



RAP[®]

Energy solutions
for a changing world

Beneficial Electrification: Exploring the Aggregation of Water Heaters

ACEEE Hot Water Forum
February, 2017

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April 18, 2016

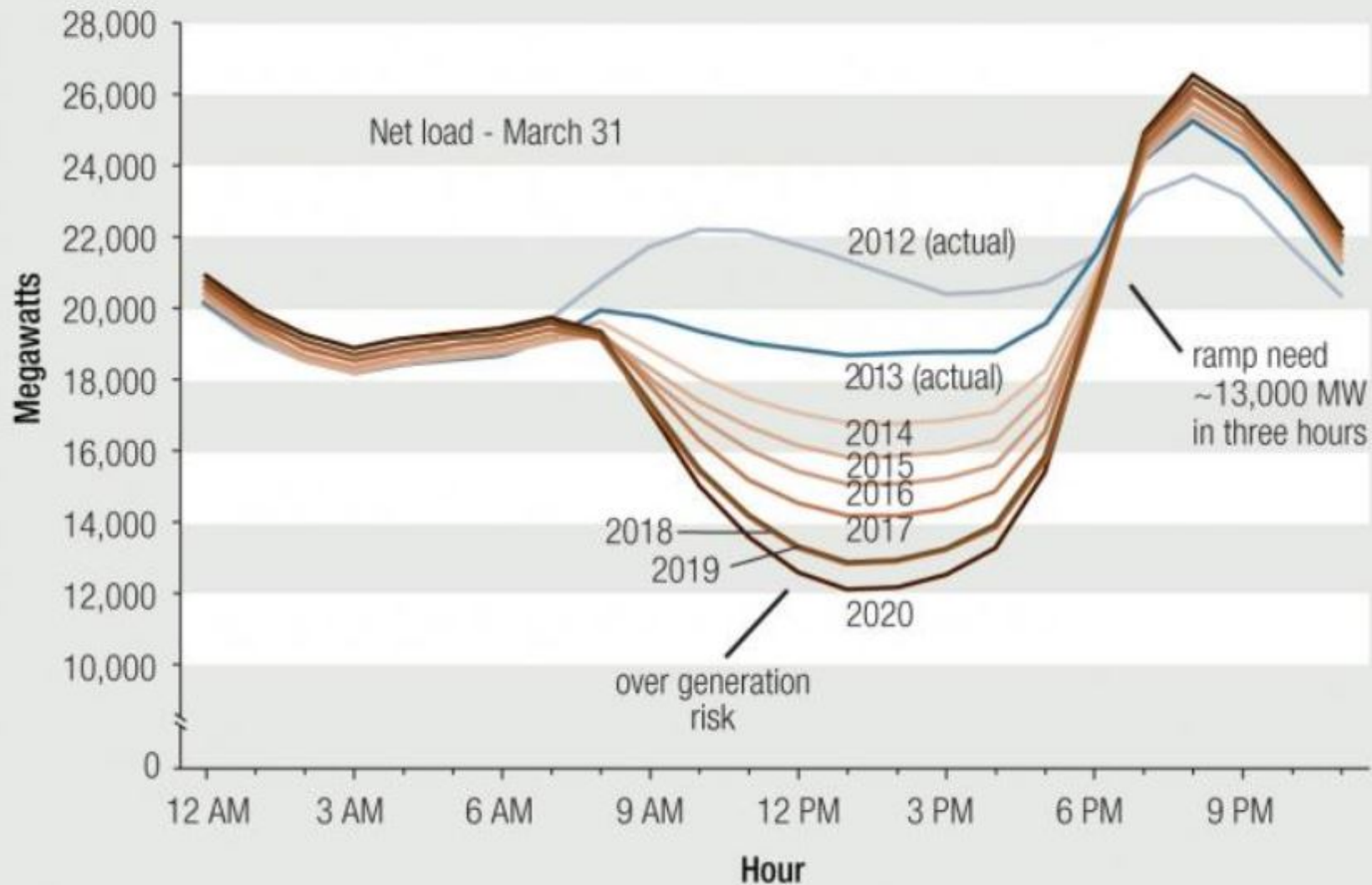
The Regulatory Assistance Project (RAP)[®]

Presentation Agenda

- I. Why are controllable water heaters valuable?
- II. Some least cost controllable loads
- III. Water heater aggregation options
- IV. Least cost load shifting aggregate impacts

Trends in resource development are leading toward a growing need for flexible generating capacity starting in 2015.

PREV



Context: Strategies 3 – 5, 7

Teaching the Duck to Fly

- Targeted energy efficiency
- Peak-oriented renewables
- **Water pumping**
- **Water heating**
- **Air conditioning**
- Rate design
- **Battery storage (EVs)**
- Demand Response
- Inter-regional power exchanges
- Retire older inflexible generating units

Teaching the Duck to Fly



Requesting Permission for Take-Off

Recommended Reading from LBNL:

<http://www.cpuc.ca.gov/General.aspx?id=10622>

- Shape: 1 GW shed, 3 GWh/day shift (TOU/CPP)
- Shift: \$700 mm market, 10% DR
- Shed: Deferring Distribution Investment to become highest value of shed
- Shimmy: AS prices may limit to commercial (variable freq drives/pumps and lighting controls)

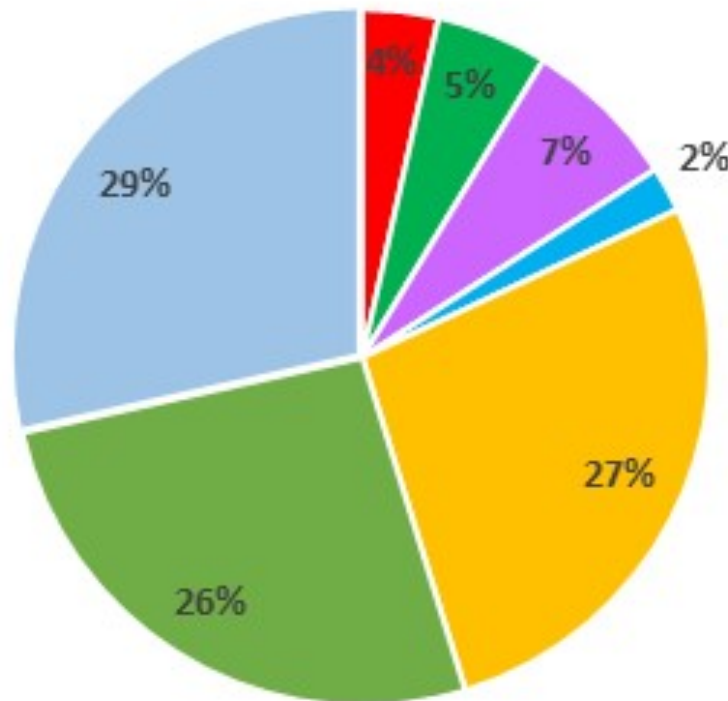
Overview: Sun and Wind Come and Go— Energy Storage Can Help!

- Air Conditioning
- Water Pumping
- Electric Vehicles
- Water Heating



These Are Big End Uses ~19% of Total Electricity Consumption

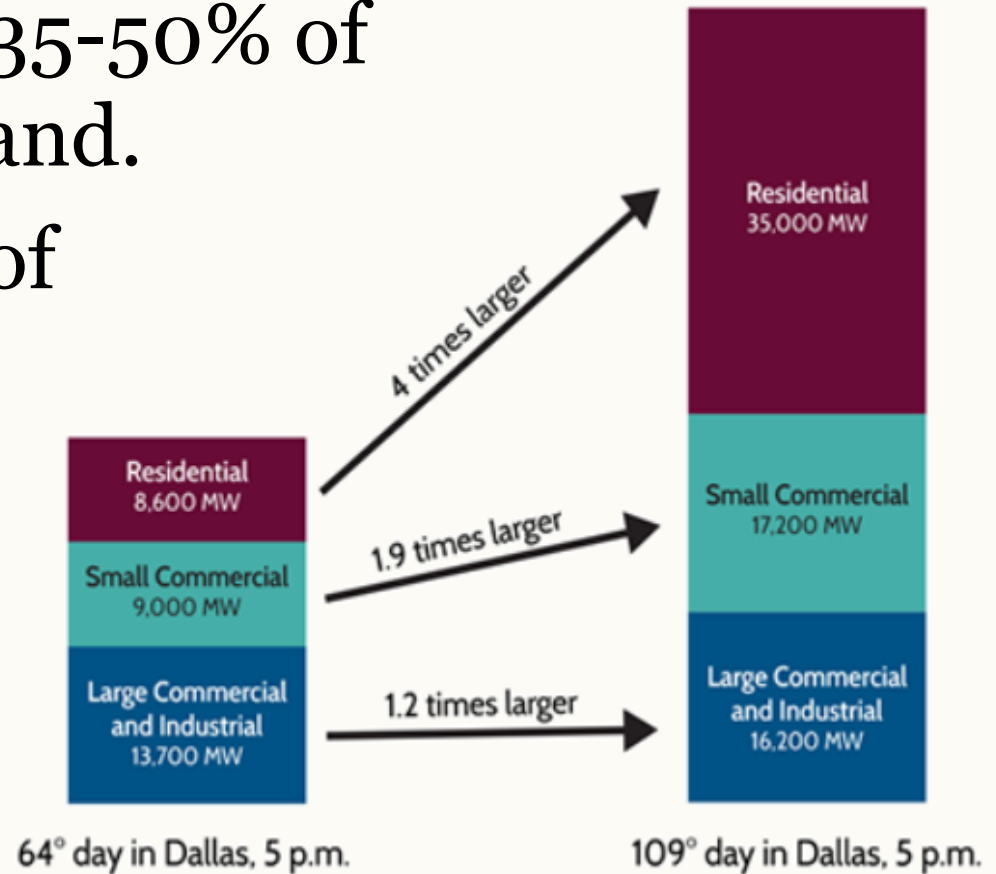
Electricity Usage in the US



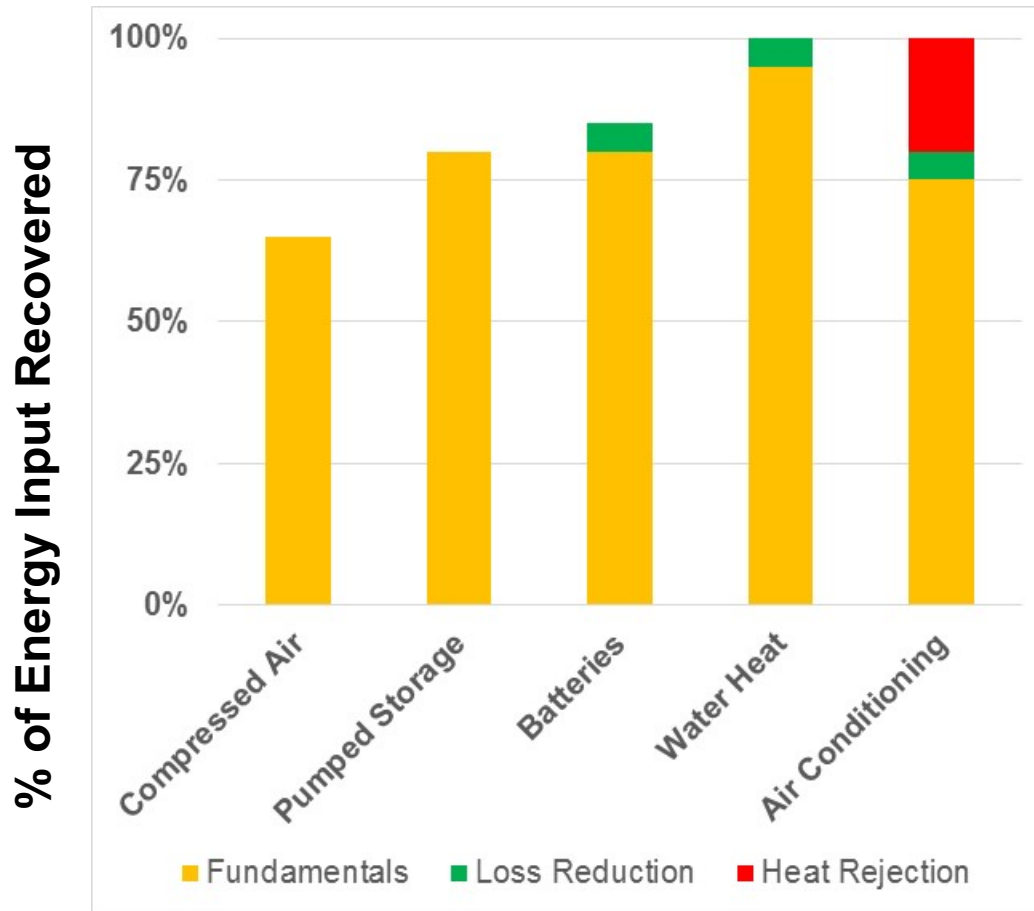
- Res Water Heat
- Res AC
- Commercial AC
- Water/Wastewater
- Other Residential
- Other Commercial
- Industrial

MUCH Bigger Share of Peak Demand

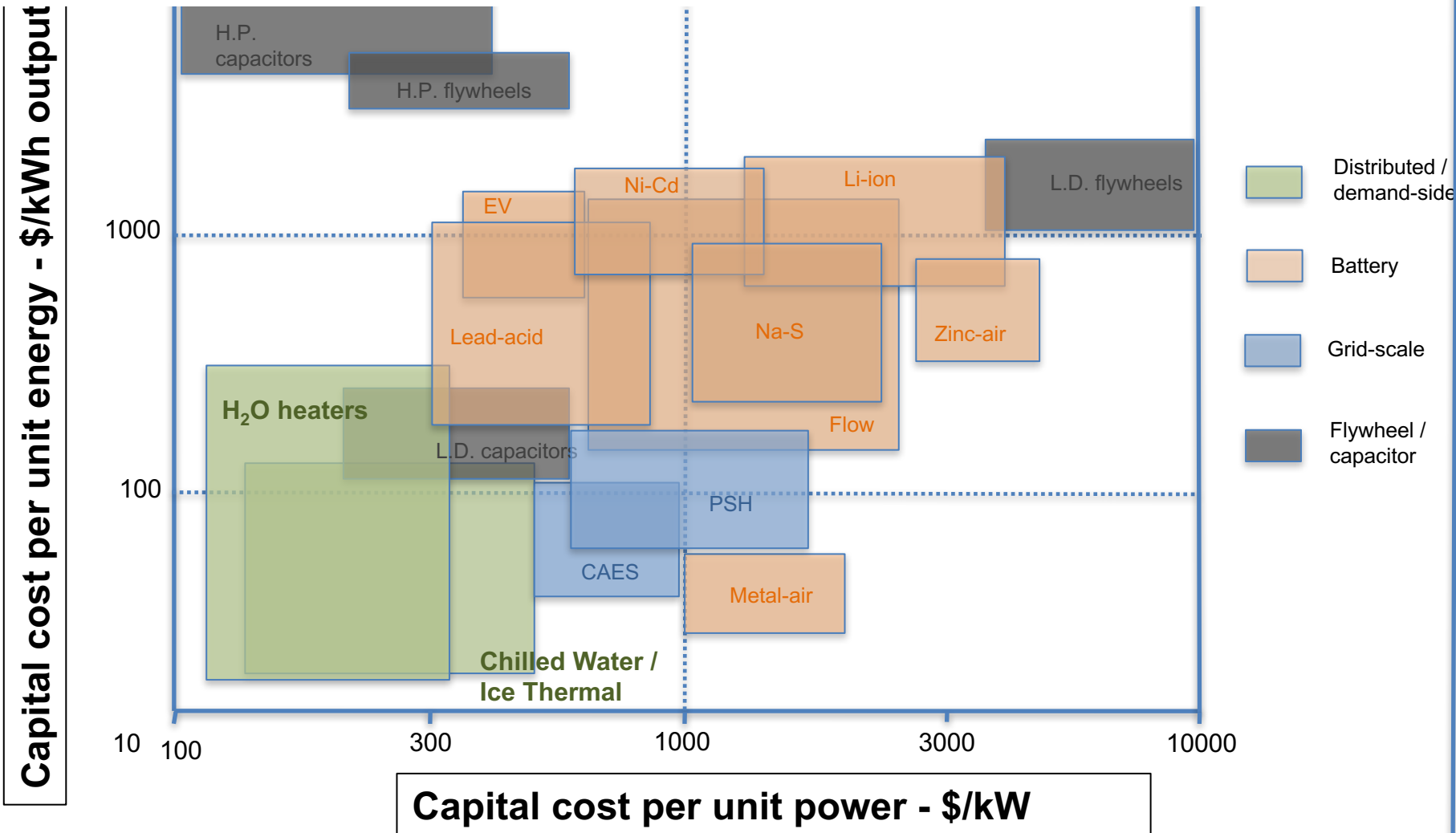
- NREL: Cooling is 35-50% of total US Peak Demand.
- Water heat: ~12% of residential peak demand



Thesis: Energy Storage Is More Efficient Than Electricity Storage

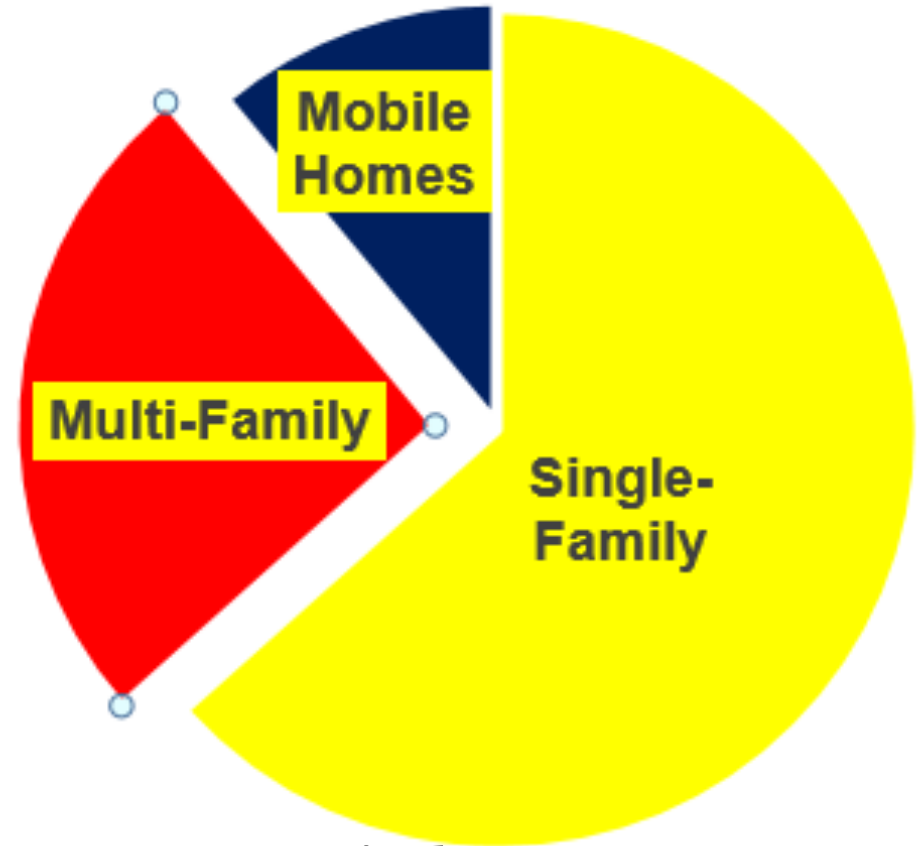


Thesis: Energy Storage Is More Economical Than Electricity Storage



Water Heating: Magnitude

- 45 million existing electric water heaters
 - ~10% of total residential electricity usage
 - ~12% of residential peak demand
 - ~70% kWh reduction possible with HPWH where applicable



Beneficial Electrification Potential:
55 million gas water heaters

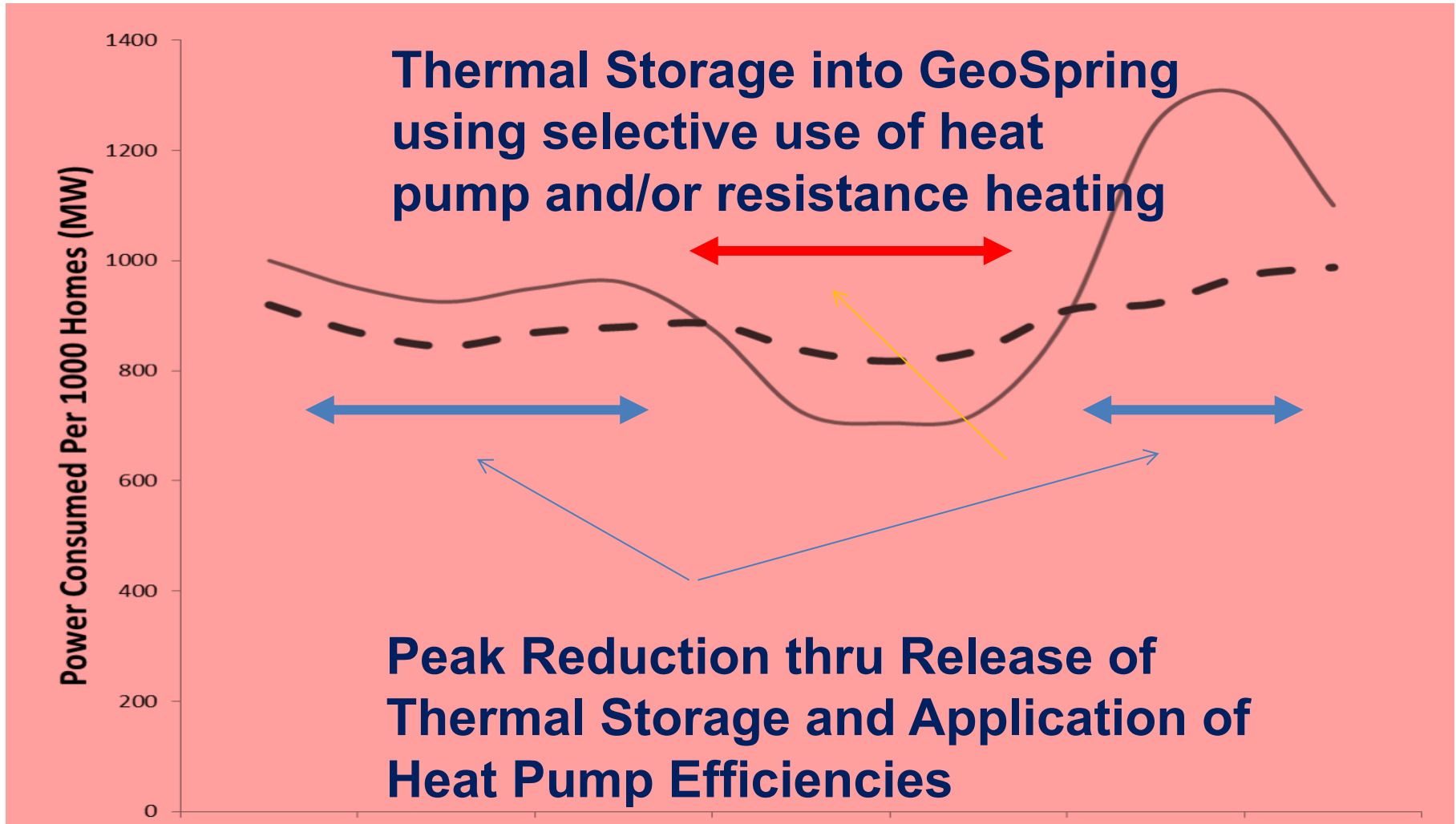
Electric Water Heaters Are Not Distributed Uniformly by Region of the US

	Total US	Northeast	Midwest	South	West
Electric Water Heaters	45,435	4,558	7,532	26,921	6,424

Single-Family: Mostly Convertible to Heat Pump



GE Geospring In GIWH Configuration



Source: General Electric

Multi-Family: Overwhelmingly Electric Resistance – and Will Stay That Way

- Fewer Options
 - **Gas:** No gas piping and venting
 - **Solar:** Cold water only plumbing
 - **HPWH:** Space limitations; indoor installs

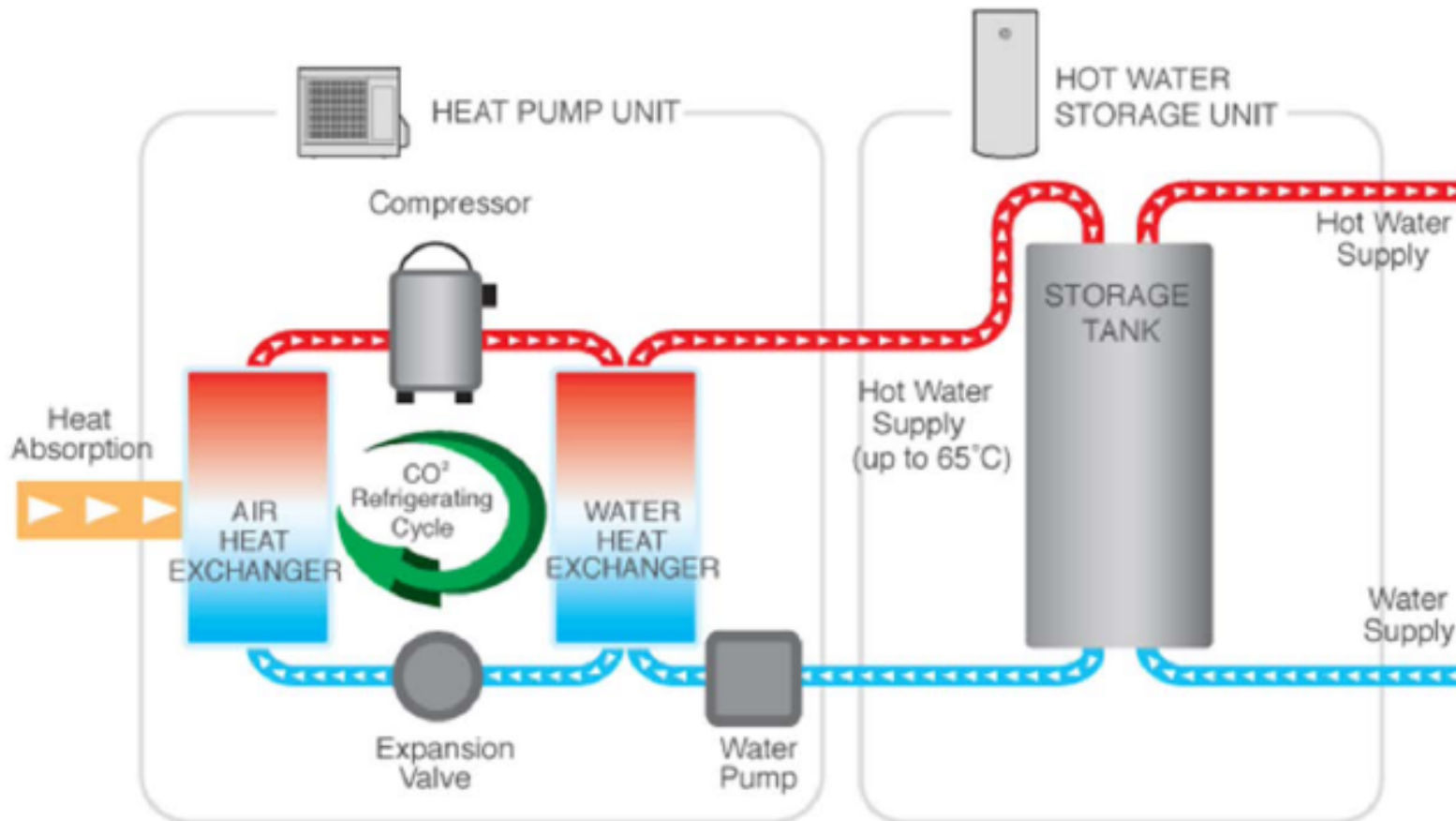


Why Multi-Family

- Access and Crew Efficiency
- Communications and Controls
- Renters with few money-saving options



Emerging Technology: Multi-Family Shared Heat Pump

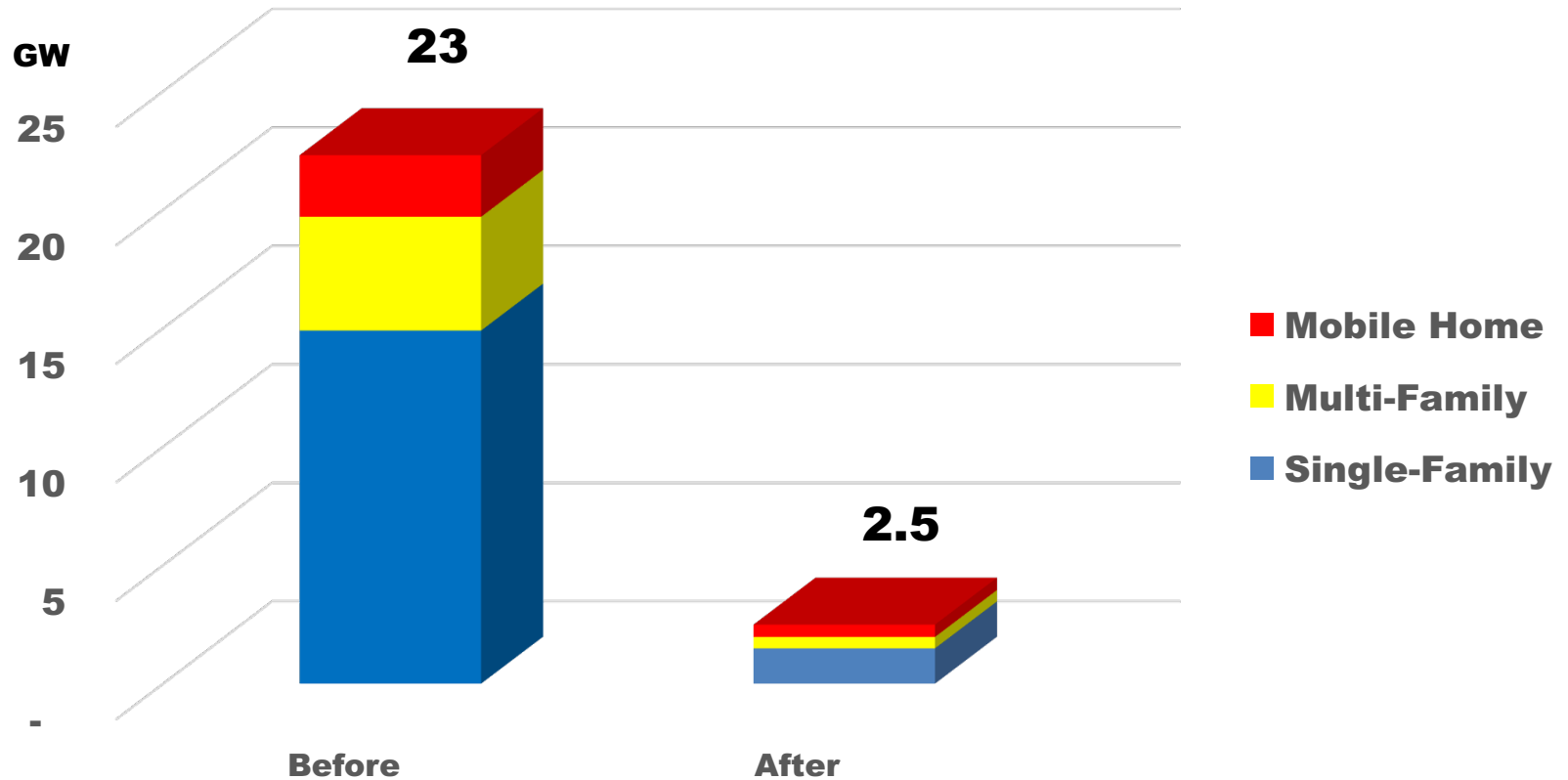


Source: Ken Eklund, WSU Energy Program

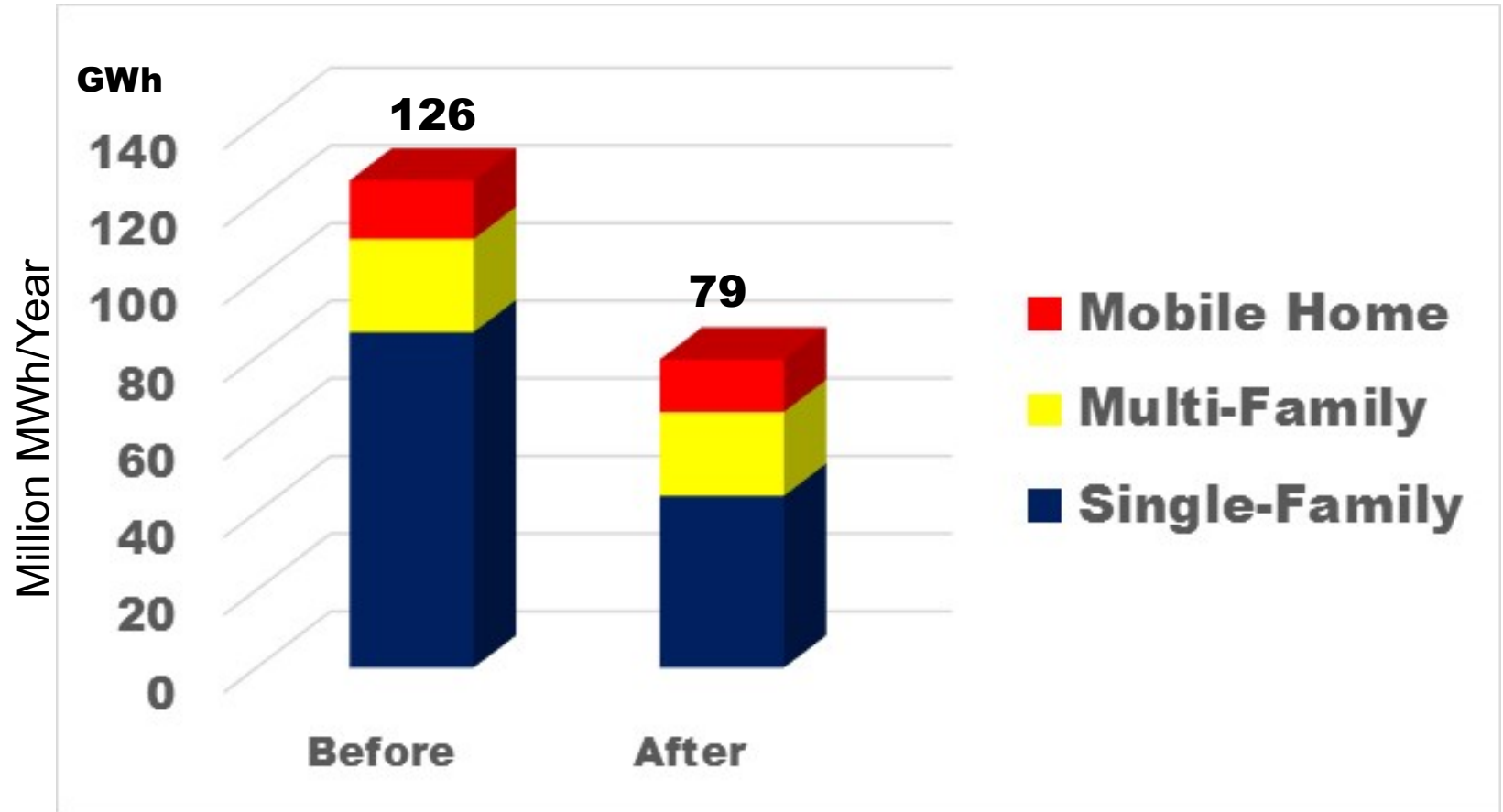
Mobile Home: Perhaps Half Convertible to Heat Pump



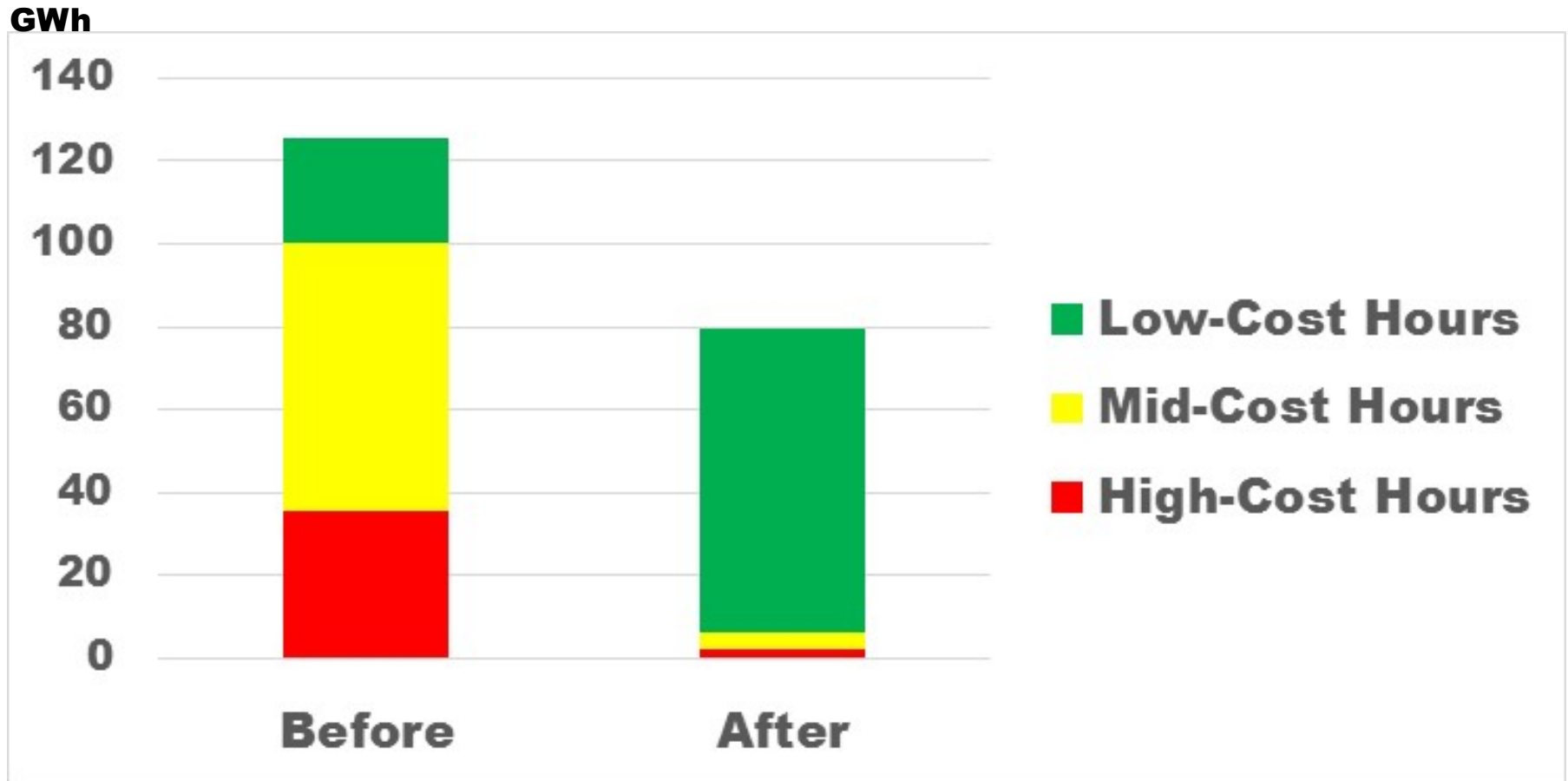
Water Heating Peak Load Impacts



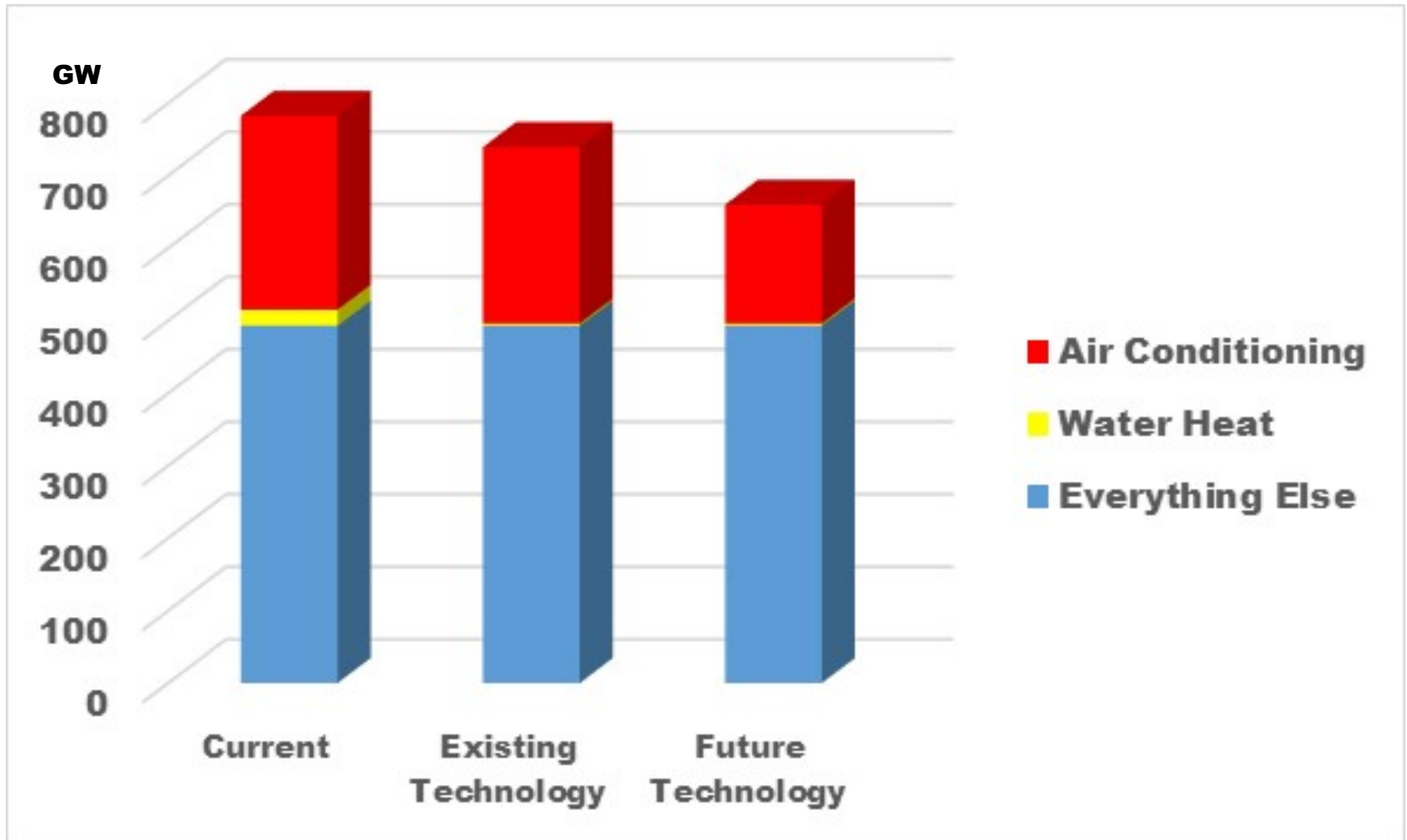
Water Heating Energy Impacts



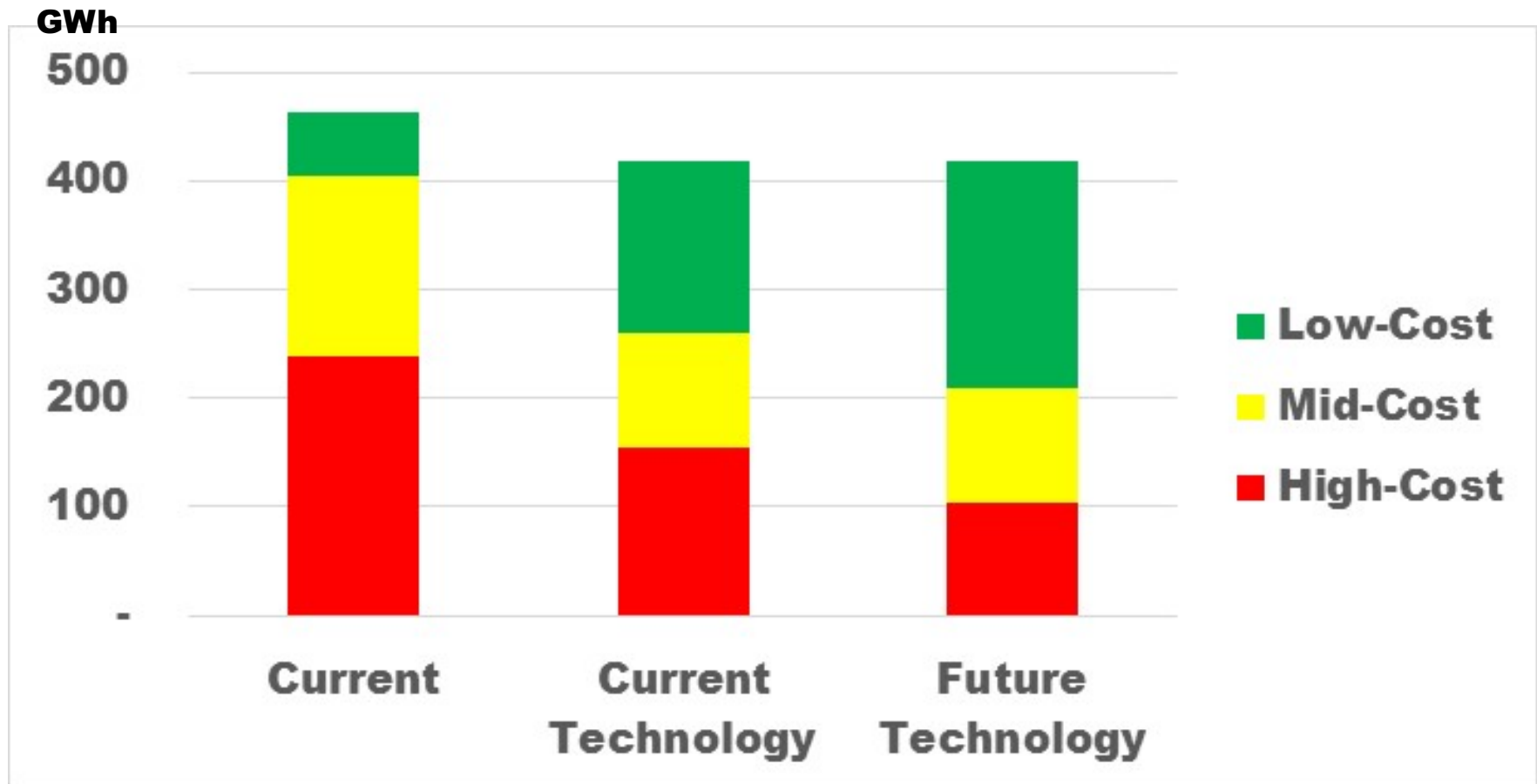
Water Heating Load Shift Impacts



Combined Peak Demand Impact



Combined Load Shift Potential



Bottom Line: Huge Potential for Peak Load Reduction and Load Shifting to Low-Cost Hours

	Units Potentially Controlled	Annual Consumption MWh	Peak Load Reduction MW
Water Heat	45,000,000	180,000,000	18,000
Air Conditioning	10,000,000	182,000,000	100,000
Water Pumping	1,000,000	150,000,000	15,000
Electric Vehicles	25,000,000	100,000,000	New Load
Total:			133,000

**1-2 MWh /day ■ 1 kW of Renewable Generation Adaption
Maybe Enough to Adapt to ~50% Variable Renewables**

RAP Rough Planning Level Estimates: Robust Analysis Needed



About RAP

The Regulatory Assistance Project (RAP) is a global, non-profit team of experts that focuses on the long-term economic and environmental sustainability of the power sector. RAP has deep expertise in regulatory and market policies that:

- Promote economic efficiency
- Protect the environment
- Ensure system reliability
- Allocate system benefits fairly among all consumers

Learn more about RAP at www.raonline.org

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The Regulatory Assistance Project (RAP)[®]

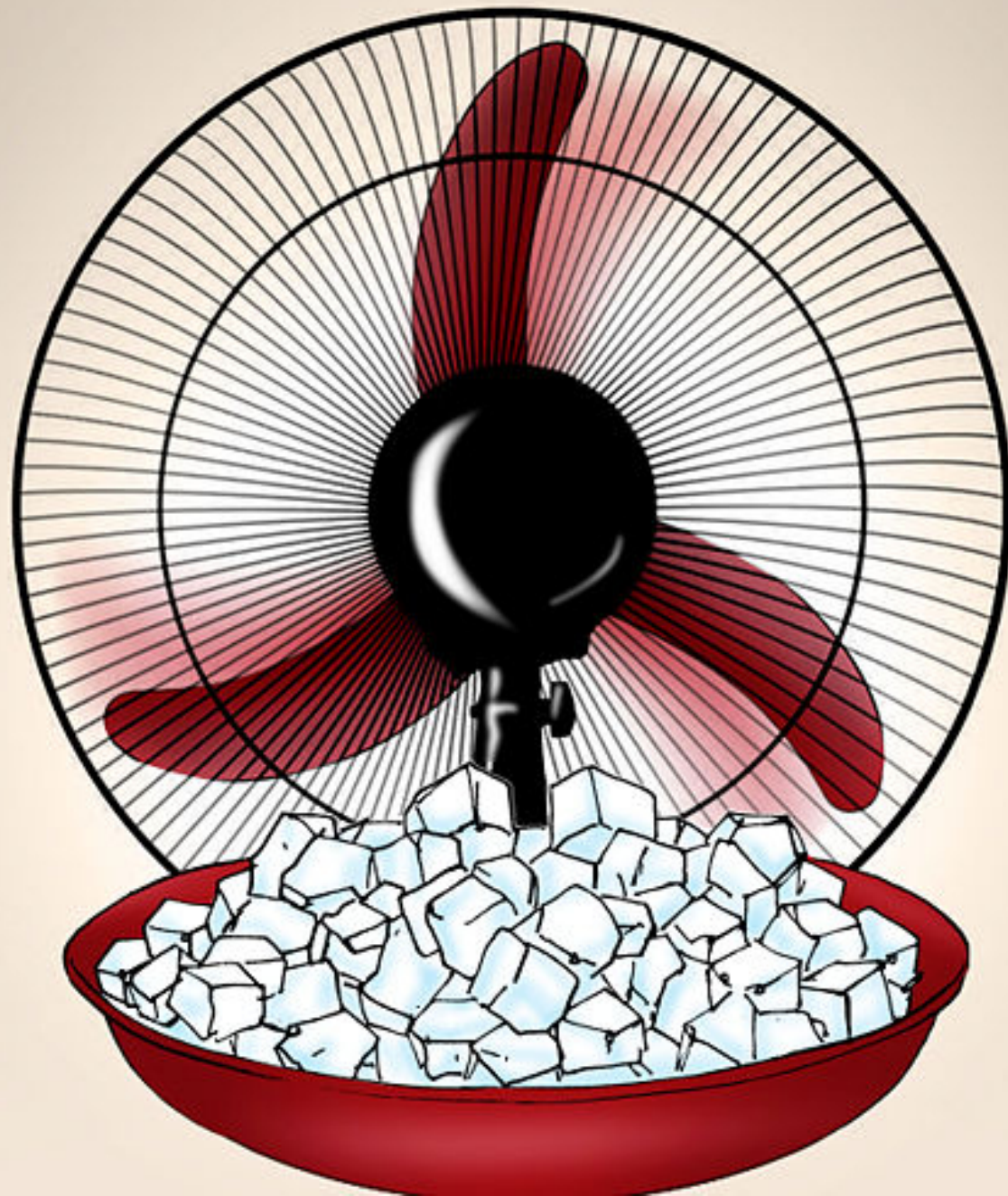
Beijing, China • Berlin, Germany • Brussels, Belgium • Montpelier, Vermont USA • New Delhi, India

www.raonline.org

Extra Slides: Quick Overview

- Air Conditioning
- Water Pumping
- Electric Vehicles

A Little More Detail on Water Heating



Central Chiller Storage

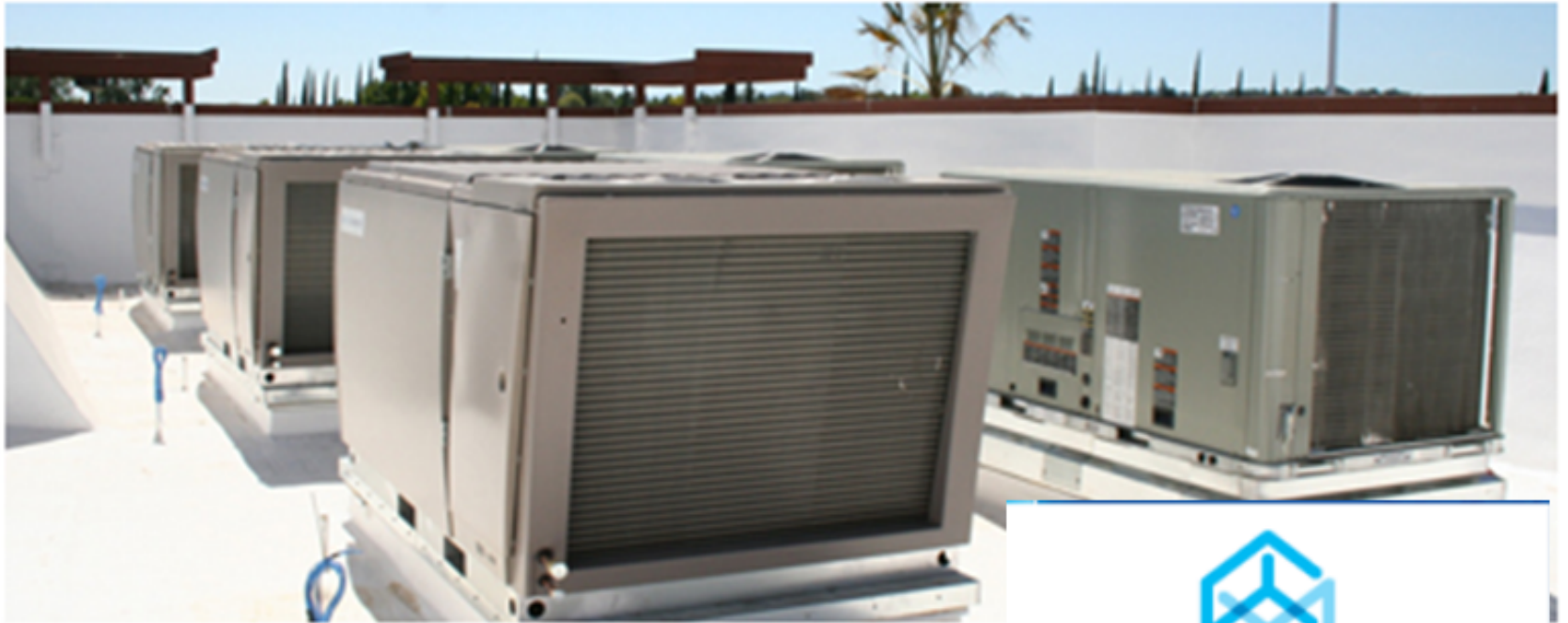
44 tanks provide peak cooling needs for 1 Bryant Square (B of A, NYC).



Photo: © Gunther Intelmann for Cook+Fox Architects

CALMAC

AC Storage for Strip Malls & Big Box



Ice Storage For Residential AC



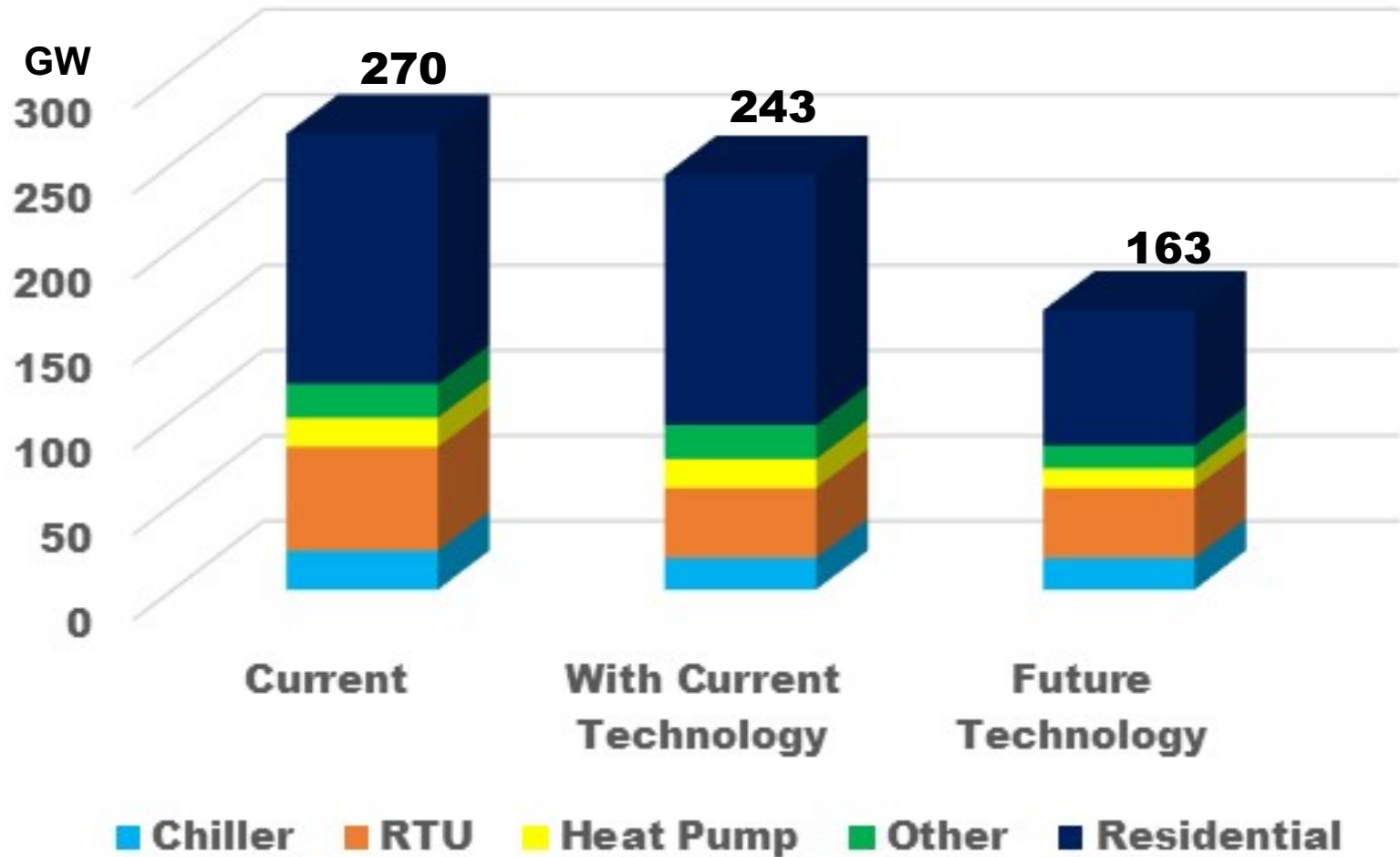
Ice-Energy “Ice Cub”

2.5 ton capacity

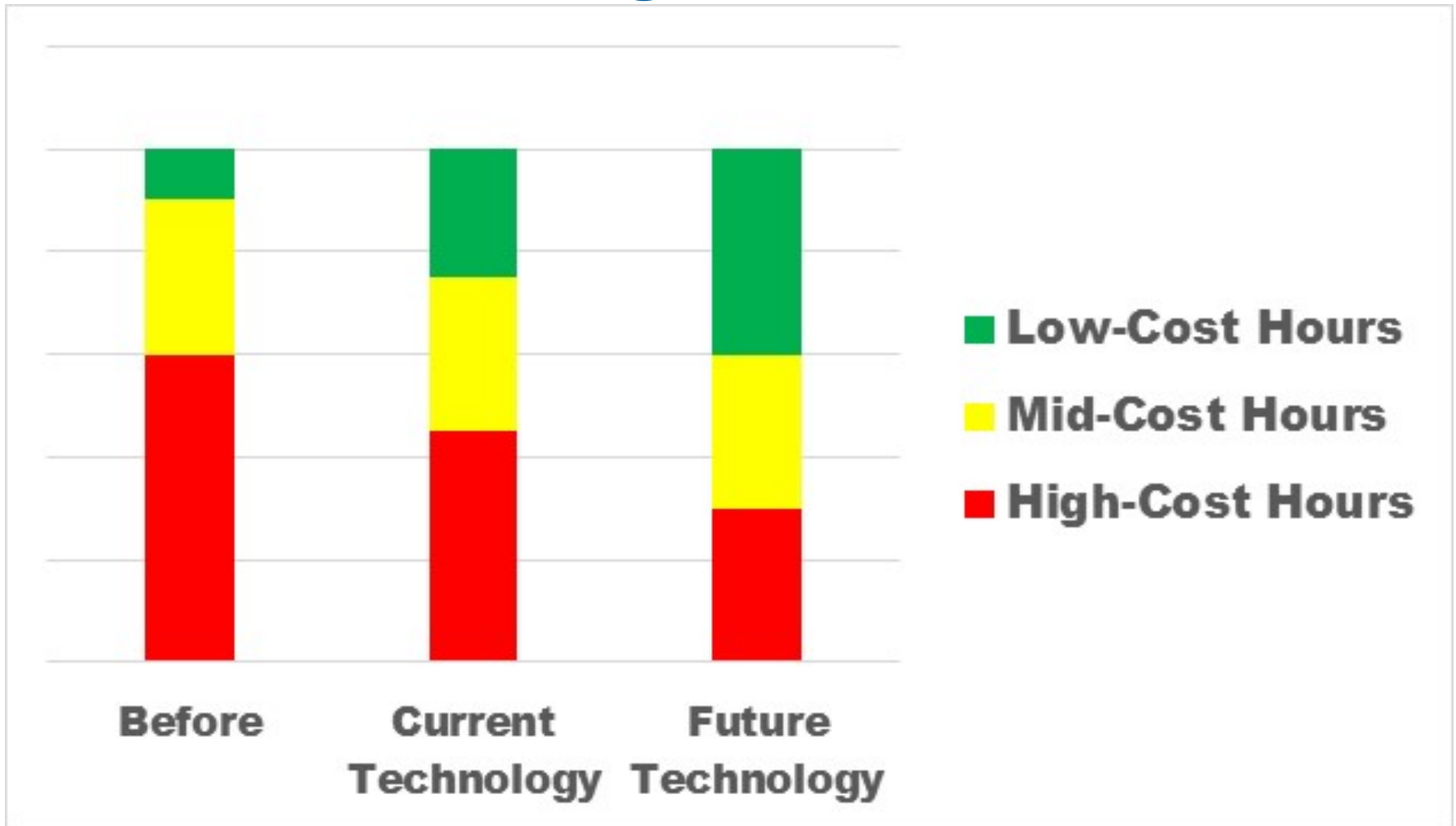
18 SEER compressor

3 hours storage, to
get through high-cost
hours

Air Conditioning Peak Load Potential

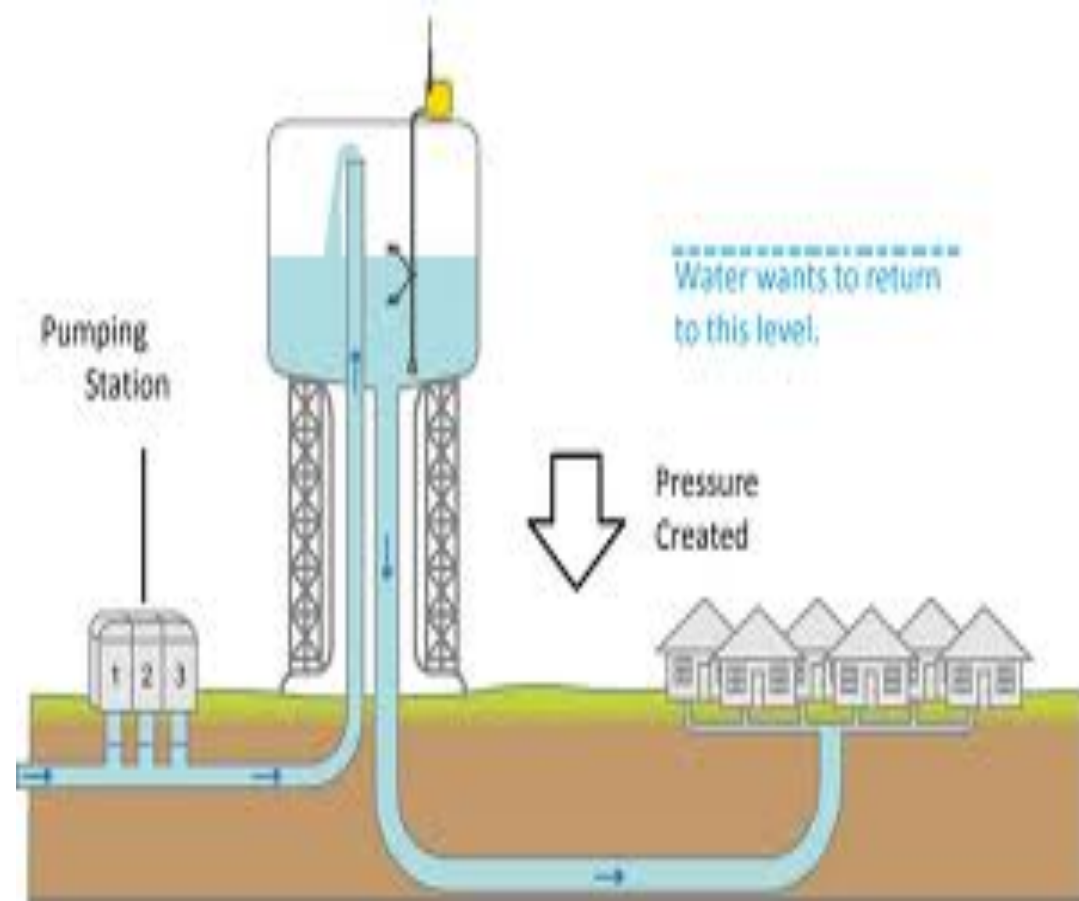


Air Conditioning Load Shift Potential



Water Pumping Potential

- Most water systems maintain significant storage capacity.
- Rate design changes can encourage fewer hours of more intensive pumping.



Electric Vehicle Smart Charging

Could be 10% of new vehicles by 2020.

1.5 million EVs in 2020

10 -20 million EVs in 2030??

Each EV has about the energy usage of a water heater , and requires only 2-4 hours to charge

