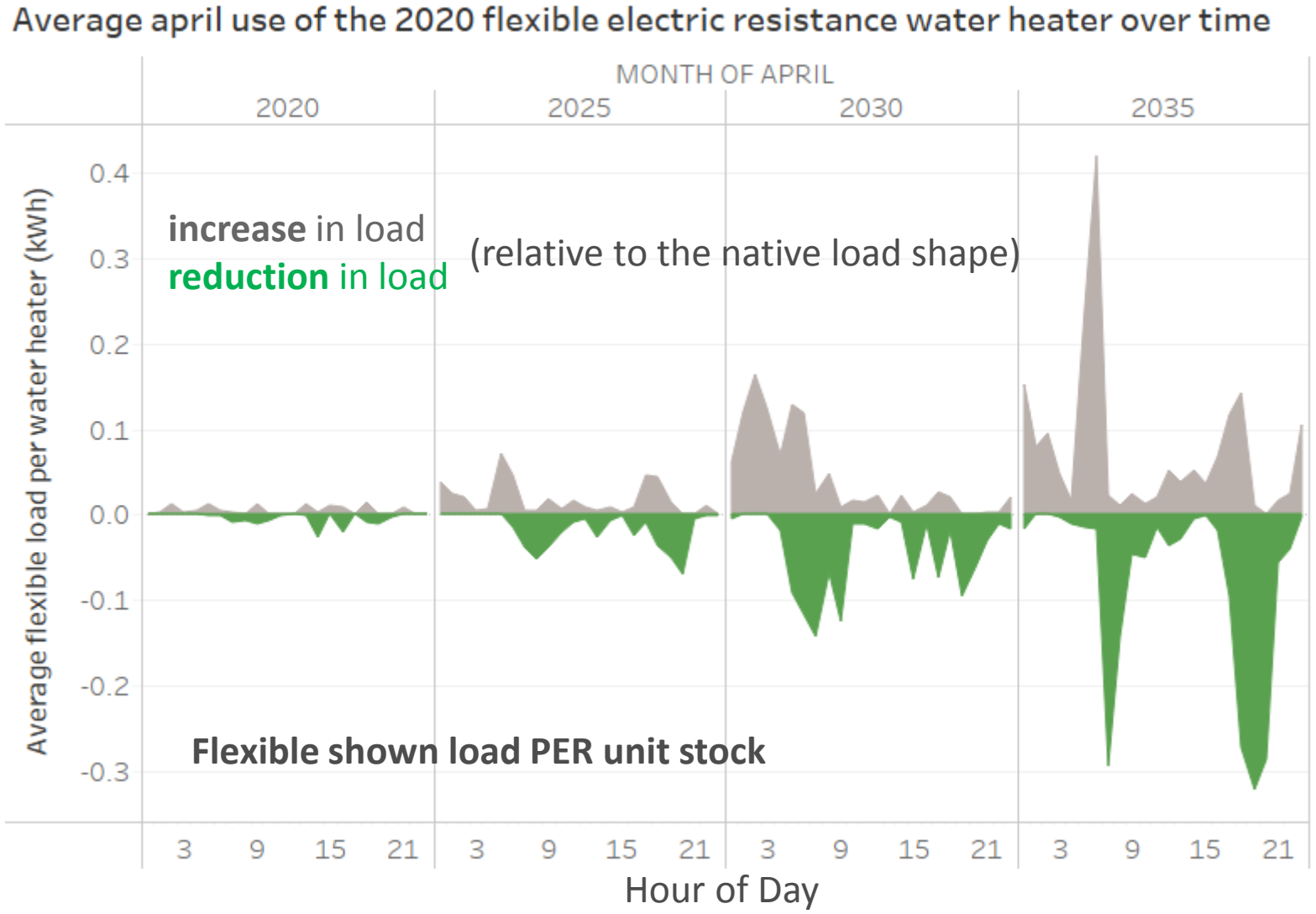
Supply curve width changes based on size of service demand

Supply curve height changes based on particulars of local electricity system and coincidence of peak load with the EE measure

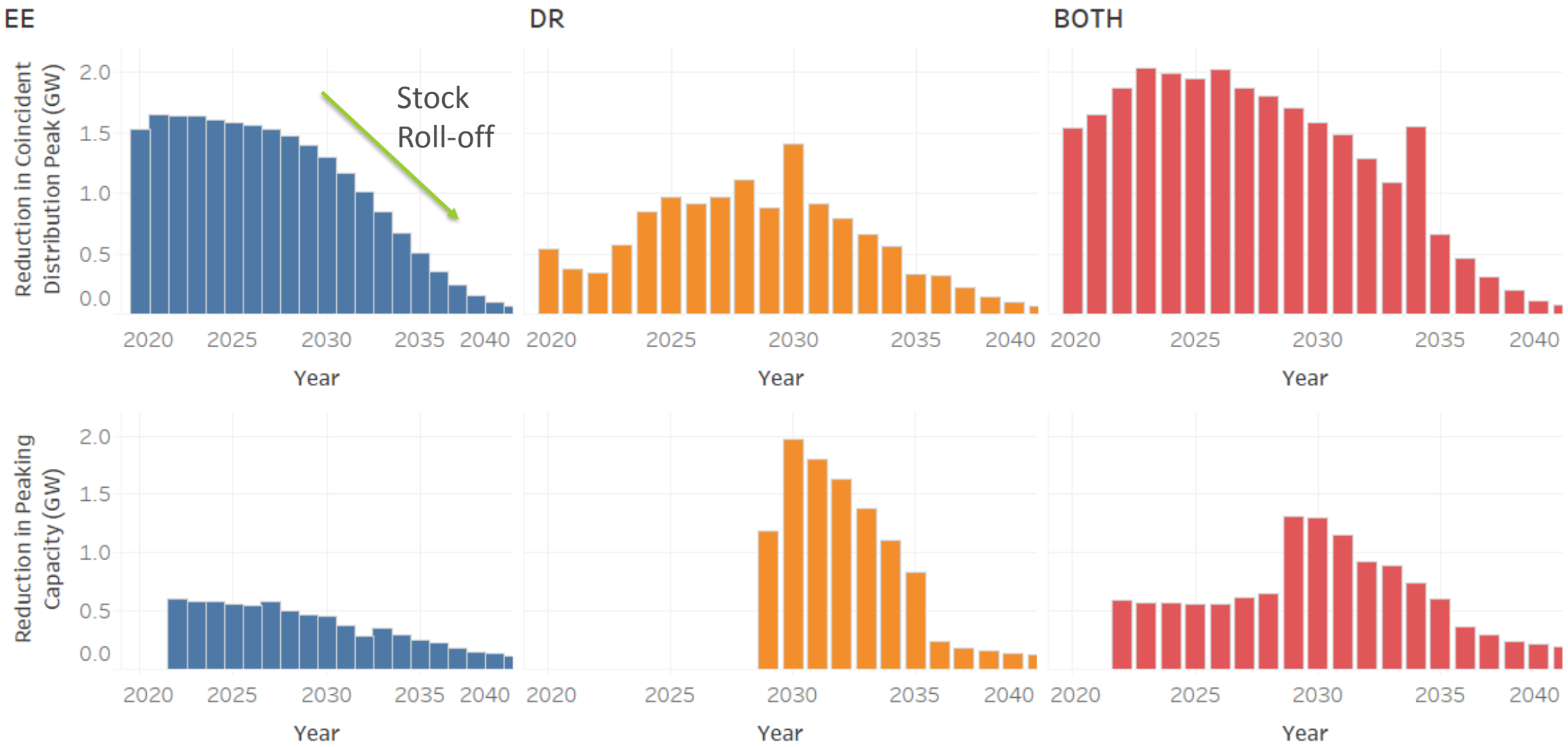


Patterns for flexible load use over time

- The model's deployment of flexible load increases over time
  - Increases are particularly pronounced in shoulder months
  - Trends primarily explained by increasing amounts of variable generation resulting in more market price volatility (especially during periods with low loads)



Investigating key impacts of electric water heaters on supply-side stock

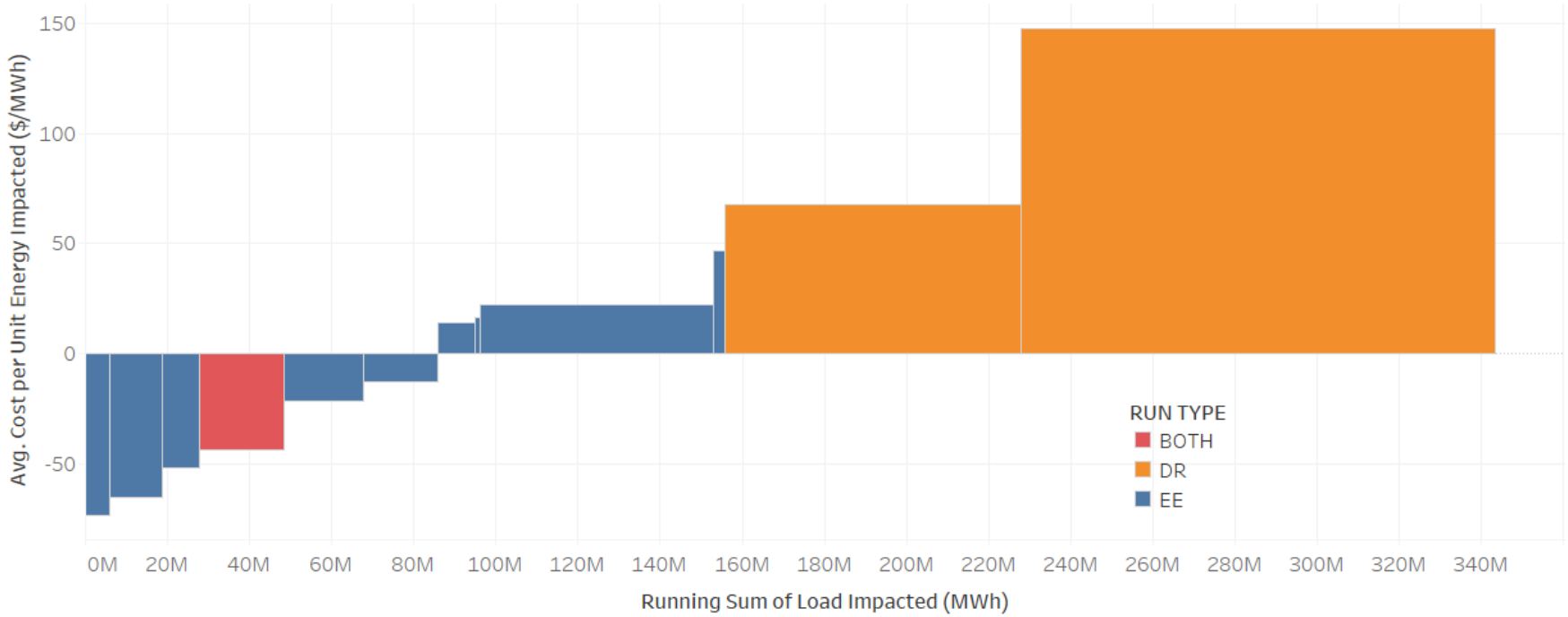


DOE is working to produce resources for energy planning and policy entities

EnergyPATHWAYS analysis:
Anticipate complete results by end of 2017

We would like your feedback –
how can we best highlight results relevant for:

States/cities/counties?
Utilities?
Commissions?
Consumer Advocates?
Efficiency program administrators?
Grid Operators?



DOE is working to produce resources that will be helpful to energy planning and policy entities

For national scoping and guide for states on integrated DER potential:

Examples of studies where ***two or more*** demand-side resources are being considered in an integrated (rather than additive) manner:

- Energy Efficiency
- Demand Response
- Distributed Generation (including PV, CHP, etc.)
- Distributed Storage

LBNL will request review from a technical advisory group before publication.

Navigant	**PSE Conservation Potential Review**	**June 2017**
Alstone et al.	Final Report on Phase 2 Results: 2025 California Demand Response Potential Study, Charting California's Demand Response Future	March 2017
AEG	PacifiCorp Demand-Side Resource Potential Assessment for 2017-2036	February 2017
Black & Veatch, SEPA	Beyond the Meter: Planning the Distributed Energy Future. Volume II: A Case Study of Integrated DER Planning by SMUD	May 2017
Navigant for PacifiCorp	Private Generation Long-Term Resource Assessment	July 2016
Evergreen Economics for CPUC	Integrated Demand Side Management Case Study Report	May 2016
Navigant for HEI	Demand Response Potential Assessment for the Hawaiian Electric Companies	December 2016
AEG	MISO DR, EE, DG Potential Study: Preliminary Potential Estimates - Eastern Interconnection Only	September 2015
GDS Associates, Nexant, Research Into Action, APEX	Pennsylvania Distributed Generation Potential Study Report	February 2015
DNV GL for NYISO	A Review of Distributed Energy Resources	September 2014
Navigant for PacifiCorp	Distributed Generation Resource Assessment for Long-Term Planning Study	June 2014
NYSERDA	EE and RE Potential Study of New York State	April 2014
Goldman et al.	Coordination of EE and DR	January 2010
ACEEE	Potential for Energy Efficiency, Demand Response and Onsite Solar in Pennsylvania	April 2009

Thank you!

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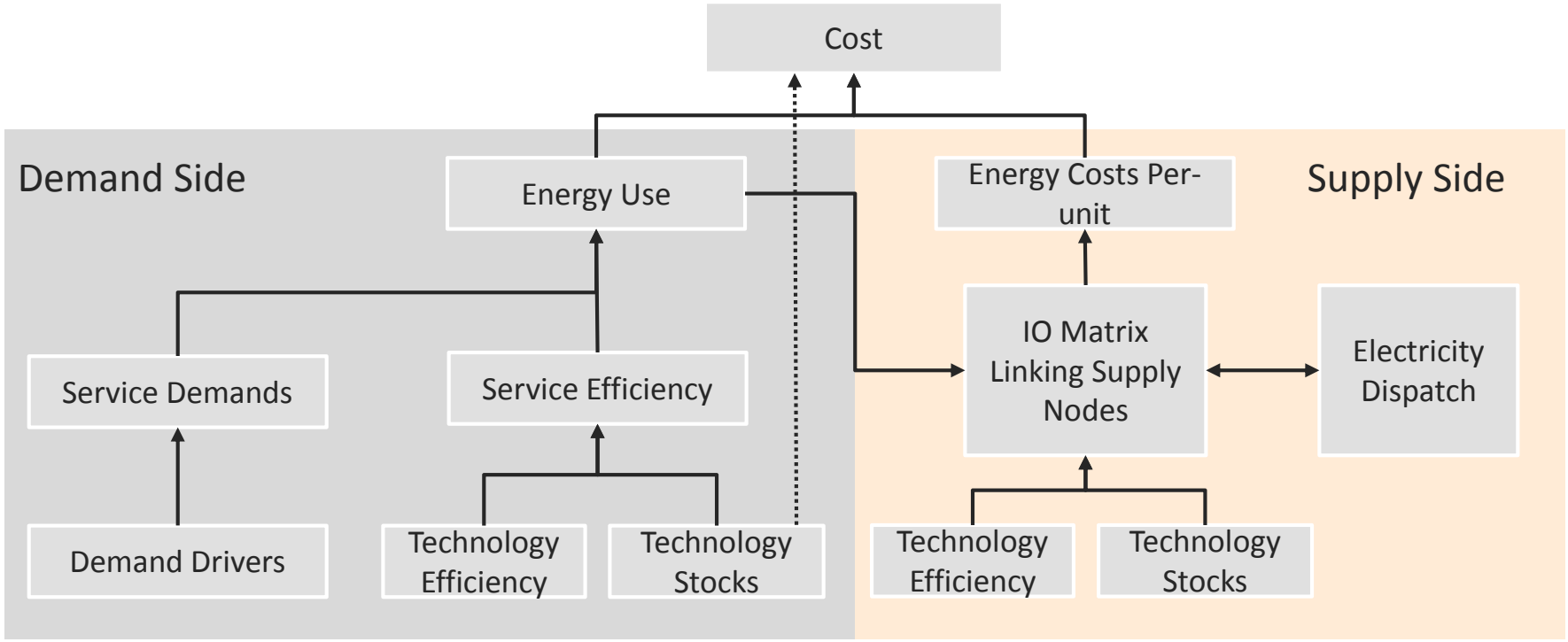
Appendix

Twenty-five demand side technologies investigated

Sector	Subsector	Deployed Technologies	Notes:
Commercial	Air conditioning	Centrifugal Chiller, Reciprocating Chiller, Central Air Conditioner, Rooftop Air Conditioner, Wall/Room Air Conditioner	
	Space heating	Air Source Heat Pump	All heat-pump also provided cooling
	Ventilation	Constant & Variable Ventilation System	
	Refrigeration	Reach-in Refrigerators, Walk-in Refrigerators, Reach-in Freezers, Walk-in Freezers	
	Water heating	Heat Pump Storage Water Heater	
Residential	Air conditioning	Room Air Conditioner, Central Air Conditioner	Deployment depended on whether homes were ducted
	Space heating	Air Source Heat Pump, Ductless Mini-Split	
	Water heating	Heat Pump Water Heater	
	Refrigeration	Bottom, Side, & Top Mount Refrigerators	
	Clothes drying	High Efficiency Electric Clothes Dryer	
	Clothes washing	Clothes Washer - Front Loading	

EnergyPATHWAYS model flow chart



EnergyPATHWAYS Data Sources

- Much of the demand-side input data is taken from the EIA's National Energy Modeling System (NEM)
  - Technology cost and performance (AEO 2015 with updates to transportation)
  - Equipment stocks (AEO 2015)
  - Historical energy demand (AEO 2015)
- Projections of future energy system demand taken from AEO 2017
  - Population and households
  - Industrial activity and other energy service demands like VMT
- Supply-side data is taken from a number of public sources including:
  - Electricity generation technology cost and performance from NREL's 2016 Annual Technology Baseline
  - Fossil fuel price projections from AEO 2017