

Thermal Strategies for Optimizing Microgrid Resiliency, Costs and Carbon

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International District Energy Association

Microgrids Conference

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45 Years of Experience in Sustainable District Energy Systems

Agenda

- Why microgrids
- Microgrid trends
- Solar role and battery storage
- Dispatchability and the role of CHP
- Non-CHP thermal opportunities
- Thermal energy storage
- Optimizing thermal integration in microgrids

Why Microgrids?

Reliability



Resilience



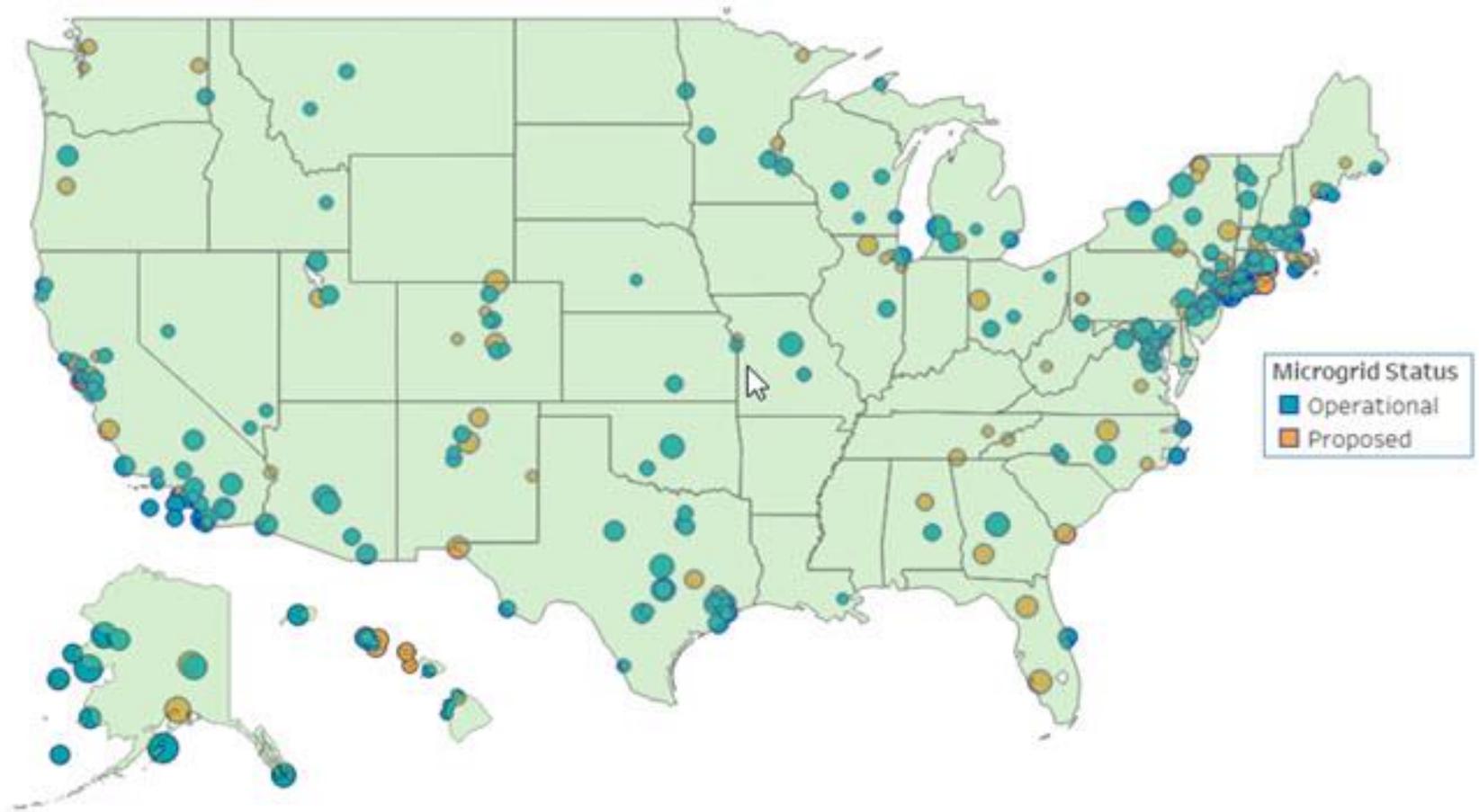
Power quality

Information technology

Sustainability



Microgrid Trends



Courtesy of ICF



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Microgrid Trends

Motivations for energy storage are changing....

Ranking of frequency of services targeted in U.S. storage projects: *

	2009-2014	2015
Renewables capacity firming	1	1
Electric energy time shift	2	8
Frequency regulation	3	3
Electric bill management	4	6
Onsite renewable generation shifting	5	4
Renewable energy time shift	6	9
Electric bill management with renewables	7	7
Voltage support	8	10
Microgrid capability	9	2
Resiliency	17	5

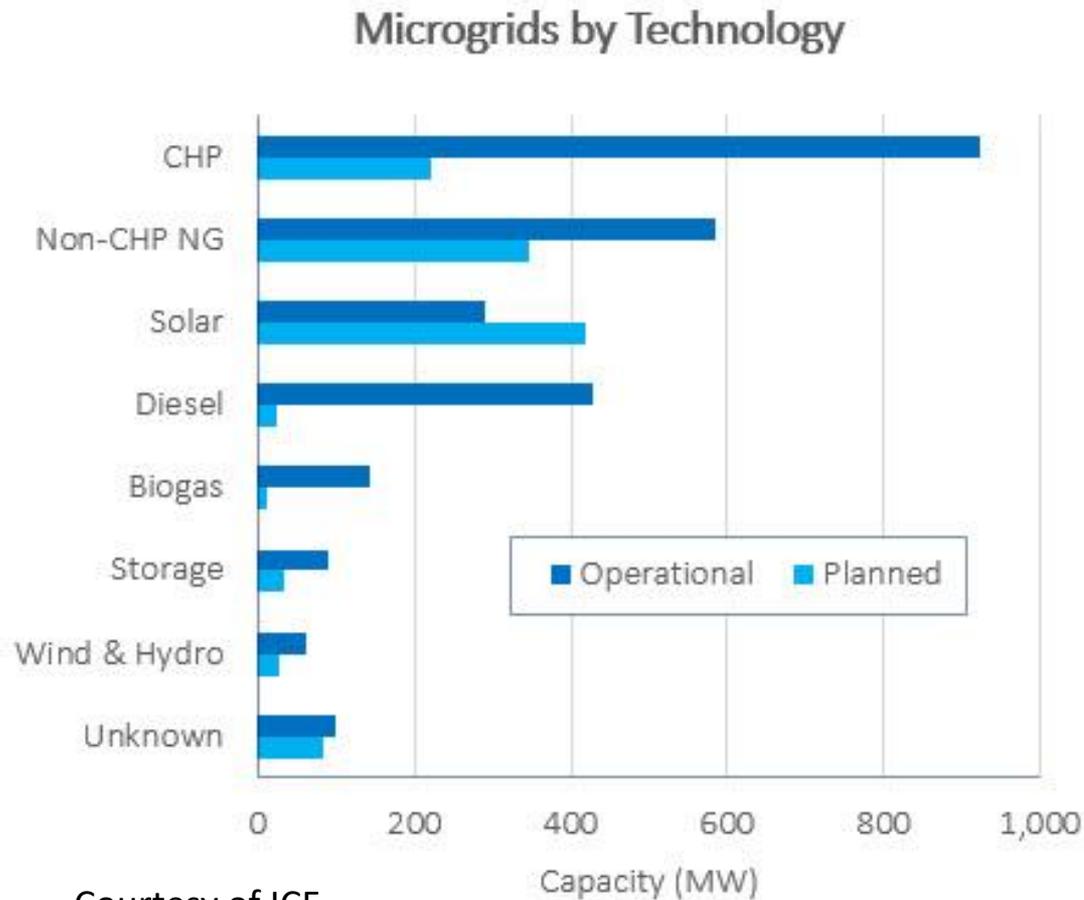
* DOE Global Energy Storage Database



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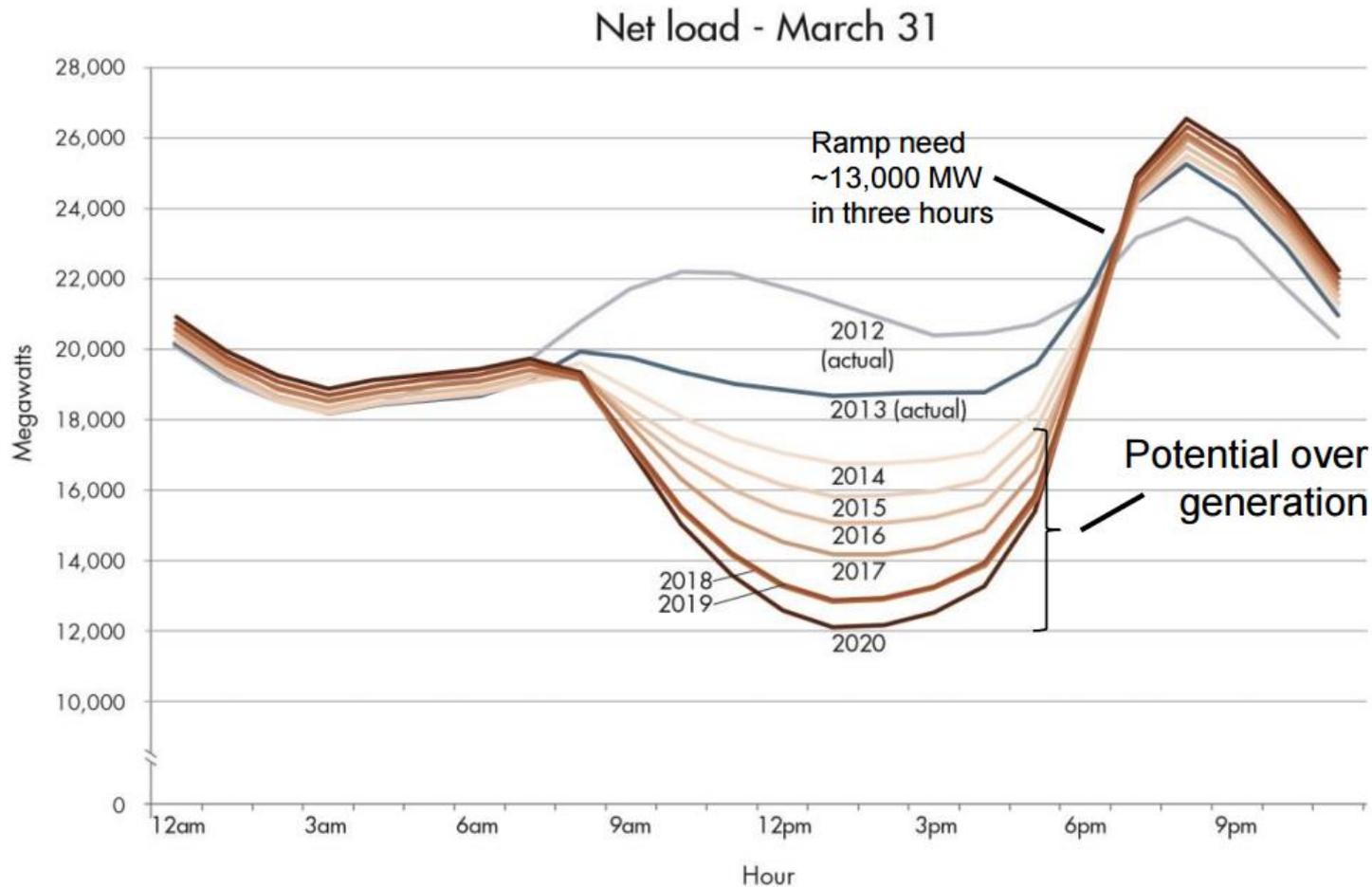
Microgrid Trends

CHP is down, solar is up

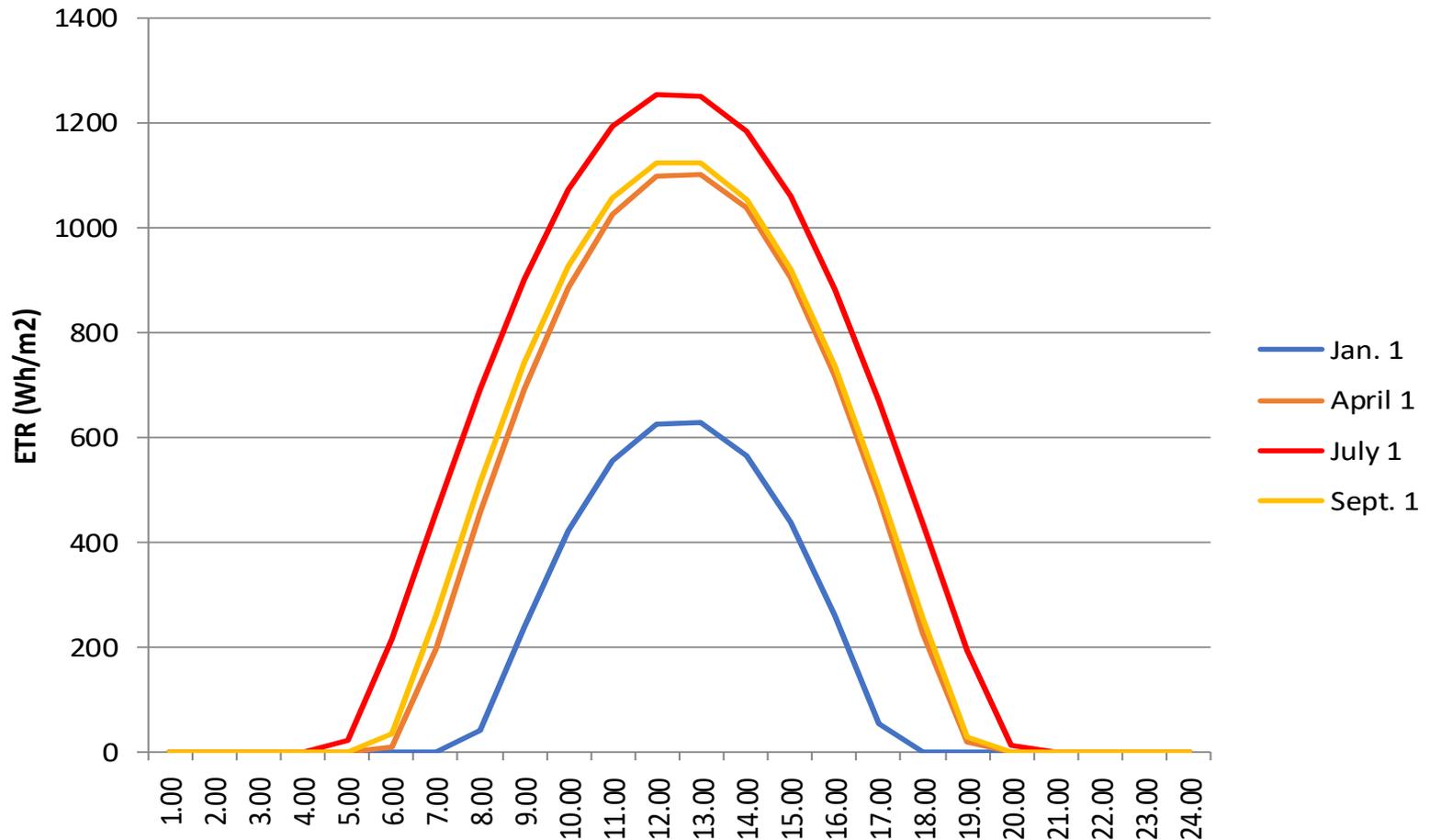


Solar Impacts on Grid

If it walks like a duck...



Solar Irradiance (New Jersey)

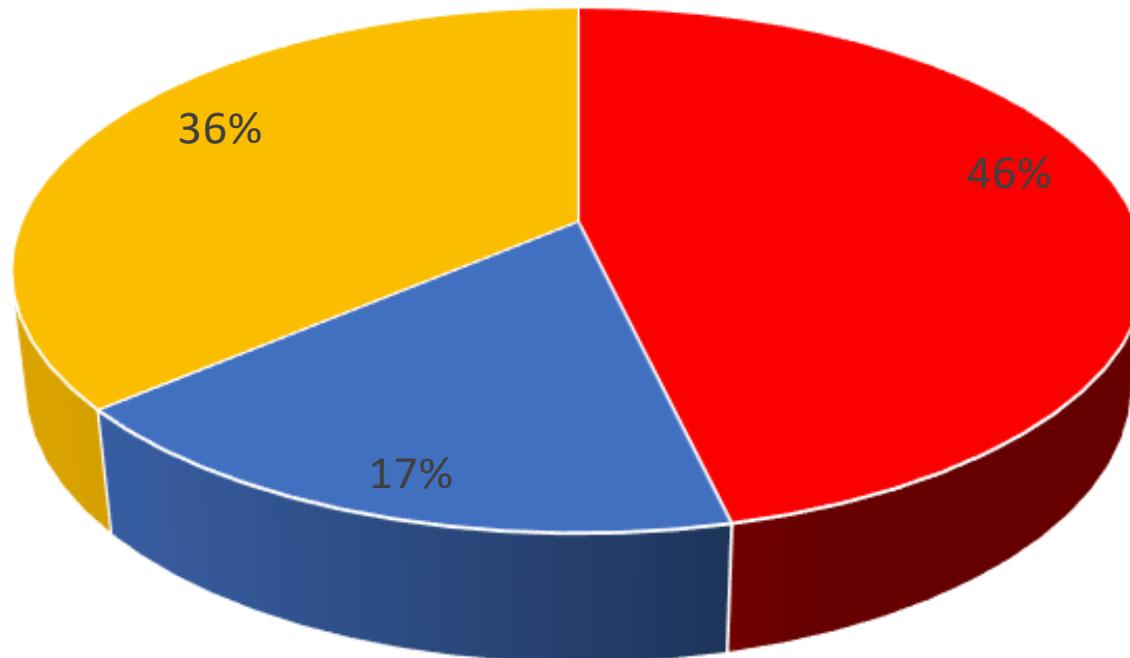


National Solar Radiation Data Base, USAF #724095 - TRENTON MERCER COUNTY AP, NJ
<http://rredc.nrel.gov/solar/>



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Seasonal % of Solar Production (New Jersey)



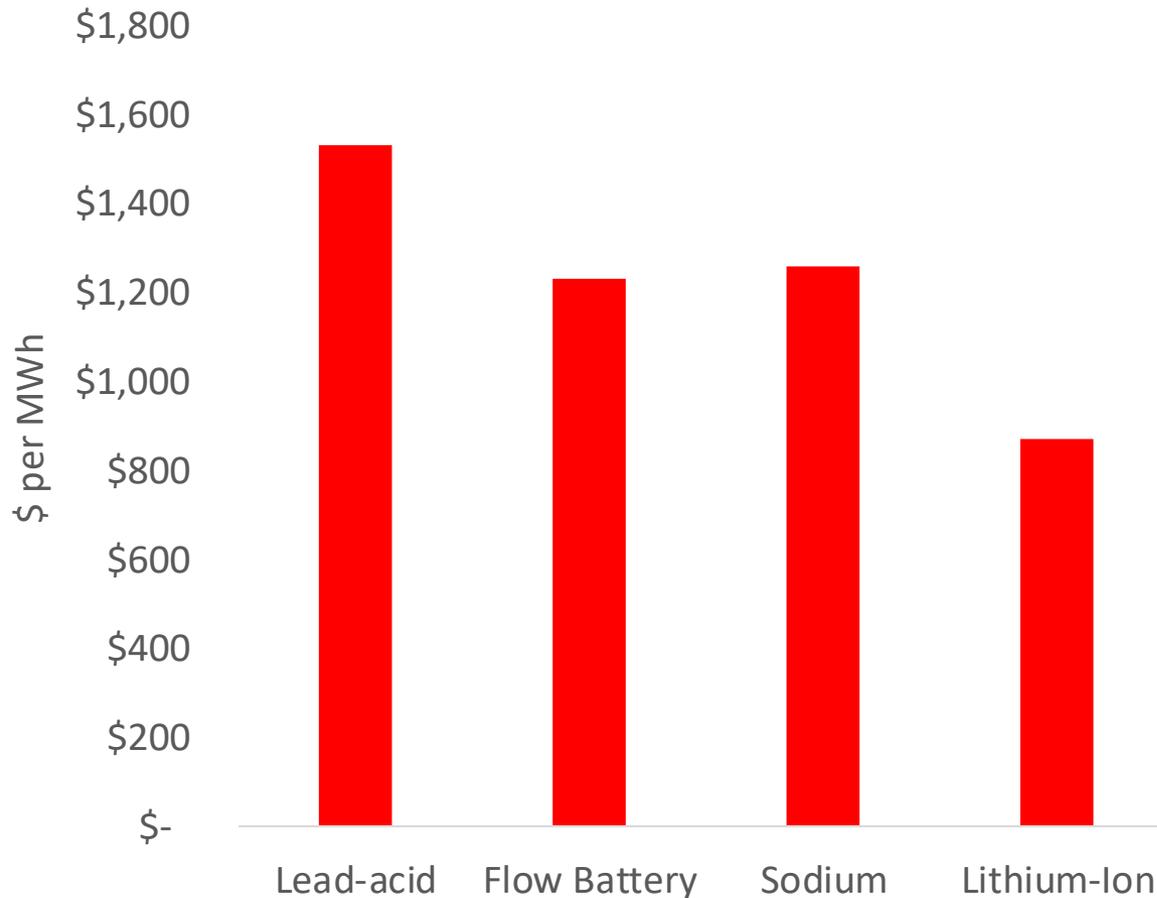
■ Summer ■ Winter ■ Shoulder

Operating data from Princeton University solar PV system



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Battery Storage Costs

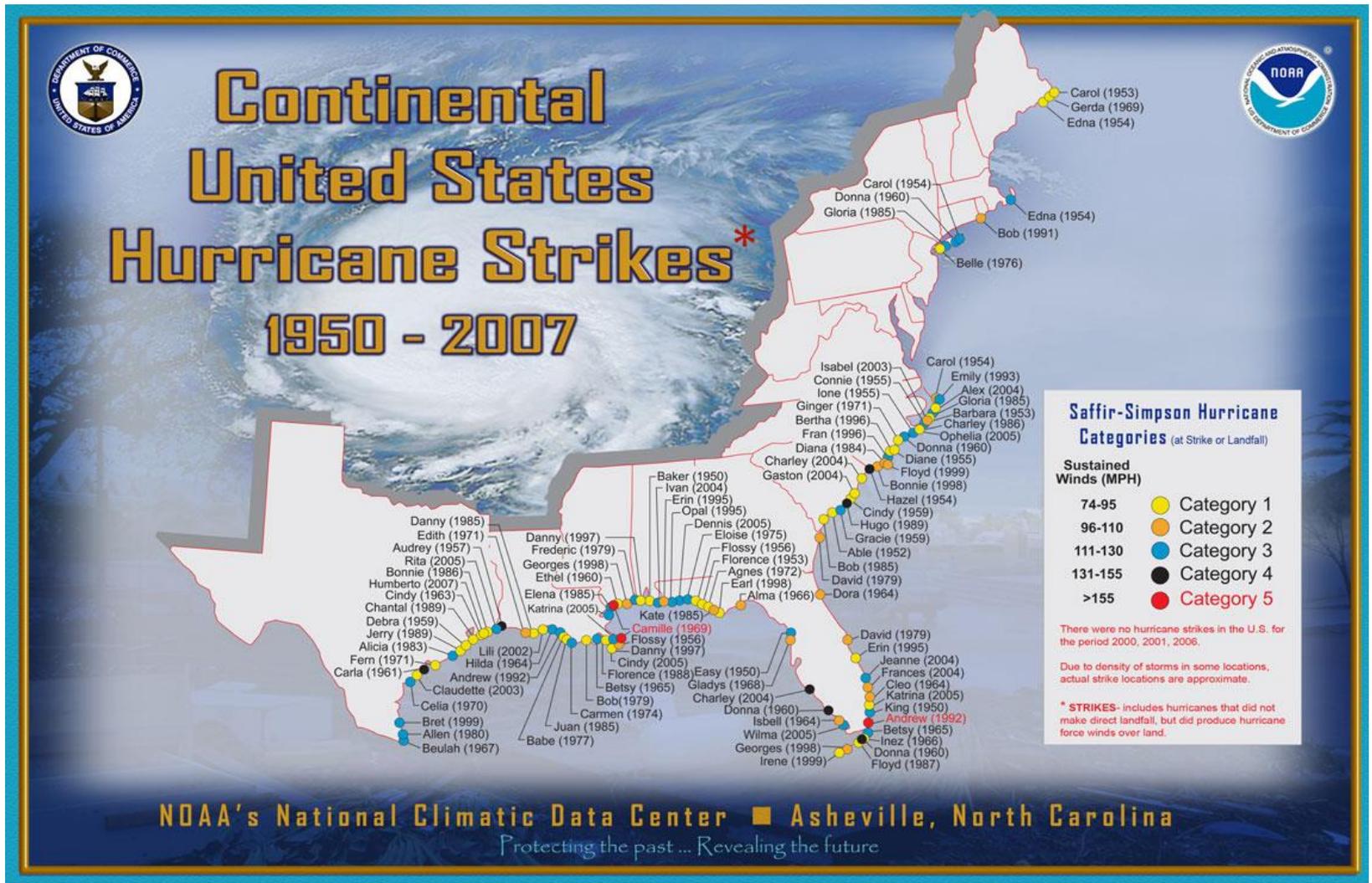


Unsubsidized Levelized Cost for Behind the Meter Islanding, per Lazard's Levelized Cost of Storage Analysis, Nov. 2015



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Hurricane Hit Parade



Dispatchable On-site Generation is a Wonderful Thing

Longest power outages of 2012:

Utility	State	Cause	Outage length (days)
Long Island Power Authority	NY	Hurricane Sandy	14.0
Someset Operating Co.	NY	Coal shortage	12.0
FirstEnergy/Mons Power Company	WV	Hurricane Sandy	12.0
Consolidated Edison	NY	Transformer explosion during Sandy	10.1
FirstEnergy/Potomac Edison	MD, WV	Hurricane Sandy	10.0
FirstEnergy/Met-Ed	PA	Hurricane Sandy	9.3
FirstEnergy/Potomac Edison	MD, WV	Derecho thunderstorm	8.0
Public Service Electric & Gas	NJ	Hurricane Sandy	7.8
Atlantic City Electric	NJ	Derecho thunderstorm	7.7
FirstEnergy/CEI	OH	Hurricane Sandy	7.3

U.S. Energy Information Administration data, per www.utilitydive.com/news/the-10-longest-power-outages-of-2012/92756/

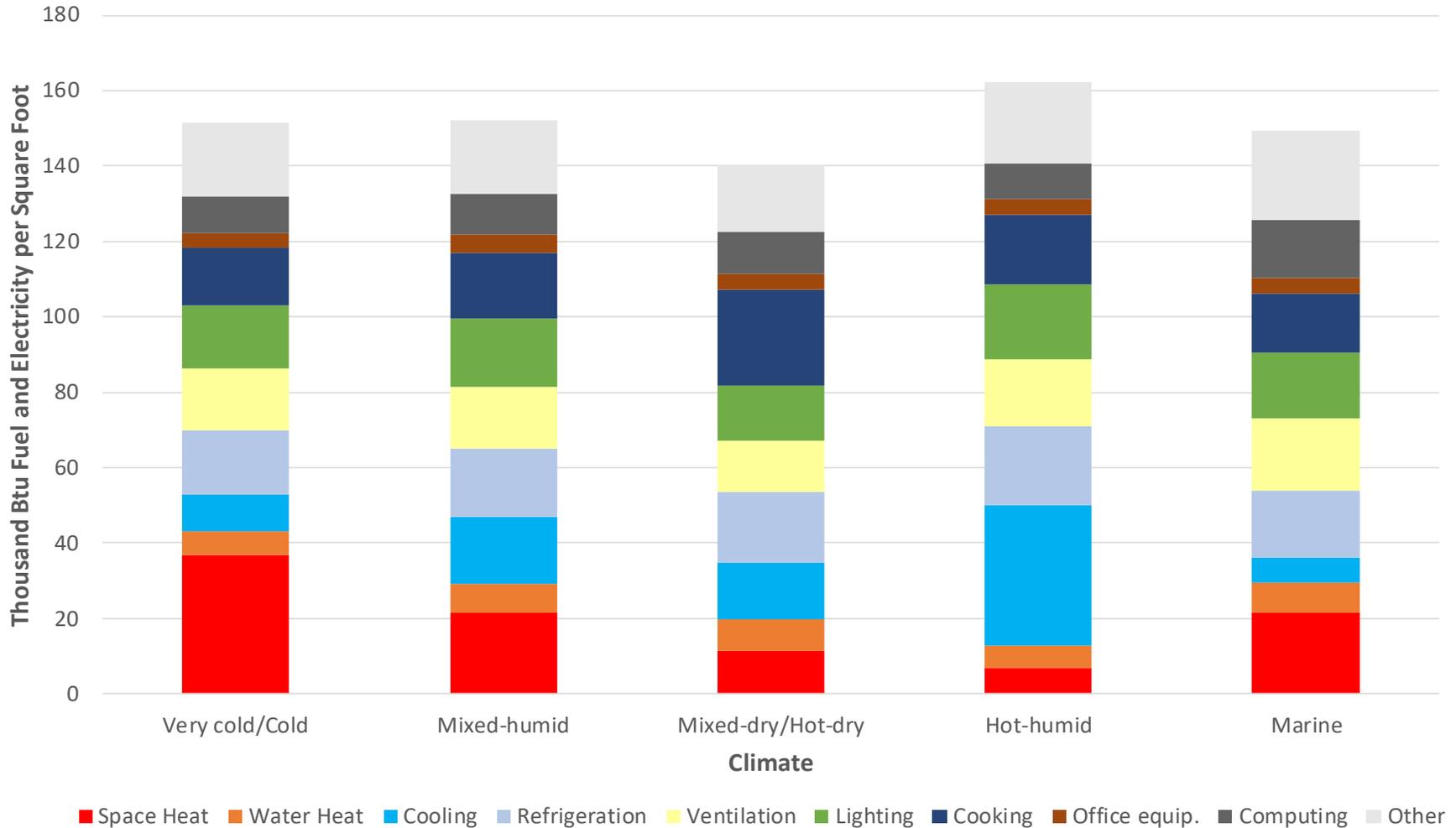


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CHP Integrated with District Energy

- District energy enhances CHP economics and efficiency
- Multiple opportunities for Demand Response
 - Ramp up CHP power generation
 - Absorb and store excess thermal or electric energy
 - Shift from electric to thermally-driven energy sources to meet energy requirements
 - Reduce grid power by drawing on thermal storage
 - Island
- Fuel flexibility (natural gas, biogas, biodiesel)

Commercial Buildings Energy End Use

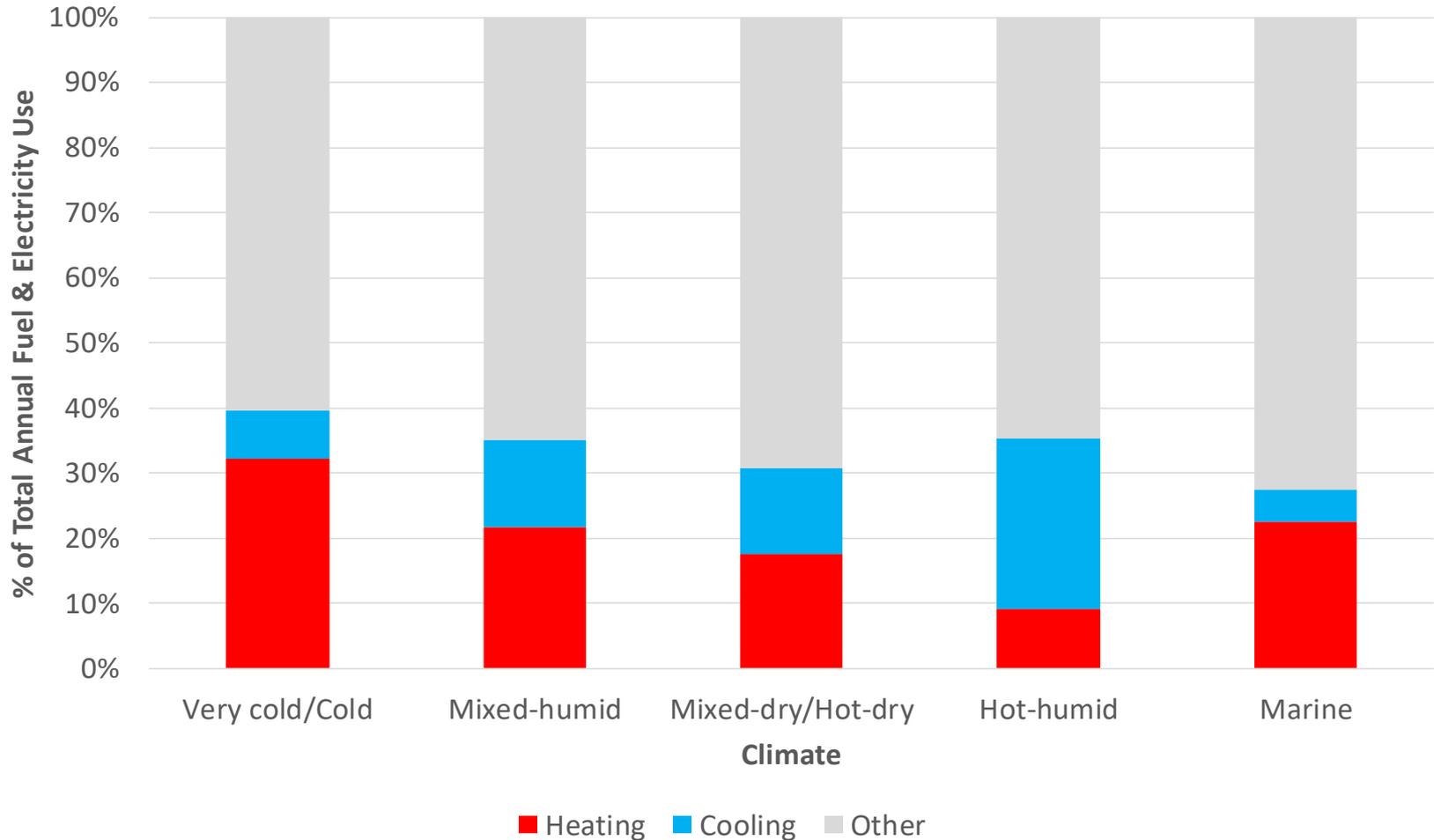


From U.S. Energy Information Administration, 2012 Commercial Building Energy Consumption Survey



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Commercial Buildings Energy End Use

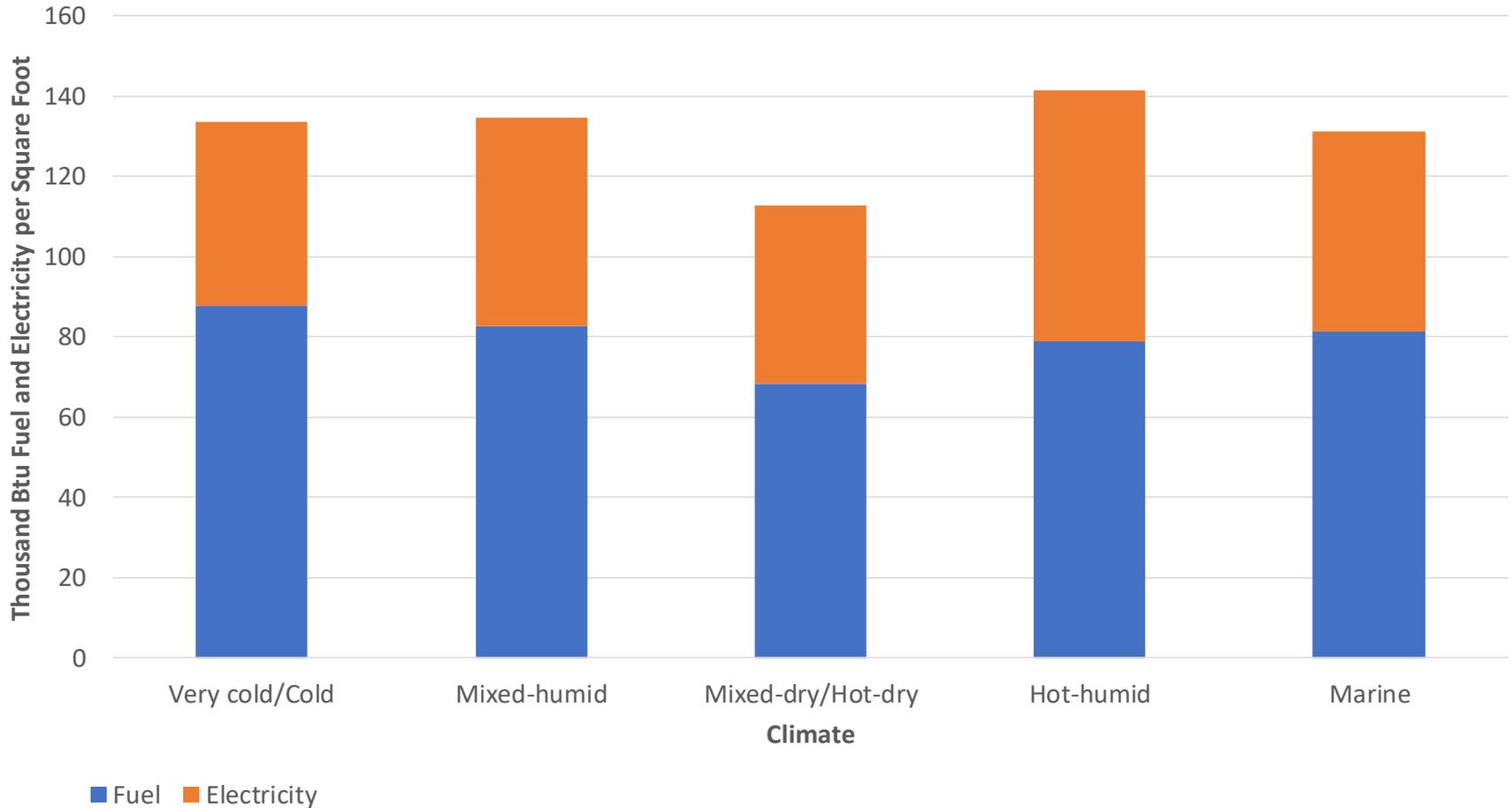


From U.S. Energy Information Administration, 2012 Commercial Building Energy Consumption Survey



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Commercial Buildings Energy Sources



From U.S. Energy Information Administration, 2012 Commercial Building Energy Consumption Survey



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Thermal Opportunities

Heat Recovery Chillers

- Essential to analyze 8760 hour loads
- Magnitude of opportunity is highly dependent on climate

Geoexchange

- Must size properly for heating/cooling load balance
- Closed Loop (borehole) most common

River, Lake or Ocean as Heat Source/Sink

Sewage Heat Recovery

- Multiple projects in Sweden
- Largest operating N. American system in Vancouver (raw sewage)
- Under consideration in Denver

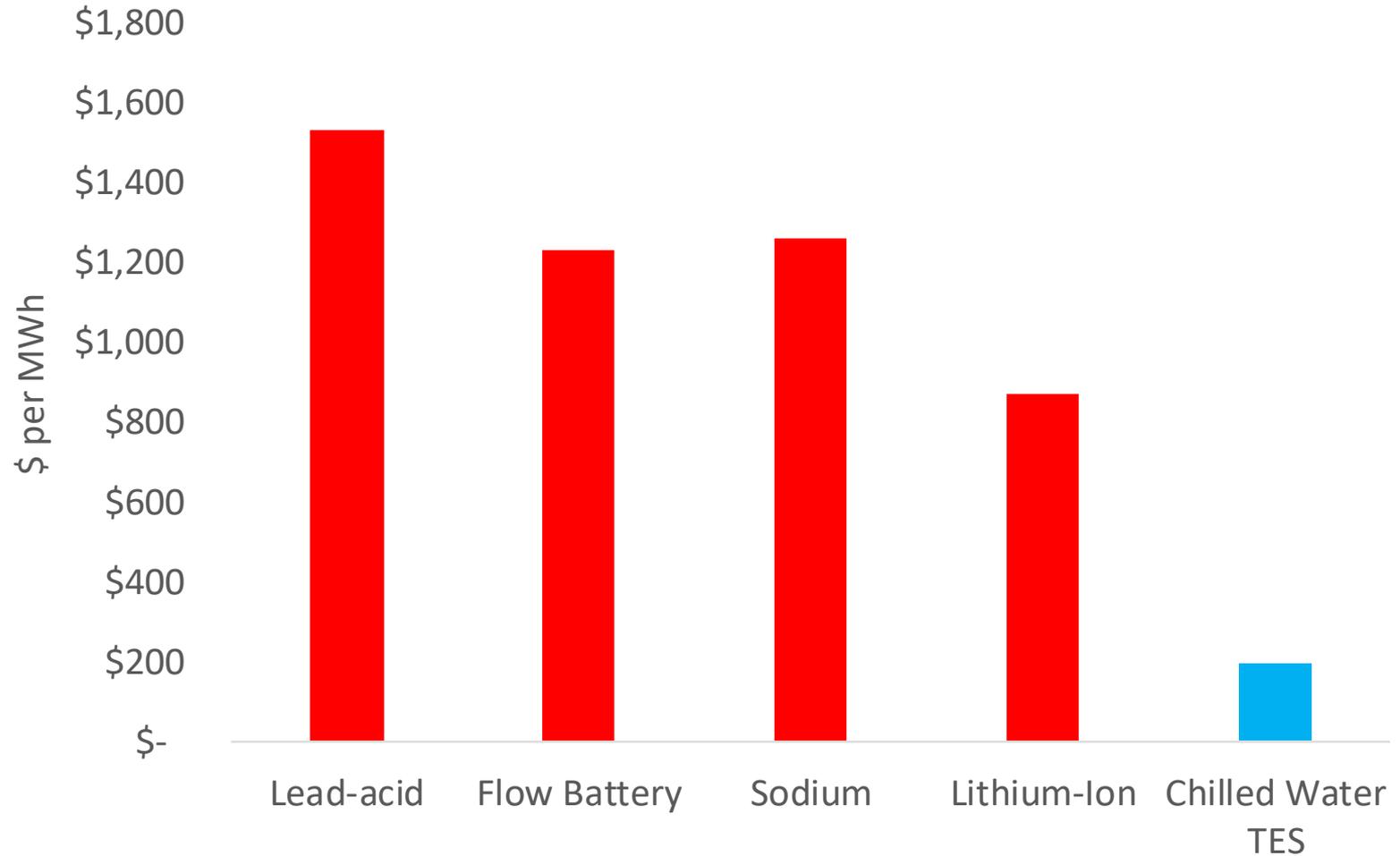


Short Term Thermal Energy Storage

- Cooling
 - Chilled Water
 - Ice
 - Phase change material
 - Low temperature fluid
- Heat
 - Hot water
 - Hot oil
 - Molten salt
 - Rock



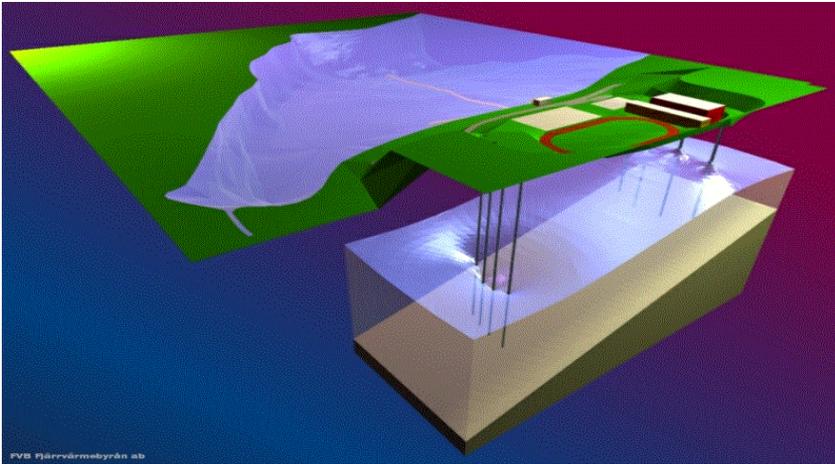
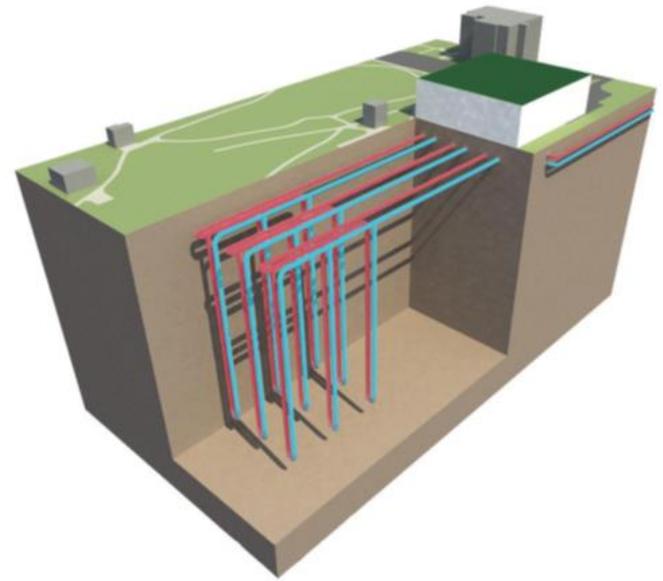
Comparing Chilled Water TES to Battery Storage



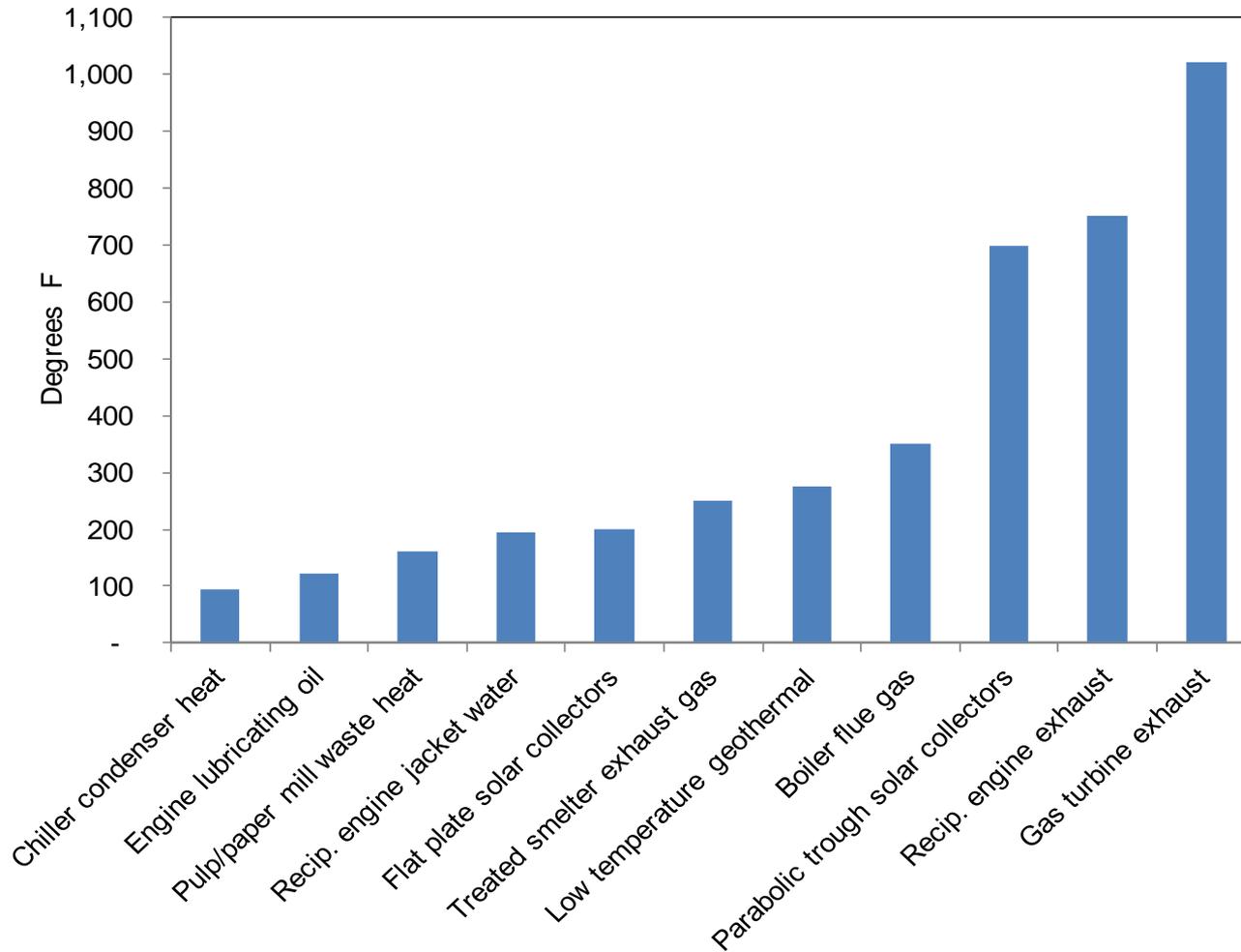
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Seasonal Thermal Energy Storage

- Aquifer
- Borehole
- Pits



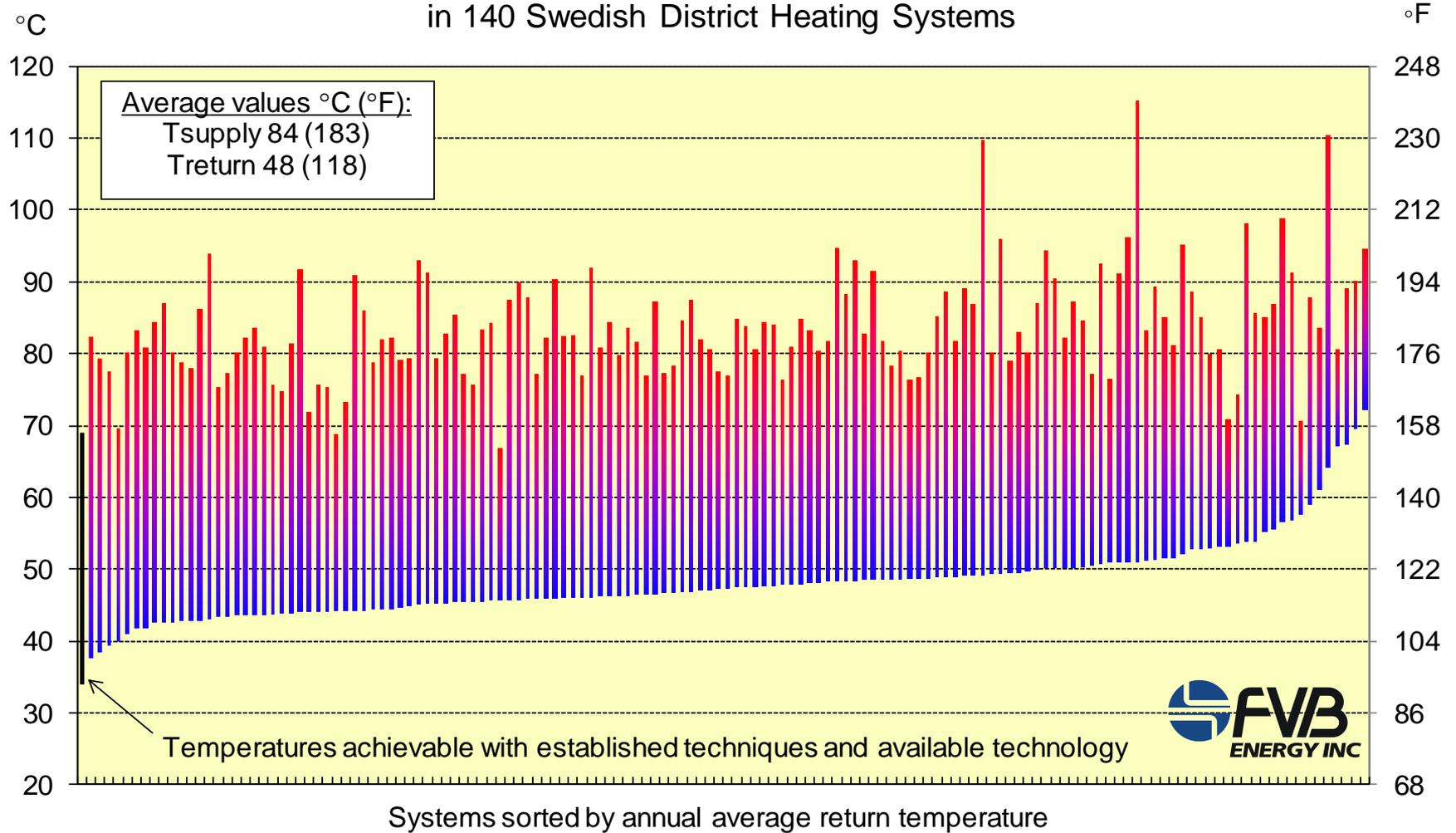
Low District Heat Temps Facilitate Low-Carbon Sources



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Temperatures in Operating Swedish Systems

Annual average supply and return temperatures
in 140 Swedish District Heating Systems



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Hot Water Piping Technologies



Thanks for your attention!

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