

Decarbonizing heating systems

Scaling heat pumps and heat pumps water heaters

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- Not-for-profit research organization working on public benefits research on electricity issues
- 450+ participants in more than 30 countries with international members comprising 25% of research funding
- EPRI members generate approximately 90% of the electricity in the US

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We have all these high efficiency products today.....



Products and the supply chain are not aligned with the decarbonization application

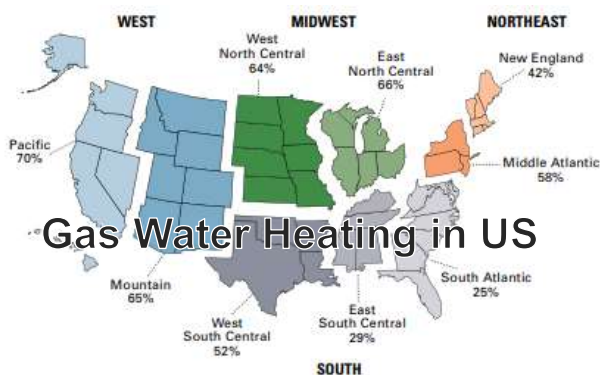
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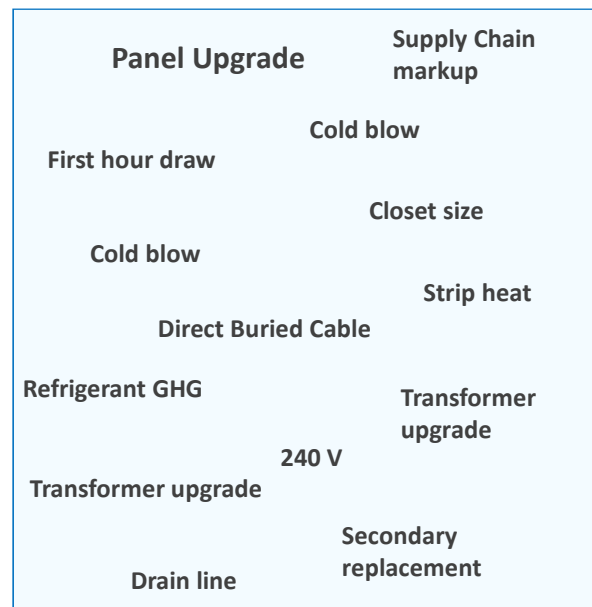
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The challenge with building decarbonization



- Barriers to adoption of electrification
 - Customer acceptance
 - Electric grid integration
 - Customer cost



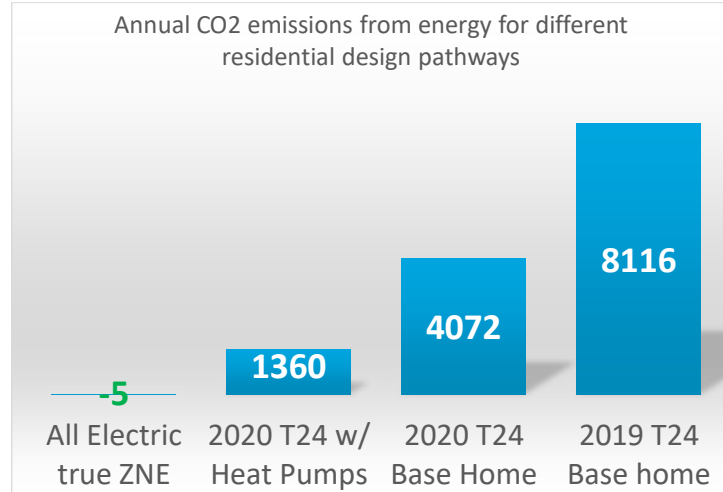
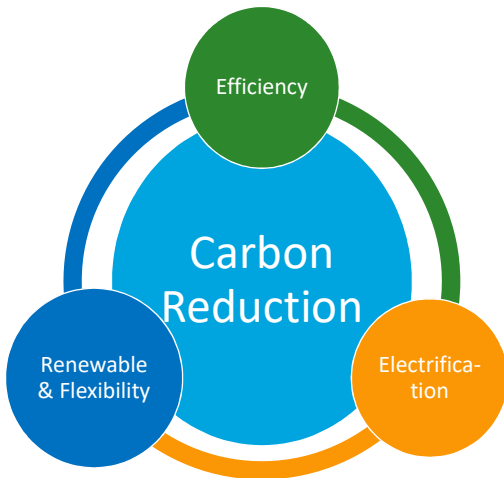
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Building Decarbonization Pathways



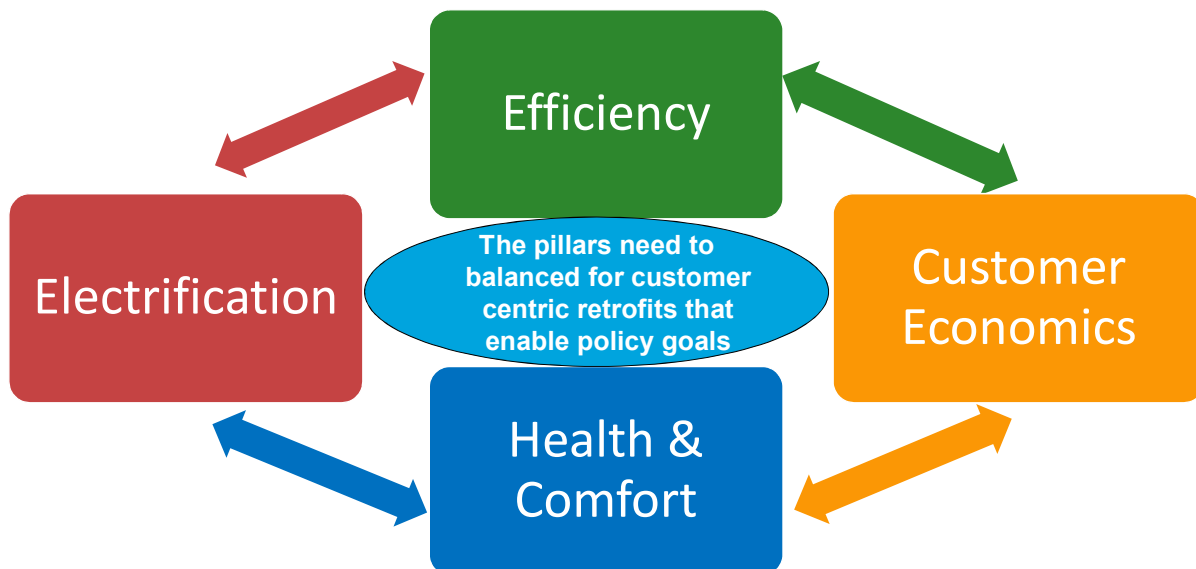
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Pillars of Success



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Heat Pumps: Working on the Supply Chain

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What if.....

Every air conditioner
sold starting today is
a heat pump?



- What are the barriers to this:
 - A long supply chain between manufacturer and installer that is not primed for heat pumps
 - Understanding sizing calculations for heating
 - Just being available and cost neutral at distributors
 - Power availability at panel in climates without air conditioning

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Programmatic Application

- Programs need to be combined with deep envelope retrofits to be cost effective, LIWP is a good example
- Massachusetts HP rebates are a model for electrification, based on site energy use
- Products exist today, get the workforce ready and bring down operating cost through efficiency



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Results from heating electrification (35 homes)

Reduced electricity use after electrification through deep efficiency measures. Important measures:

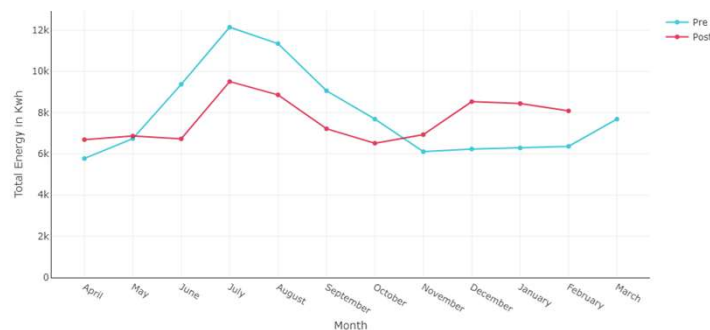
- High efficiency heat pumps
- Insulated roof

Pre-retrofit
87130 kWh

Post-retrofit
84381 kWh

Energy
Savings
of 2749
kWh

Pre VS Post Retrofit AMI Comparison



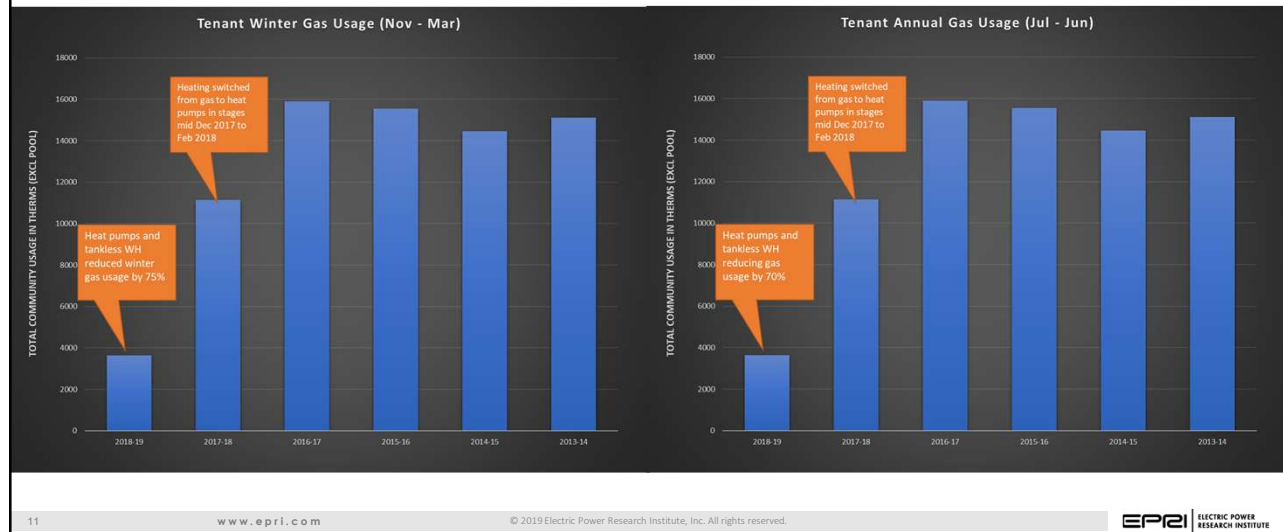
	Summer (June 1 st to Aug 31 st)	Winter (Nov 1 st to Feb 28 th)
Pre-retrofit period (total kWh consumption)	32870.88	24993.52
Post-retrofit period (total kWh consumption)	25096.65	31993.26
Savings (or delta)	7774.23 kWh	-6999.74 kWh

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Impact of electrification on gas usage

- Gas analysis shows combined impact of efficiency and electrification



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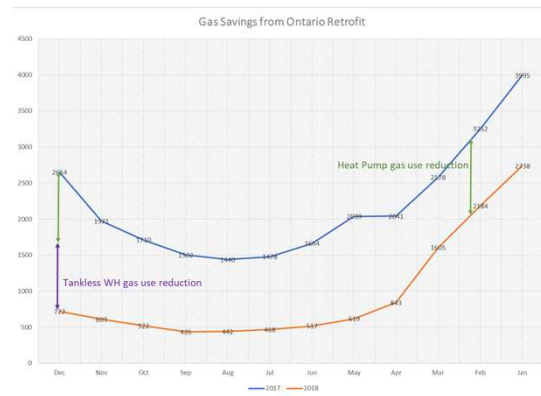
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Diving deeper: attribution of energy use reduction and electrification

- Heat pumps were installed Dec – Feb 2017 and tankless water heaters were installed April 2018
- Heat pump replacement was net zero cost adder to air conditioner replacement
- Breaking down the data, shows approximately 35% gas savings from heat pumps, and 35% gas savings from efficient tankless water heaters
- From a carbon perspective,
 - We can get significant carbon reductions from heat pump replacements without service addition
 - Tankless gas can provide cost effective carbon reductions with current HPWH product line



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Technologies for the future: Key retrofit technologies



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Heat Pump Water Heaters: Aligning Products to Markets

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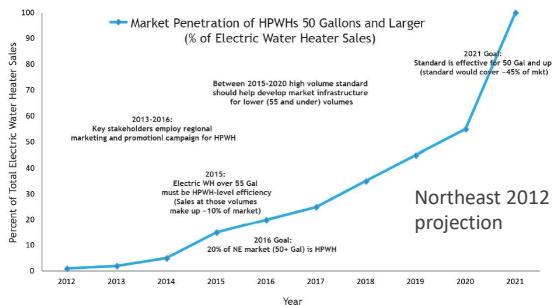
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The opportunity to leapfrog & kickstart the market

- Many false starts, but US penetration only at ~1% (70,000 units)



Housing type	NATURAL GAS	ELECTRIC	PROPANE
Single family	5,744,637	342,114	305,322
Multi family	2,335,599	338,635	35,542
Mobile Home	292,778	44,851	62,349
Other	89,565	14,627	10,382
Total	8,462,578	740,226	413,595
%	79%	7%	4%

- Combined market potential in California and NorthEast is ~300 times current HPWH sales in total, but
- We need to learn from adoption barriers in the Southeast and Northwest

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Decarbonization Strategies for Water Heating

Efficiency



Renewables



Electrification



- Multifamily water heating is more complicated - technology plays a part, but...
- Application design and guidance play a much more significant role

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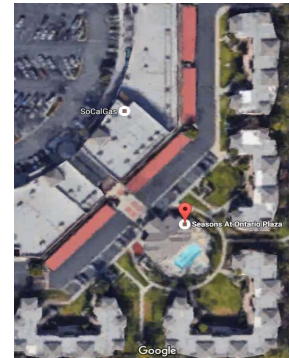
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Retrofitting Challenges in non-electric markets

- Targeted Near Zero Energy multifamily whole building retrofits
- Solar PV Net Energy Metering drives electrification
- Electrification offsets solar production and reduces GHG substantially
- However, significant costs due to gaps in product offering



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The state of systems in existing homes.....

Heating and Cooling Systems



Gas Fired Wall Furnace



Evaporative Coolers



Water Heating



Water Heater Outside

Water Heater Inside

Controls



Electrical Panels



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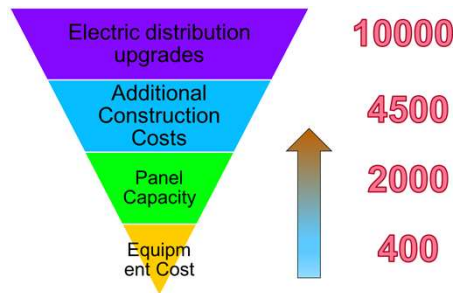
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And this is what results....



- Heat Pump water heater cost adder to replace 40gal gas WH was ~\$12000/apartment



Line Item (per apartment unit)	Net cost adder
Equipment cost	-\$100
Closet construction/ outdoor location protection	~\$2000
Panel upgrade	~\$1500
240 V wiring to location	~\$1800
SCE distribution upgrade (Meter, Xformer & secondaries)	~\$7000

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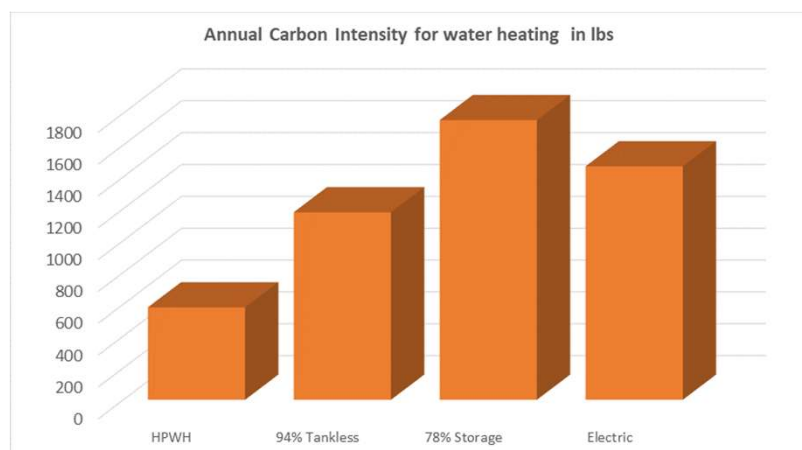
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Electric WH market a carbon beachhead for HPWH market

- Carbon benefits from efficiency (i.e., converting electric to heat pump water heaters) greater than carbon benefits from electrification even in a low emission grid
 - This will change as states move towards 100% renewable goals
 - However, efficiency will always provide avoided cost benefits and reduce grid variability



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We have been down this path before.....

1980s

**E-Tech Retrofit
HPWH (1988)**



2000s

Coordinated Early Deployments

2008 EPRI HPWH Early Deployment: Who Does What



2010s

**Small Commercial
Evaluation**



- How are we going to make it different now?

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Building and Grid Integration

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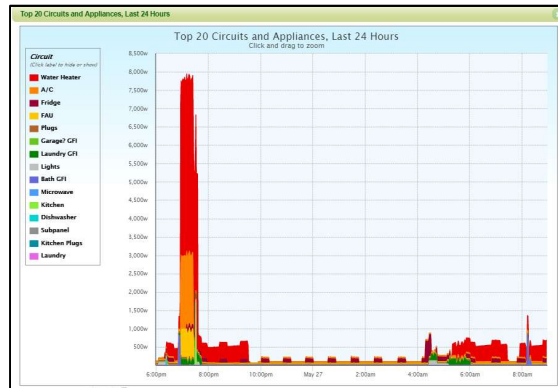
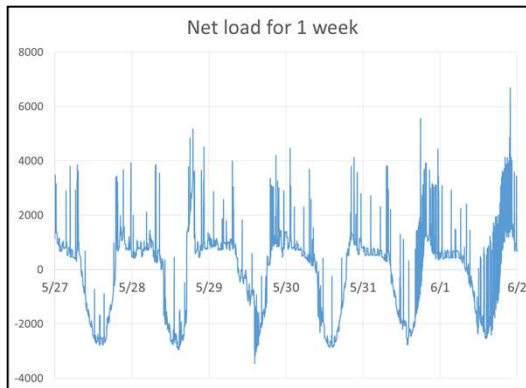
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Grid Planning for Electrification

- Lower energy use but greater peaks
- Distribution Planning \neq Distribution Operations
- Look at grid impact not individually, but as the sum of HP, HPWH, EV, PV and storage
- Be prepared to invest in growing utility distribution assets to decarbonize



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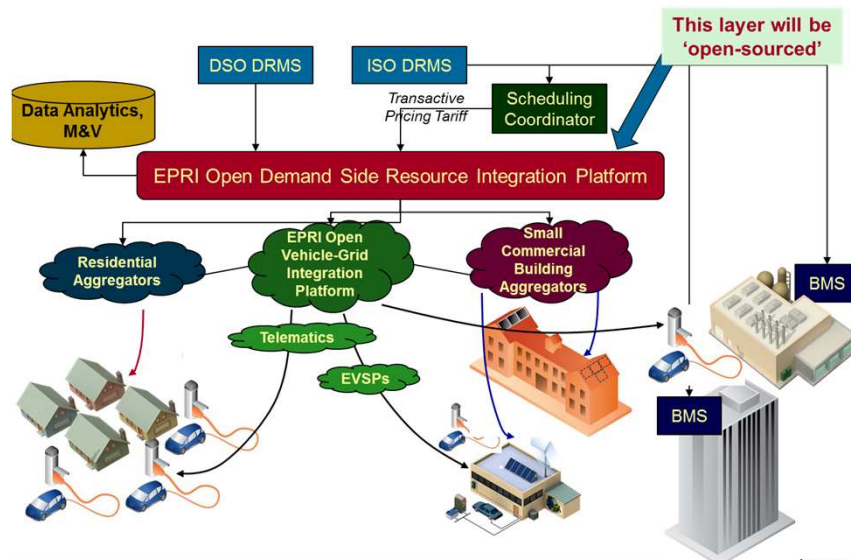
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Aggregate customer resources for flexibility in a decarbonized environment

As the peak shifts to later and narrows, aggregation platforms can help peak load management



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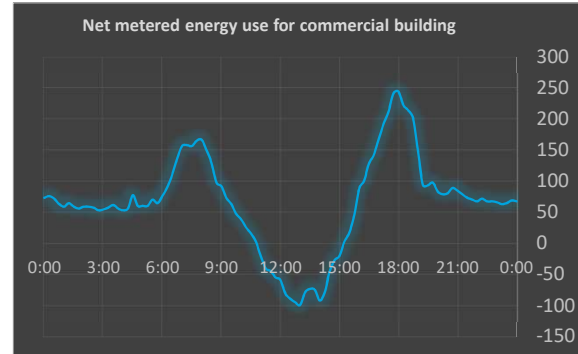
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Flexibility focus: Smart Thermostats and EVs

Smart Thermostats with building mass storage have high potential for addressing peaks



EV charging management could be critical to addressing evening load peaks



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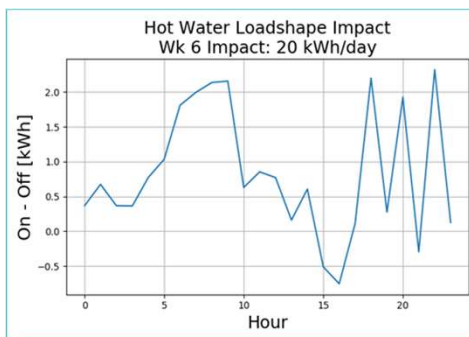
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To Flex or not to Flex..... That is the big HPWH question

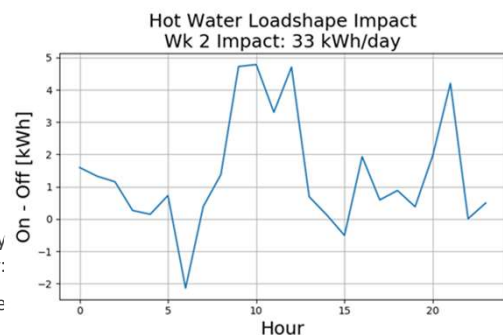
- Field results from HPWH show limited flexibility/ DR capacity
- Flexibility requirements should not be needed now.... As they could detract from electrification market transformation

Aggregate results from 62 home community in warm climate



Summer Flexibility Availability:
2 kWh aggregate

Winter Flexibility Availability:
6 kWh aggregate

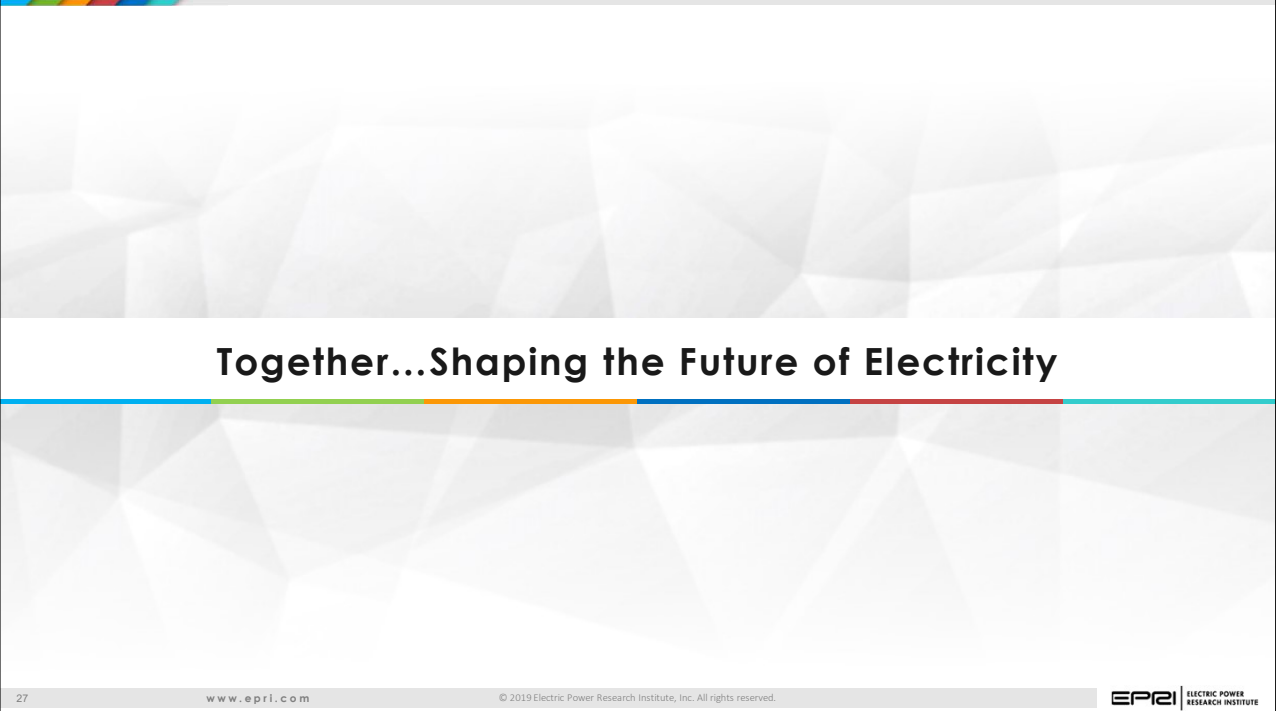


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Together...Shaping the Future of Electricity

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