

\$3.6 Billion in the Basement

Market potential of grid-interactive water heaters, how to tap it, and implications for the grid

ACEEE Hot Water Forum, February 22, 2016

Mark Dyson, Manager – Rocky Mountain Institute

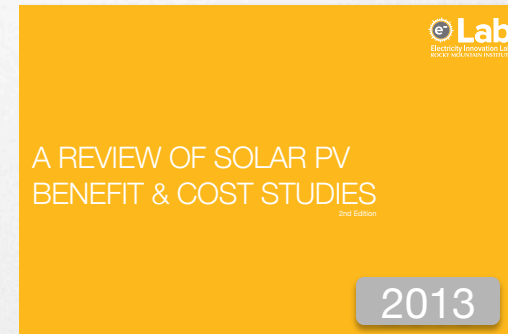
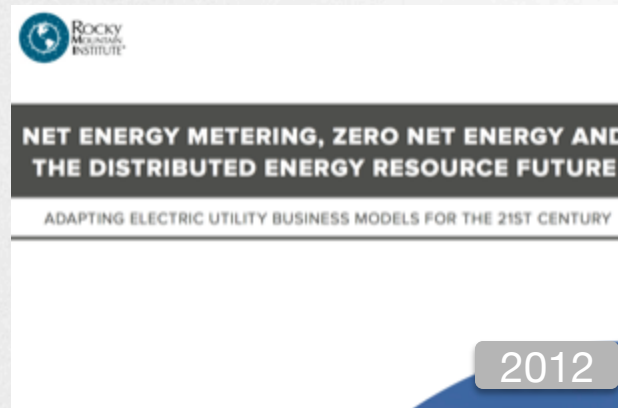
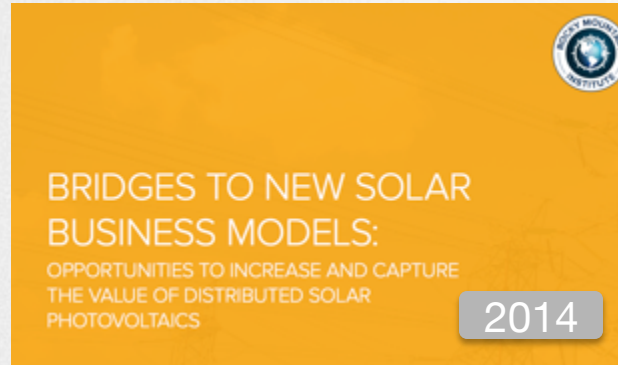
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FURTHER, FASTER, TOGETHER

About RMI and our recent electricity work

Rocky Mountain Institute, a Colorado nonprofit corporation, works across industries on challenging energy issues to drive the efficient and restorative use of resources using market-based approaches.



http://www.rmi.org/electricity_impact
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Transforming global energy use to create a clean, prosperous, and secure low-carbon future.

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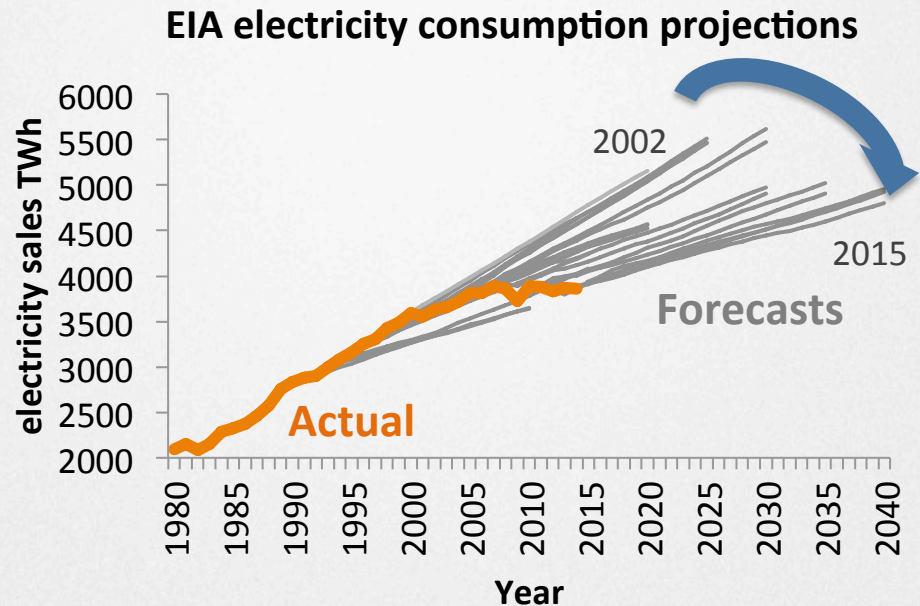
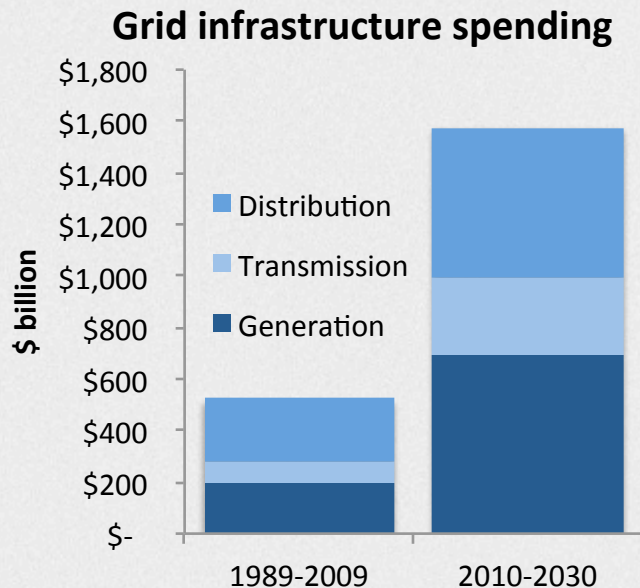
Context: The “G” in GIWH



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Grid spending is rising, but demand is flat

Utilities plan to invest \$1.4 trillion in infrastructure upgrades through 2030, but sales have declined 5 out of the last 7 years, and growth forecasts have been systematically lowered.



Source: EEI/Brattle Group; EIA EPM and AEO

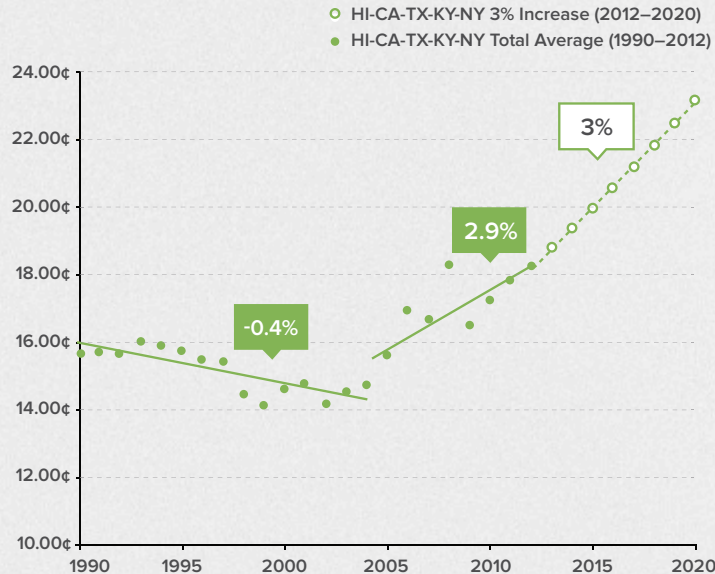


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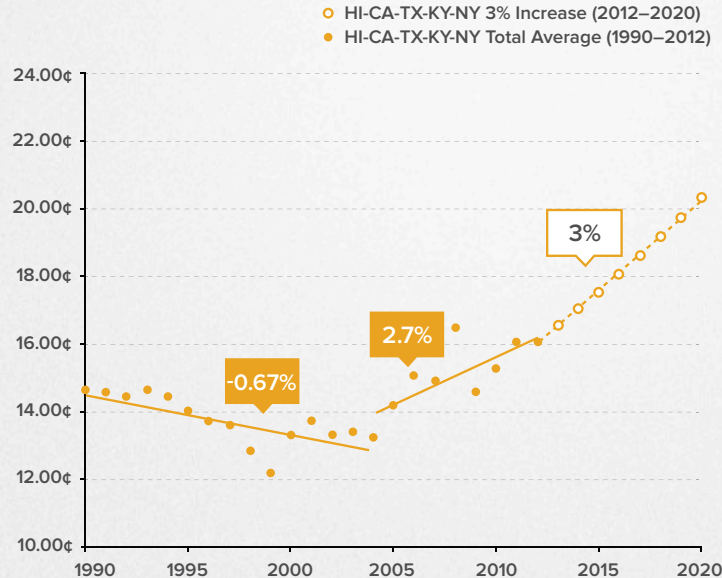
Retail rates are rising

Across many states, retail electricity rates are rising for commercial and residential customers alike, and forecast to continue to do so.

5 STATE AVERAGE U.S. RESIDENTIAL RETAIL RATES
[Y-Axis ¢/kWh]



5 STATE AVERAGE U.S. COMMERCIAL RETAIL RATES
[Y-Axis ¢/kWh]



Source: RMI Economics of Grid Defection; EIA



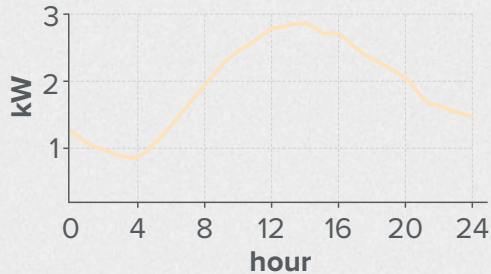
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Consumers have expanding options

To meet demand for electricity, utility customers used to buy it. Now, it is increasingly easy for third parties or utilities to help them make it, avoid it, or shift it.

Grid Purchases

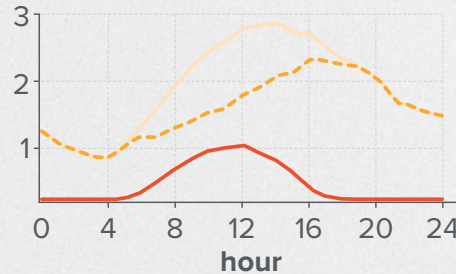
Buy kWh from the grid as and when needed.



Normal Load

Distributed Generation

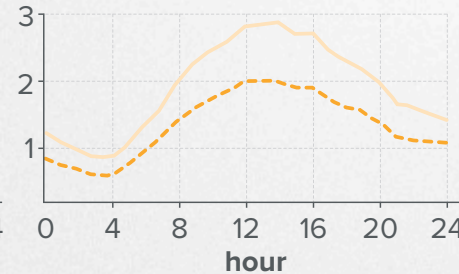
Generate electricity, changing the profile of net grid demand while reducing total grid demand.



Normal Load PV Net Load

Energy Efficiency

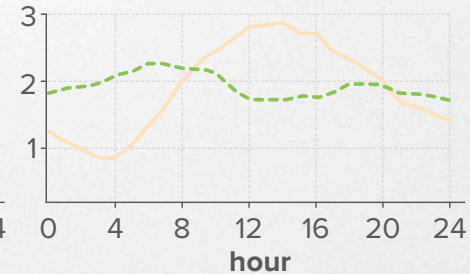
Reduce demand whenever load is operated, thus lowering the daily load curve.



Normal Load Efficient Load

Demand Flexibility

Shift eligible loads across the hours of a day to lower-cost times, reshaping the daily load curve.



Normal Load Flexible Load

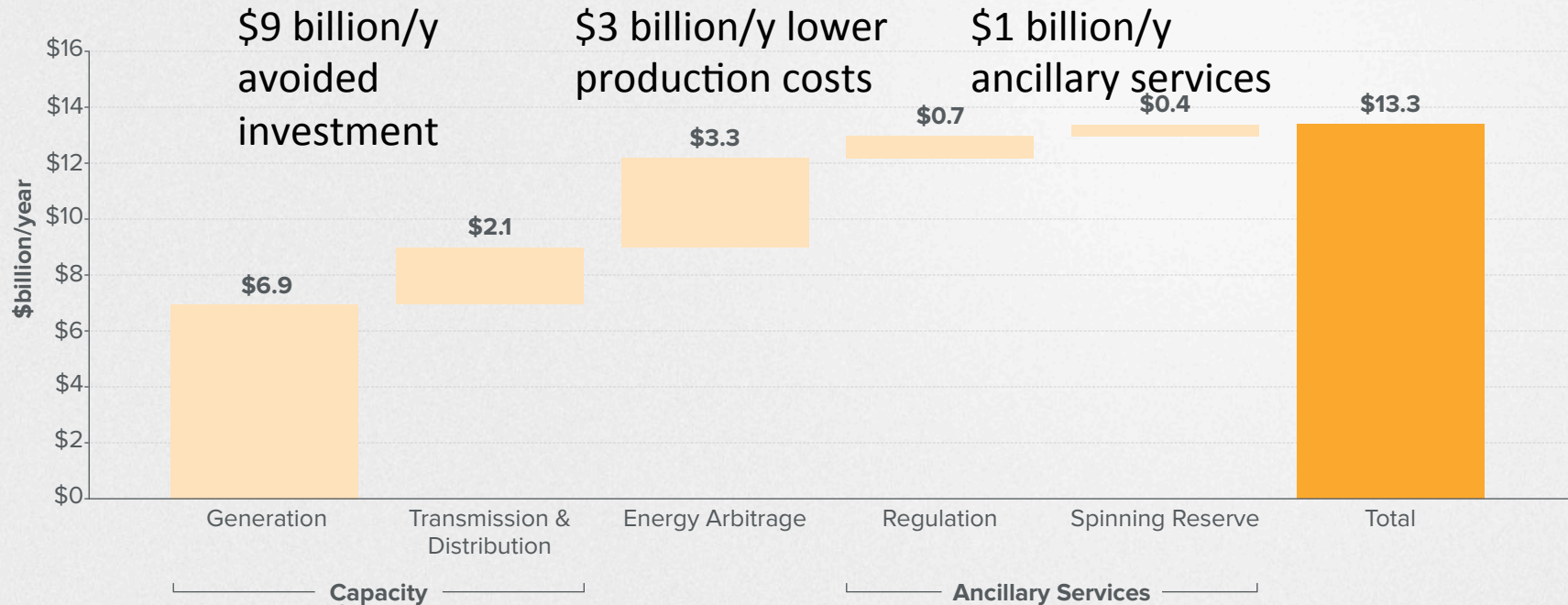
Source: RMI The Economics of Demand Flexibility



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Demand flexibility can unlock \$13 B/year

Enabled by sophisticated rate design, utility programs, or third-party aggregators, the demand side can be a powerful source of flexibility for the grid



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Why water heaters?

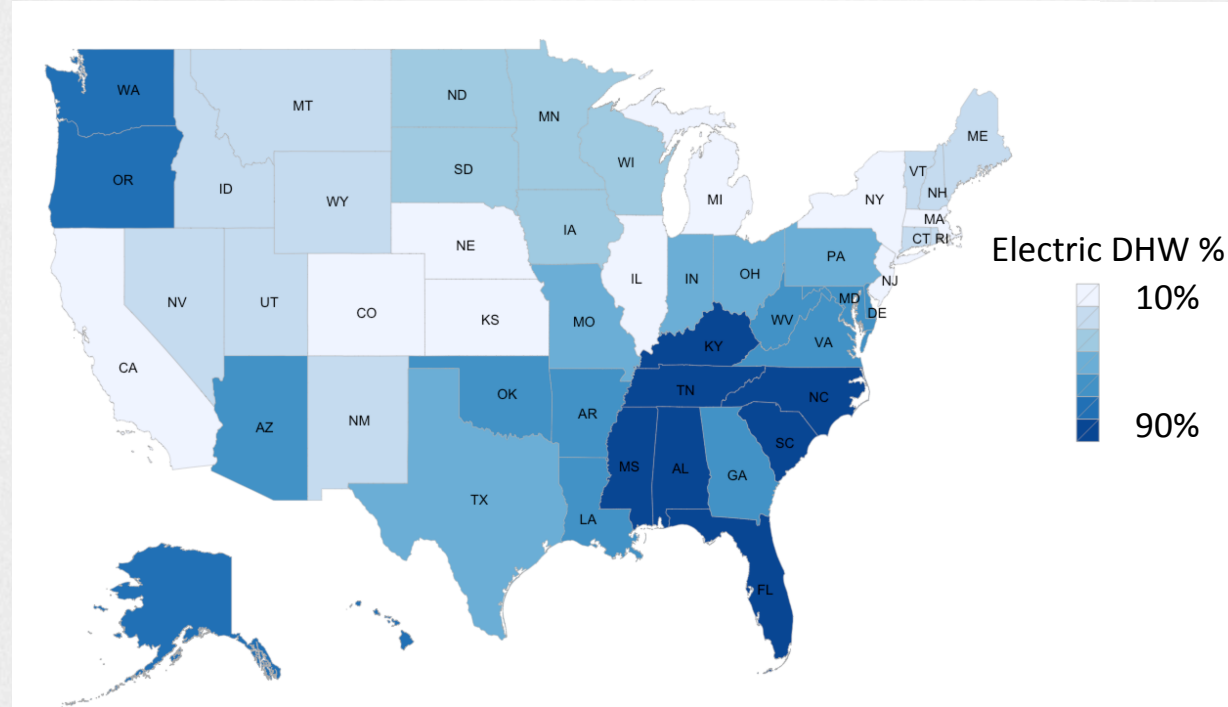


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Water heaters are ubiquitous

There are ~50 million electric water heaters across the US, with several distinct geographic concentrations

- ❖ The Northwest and the Southeast represent concentrated markets for GIWH technology
- ❖ In other regions, electric water heating is concentrated in rural areas



Source: EIA RECS

Water heaters are highly flexible

Electric water heaters have a low load factor, a tank heat capacity of 7 kWh, and thermal stratification and insulation that allow for many forms of grid value

- ❖ Depending on the draw profile and grid use case, between 40-60% of kWh used for water heating can be shifted
- ❖ Letting average tank temperature drift while keeping tank-top temperature within bounds keeps showers hot while flexing energy use



- ❖ **Energy arbitrage:** Shifting kWh use to lower-cost hours of the day
- ❖ **Ancillary services:** Modulating or cycling power use for a water heater fleet to balance grid supply with demand
- ❖ **Peak demand reduction:** Briefly curtailing electricity use during the highest-demand periods for a home, feeder, or utility

Source: Brattle 2016; RMI The Economics of Demand Flexibility

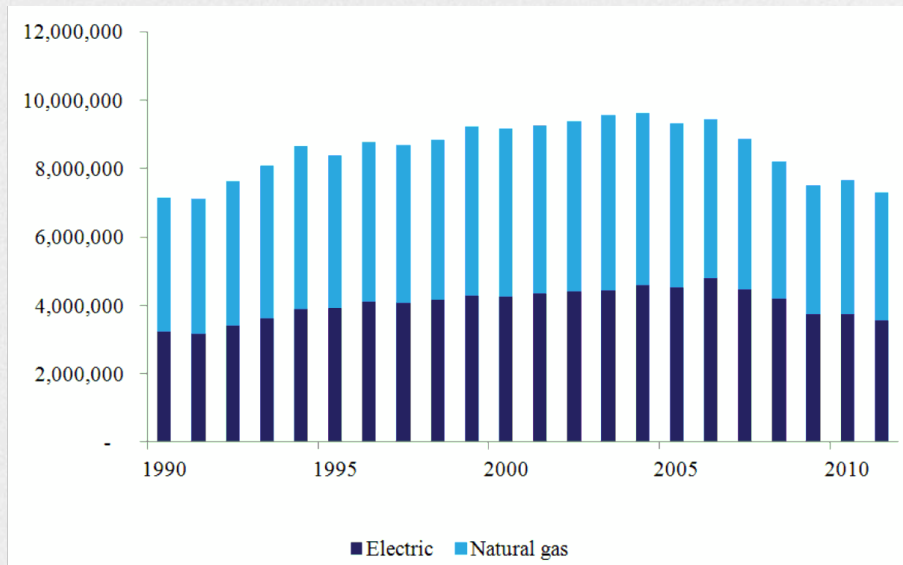


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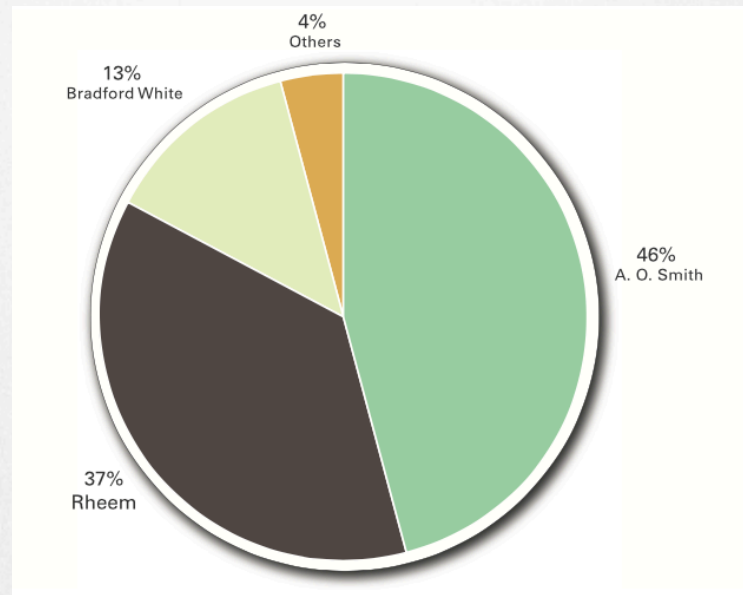
Water heater innovation is scalable

Residential water heaters are manufactured at scale, with a few big companies dominating market share, and adding controls is potentially very inexpensive

US annual water heater sales



US water heater market share (2008)



Source: NEEA 2012; US DOE ENERGY STAR



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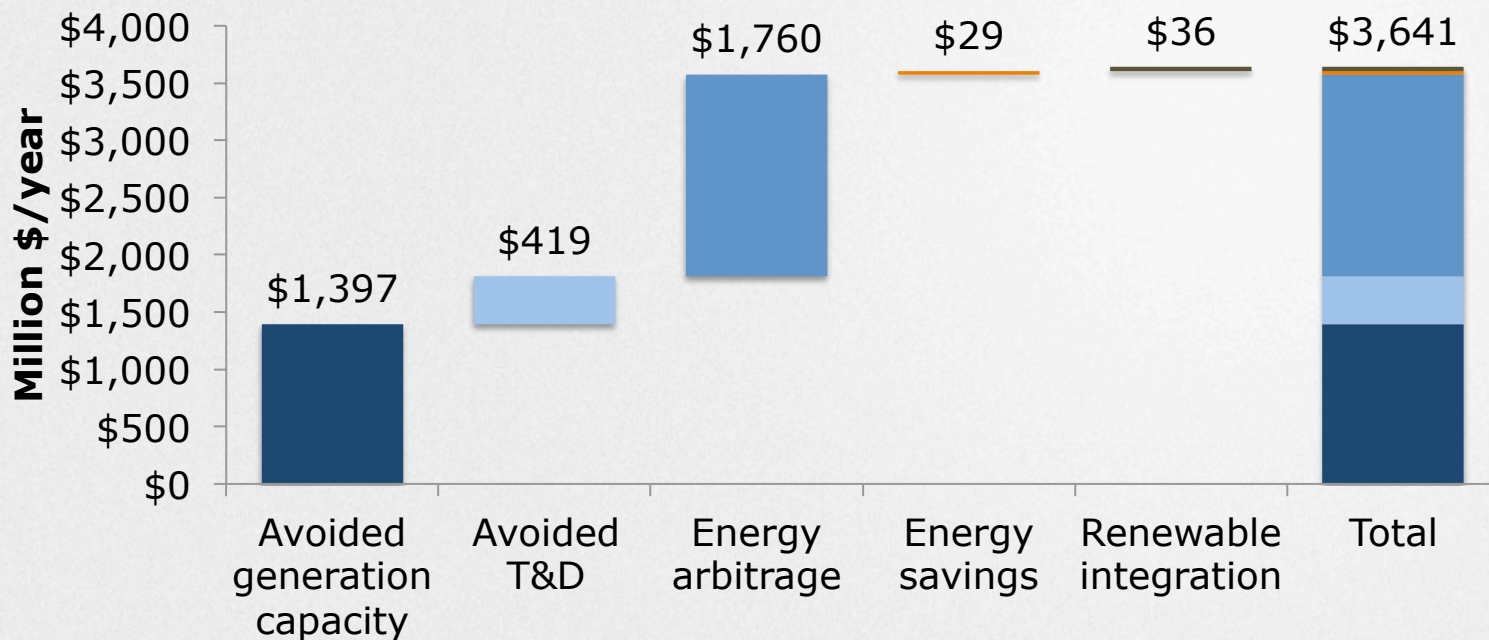
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The system value of GIWH



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We estimate a \$3.6 billion/year value of a 100% grid-interactive electric water heater fleet



Source: RMI analysis

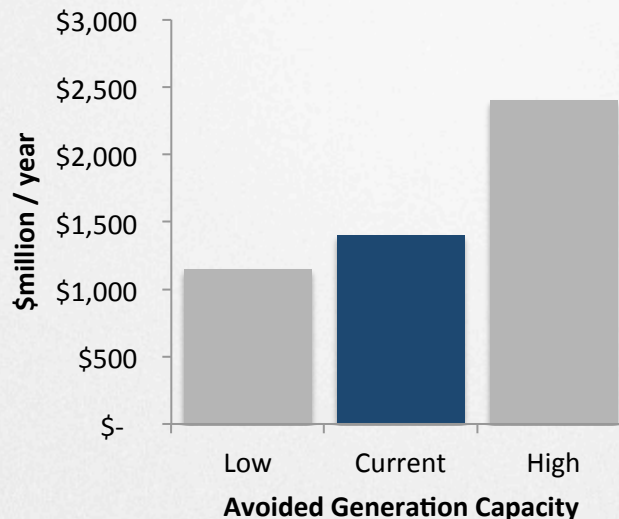


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Avoided generation capacity: \$1.4B/year

This value is highly sensitive to the assumed peak-coincidence of baseline electric water heating load profile

- ❖ We estimate that water heater load has a peak coincidence of approximately 5-12%, depending on region.
- ❖ With 7% peak coincidence (i.e. 300 watts on-peak per unit), electric water heaters would make up 1.6% of peak load in the US.



Source: RMI analysis; NEEA RBSA

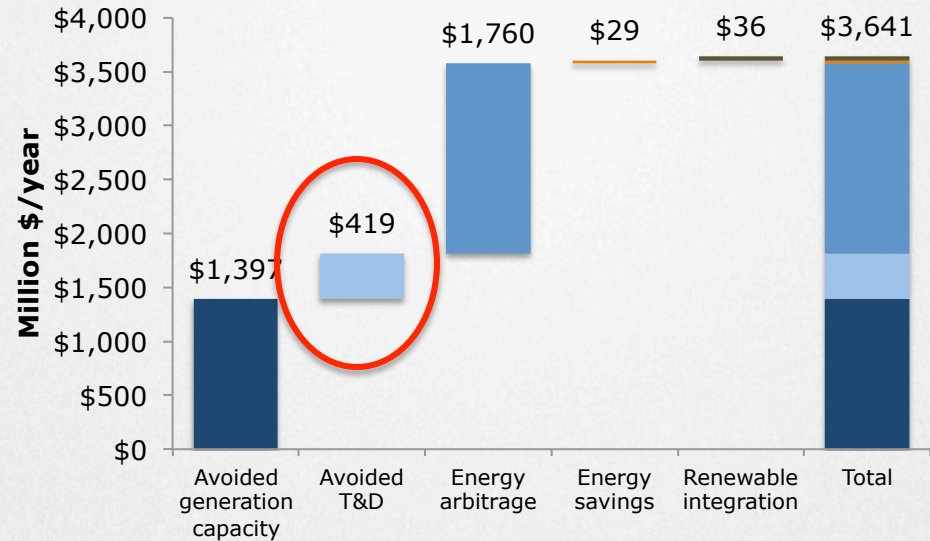


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Avoided T&D capacity: \$420M/year

Lowered peak demand can lead to avoided investment in transmission & distribution infrastructure in addition to generation

- ❖ The value of avoided T&D investment has been calculated between \$30-\$100+/kW-yr; we assume the lowest value
- ❖ This avoided cost potential is likely concentrated in congested areas and areas with significant growth expected



Source: RMI analysis

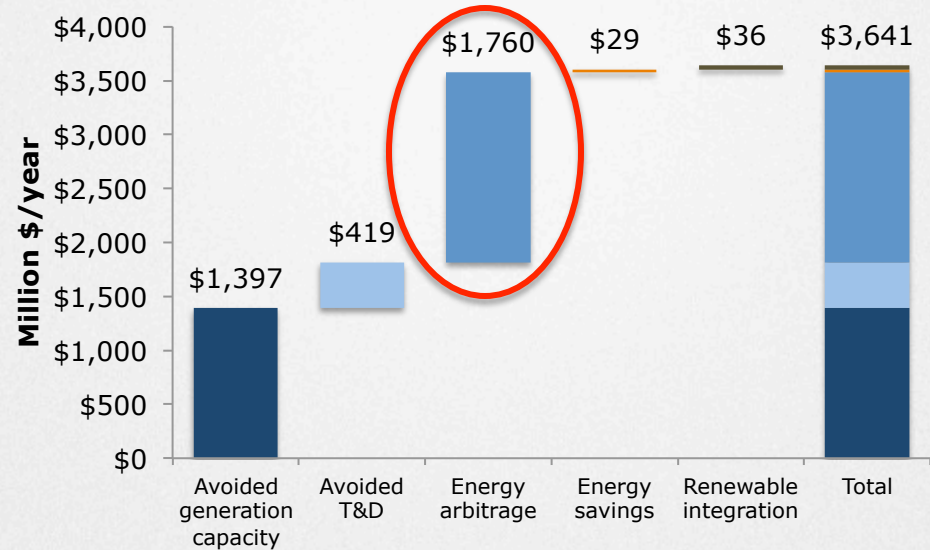


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Energy arbitrage: \$1.8B/year

Scheduling water heating load to coincide with low-cost hours in wholesale markets can reduce energy costs by 25-35%

- ❖ Using 2014 wholesale market prices, the average marginal energy cost to use an electric water heater across the US was \$125.
- ❖ Savings of 25-35% are possible while still ensuring that hot water is available on demand.



Source: RMI analysis

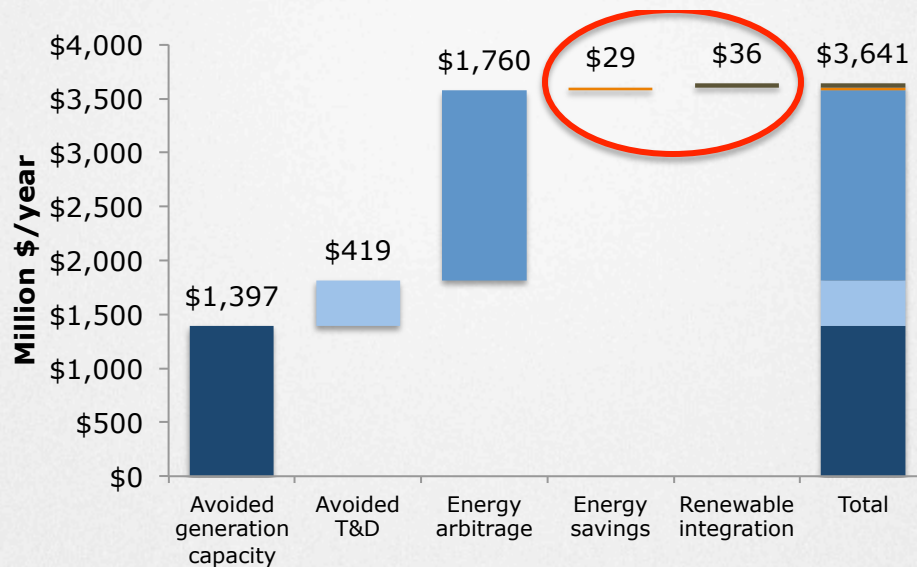


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Other values: \$65M/year, not including ancillaries

Reducing standby losses and avoiding current levels of renewable curtailment can provide additional value; avoided ancillary service costs in wholesale markets could add much more

- ❖ Enabling “vacation mode” can reduce standby losses and energy consumption
- ❖ Charging during windy, low-load hours can avoid renewable curtailment
- ❖ The frequency regulation market is currently on the order of \$400-700M/year, and GIWH can technically participate, but the market is thin



Source: RMI analysis



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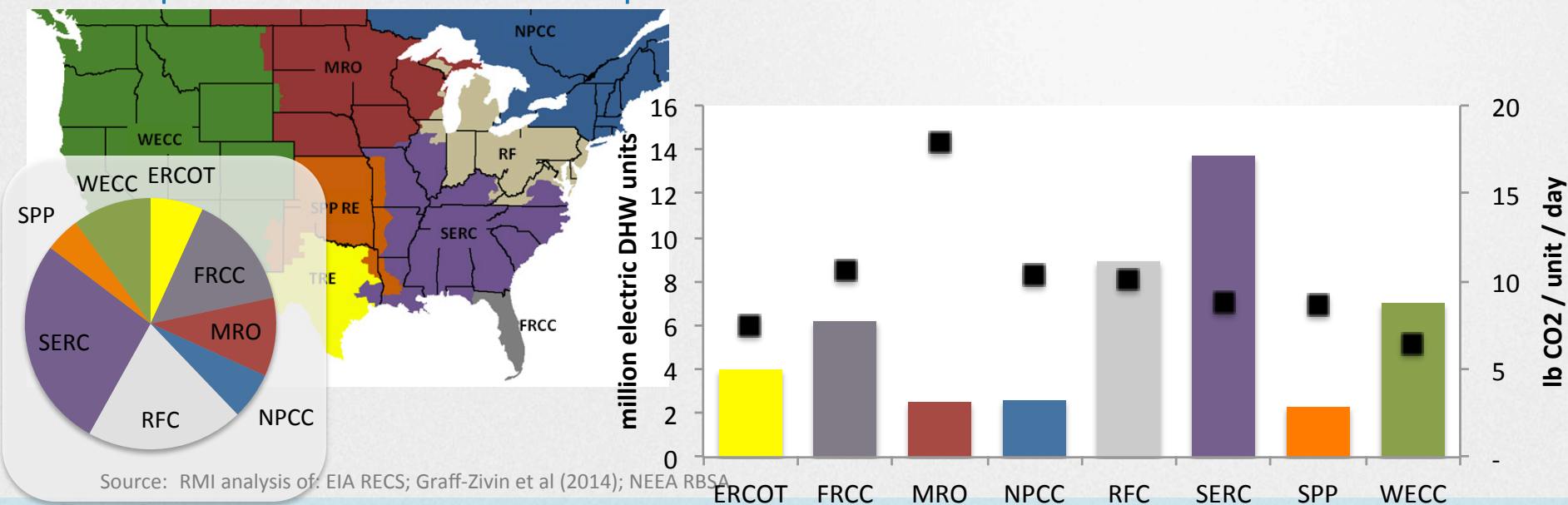
The carbon impacts of GIWH



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We estimate electric domestic hot water is responsible for ~74 million tonnes/year of CO₂

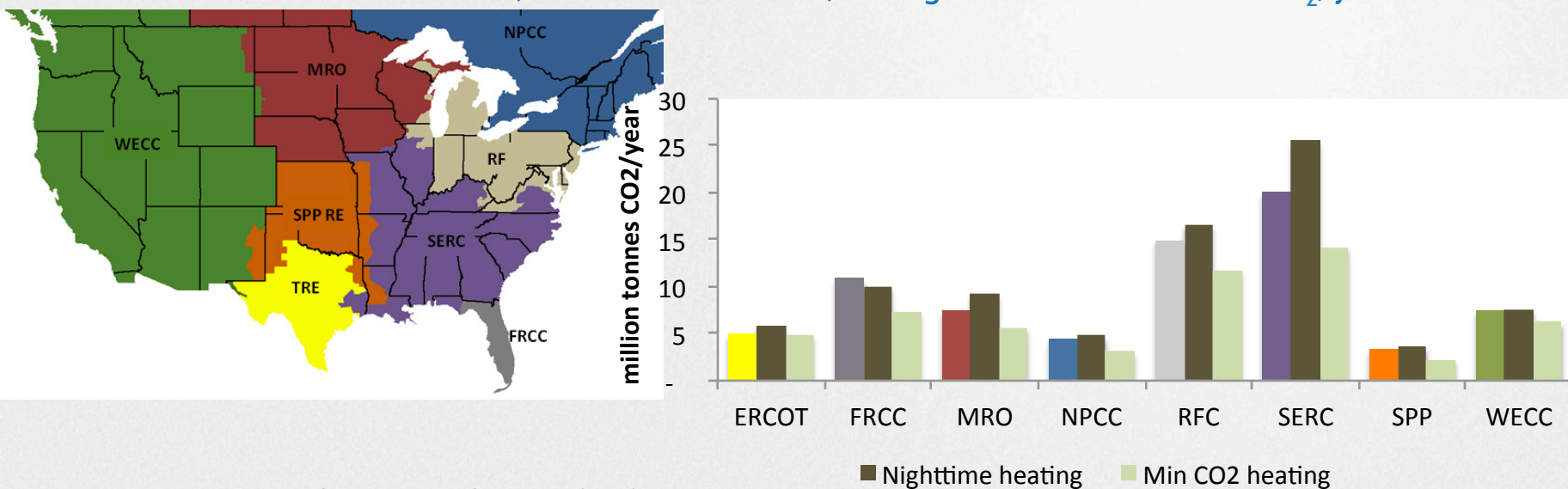
Water heater-caused emissions are concentrated in the Midwest and Southeast due to grid composition and electric DHW adoption rates



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Low-*cost* versus low-*emissions* heating strategies have widely different CO₂ impacts

If all water were heated at night, emissions increase by 13%. If all water were heated during the lowest-emission hours, emissions fall 25%, saving ~18 million tonnes CO₂/year.



Source: RMI analysis of: EIA RECS; Graff-Zivin et al (2014); NEEA RBSA

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Implications & opportunities



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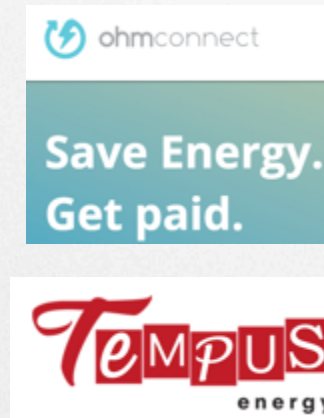
Many actors can capture this value

Utilities, GIWH manufacturers, installers, solar companies, aggregators, and customers themselves can all capture a piece of this \$3.6 billion/year prize

Successful business models will...

- ❖ Capture more than one source of value from GIWH deployment
- ❖ Rely on standardization and scale to reduce costs
- ❖ Provide customers things that they want, not just services that the grid values

Competition is not limited to traditional players



greentechgrid:
SunPower Invests \$20M in Tendril to Link Solar With Home Energy Management



SIMPLE ENERGY MARKETPLACE

Thank you

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