

Thermal Strategies for Optimizing Microgrid Resiliency, Costs and Carbon

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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



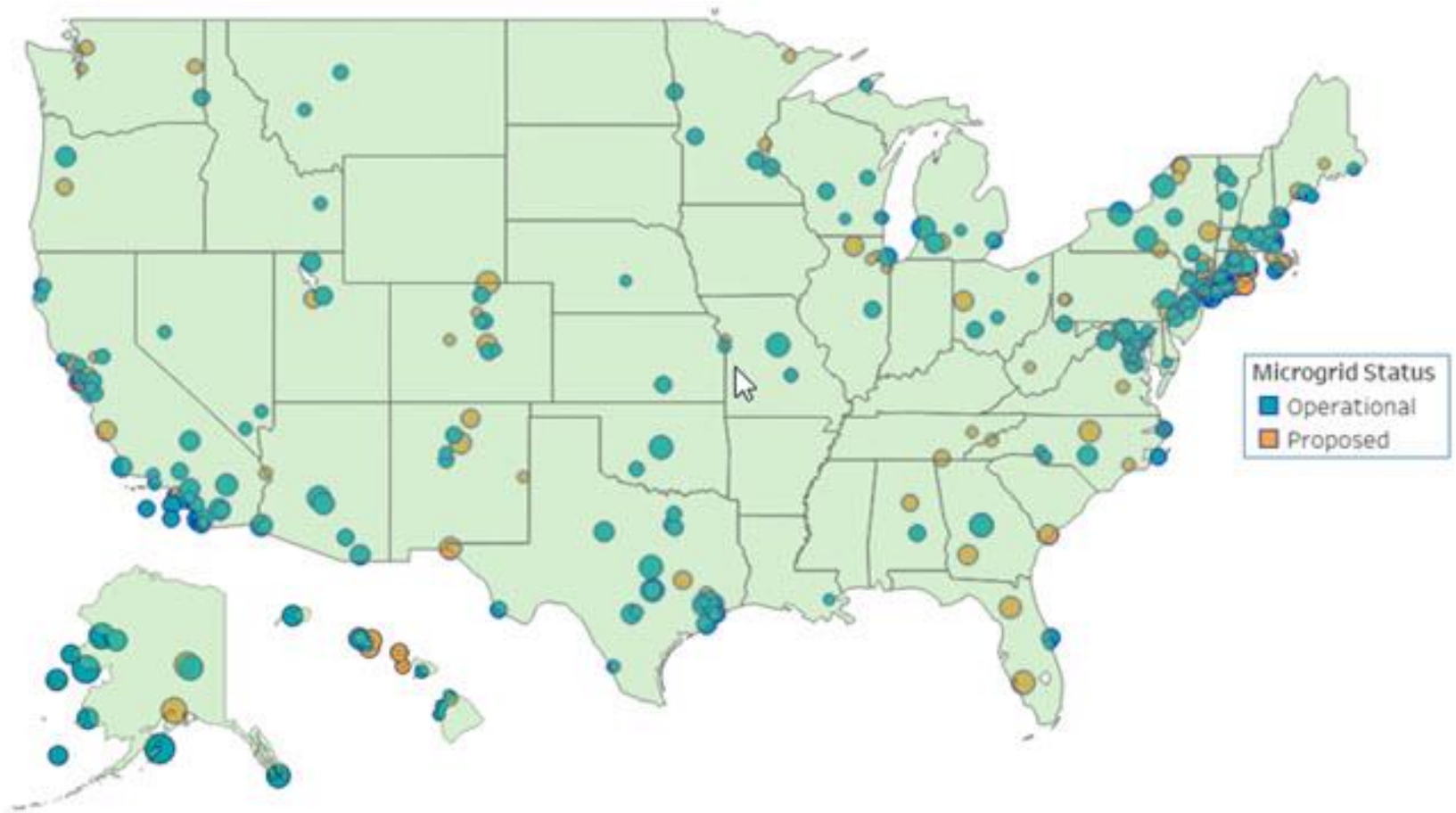
Power quality

Information technology

Sustainability



Microgrid Trends



Courtesy of ICF

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

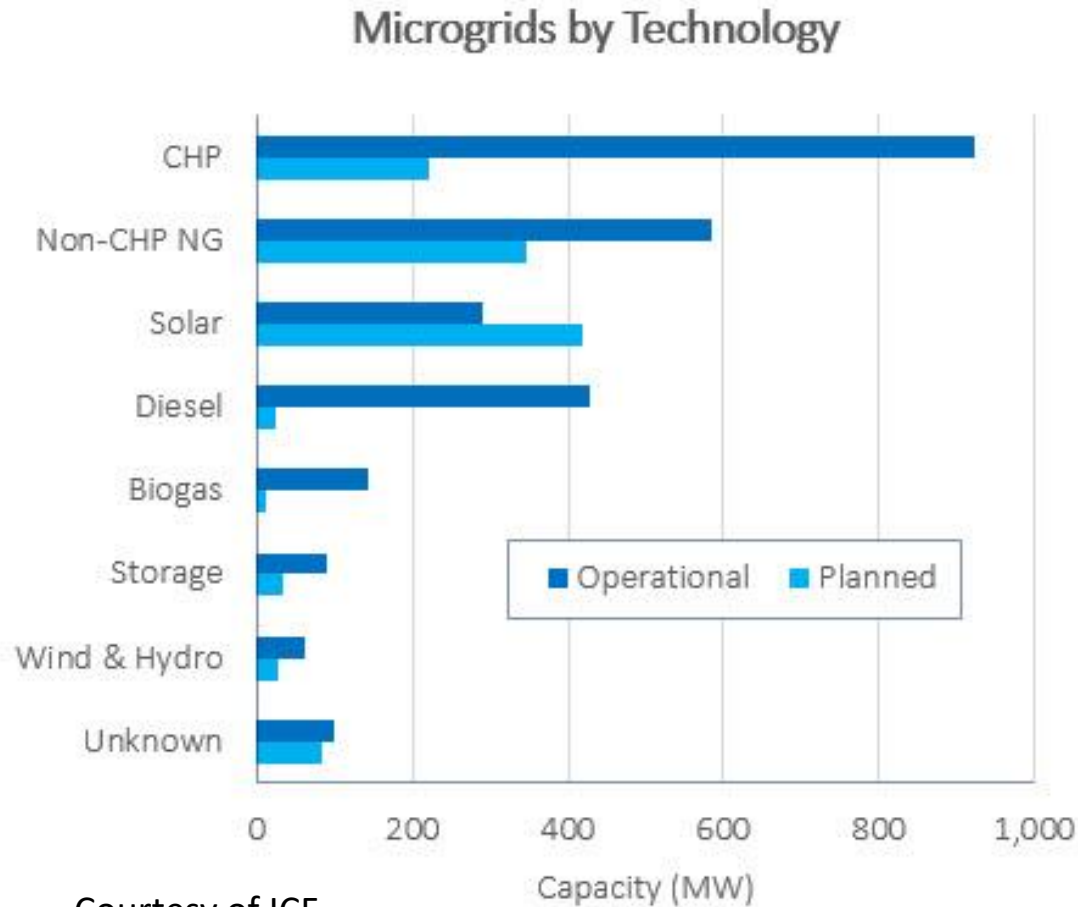
* DOE Global Energy Storage Database



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Microgrid Trends

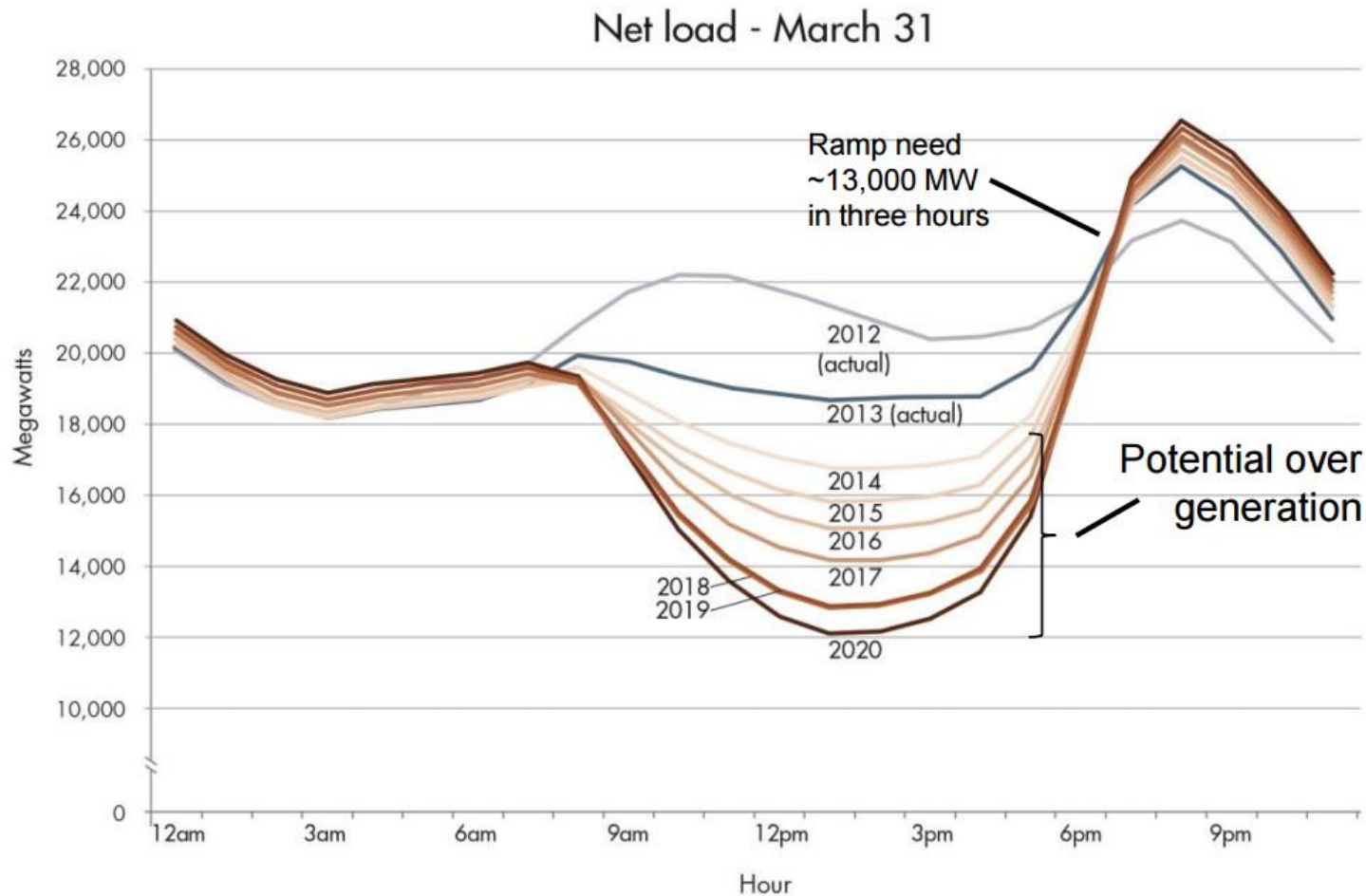
CHP is down, solar is up



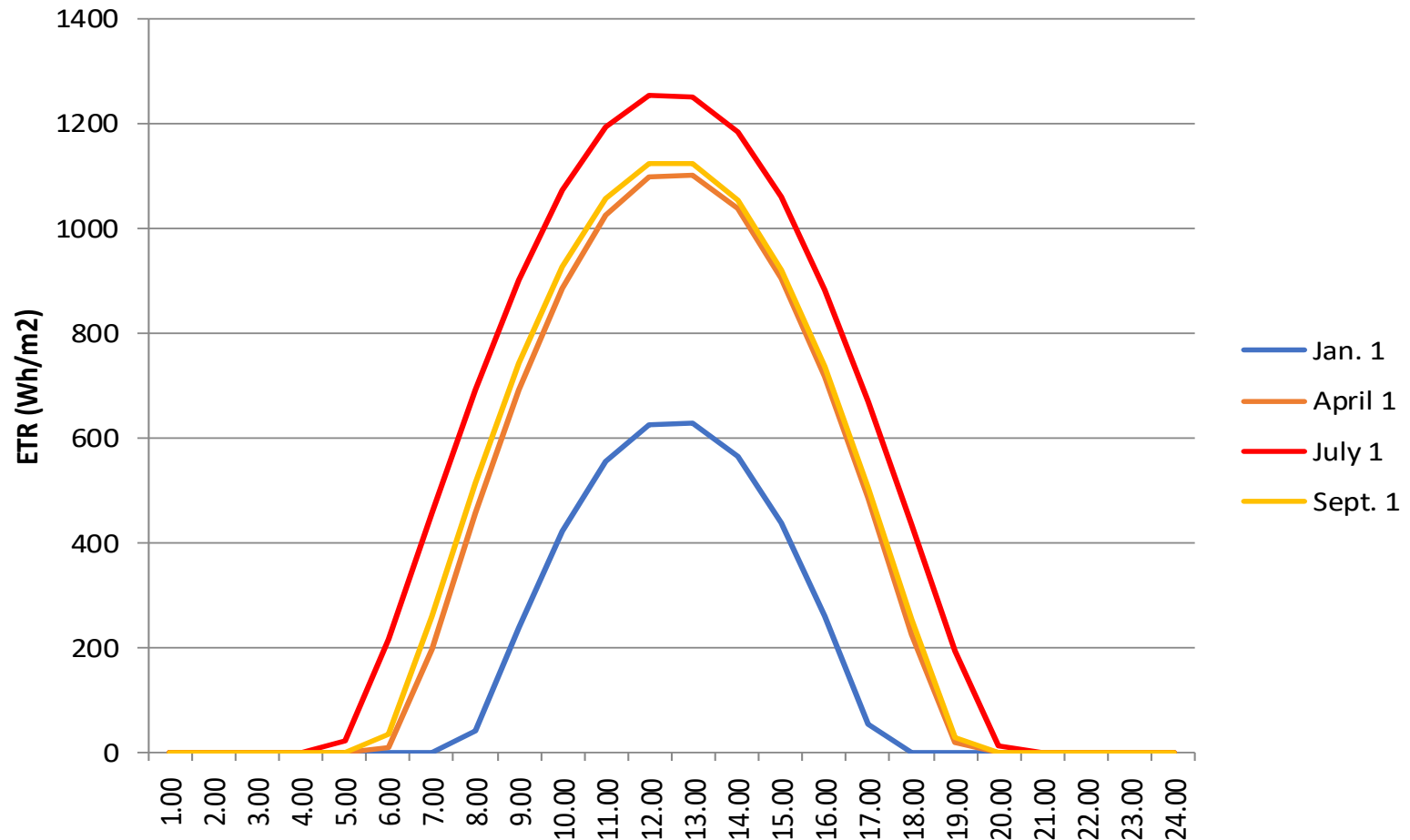
Courtesy of ICF

Solar Impacts on Grid

If it walks like a duck...

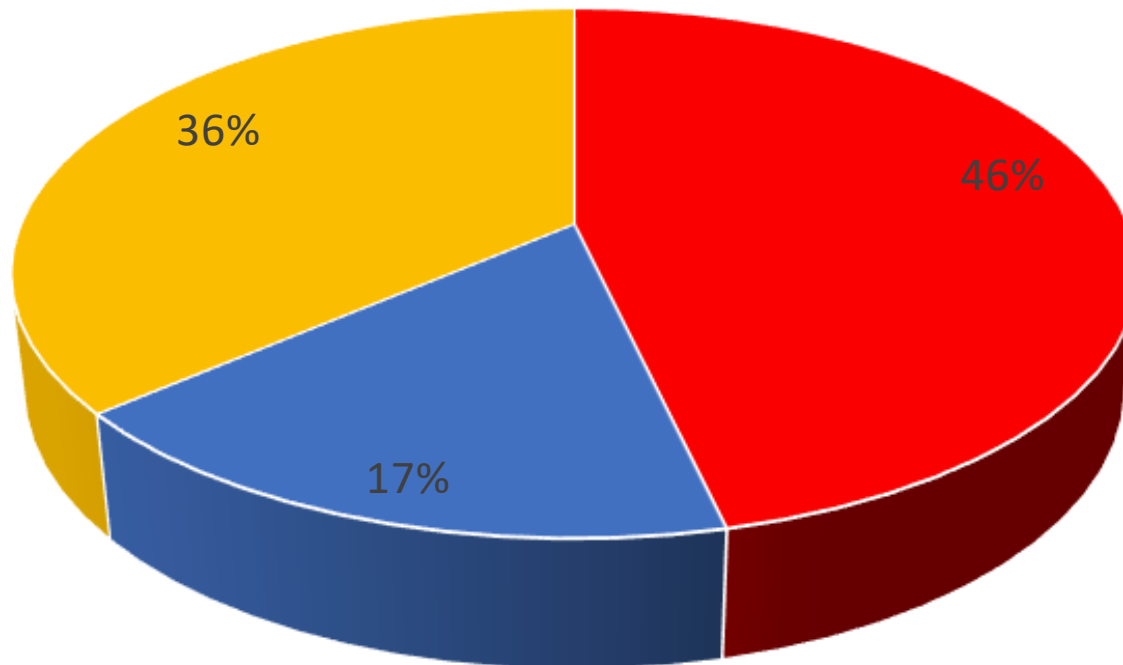


Solar Irradiance (New Jersey)



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

Seasonal % of Solar Production (New Jersey)



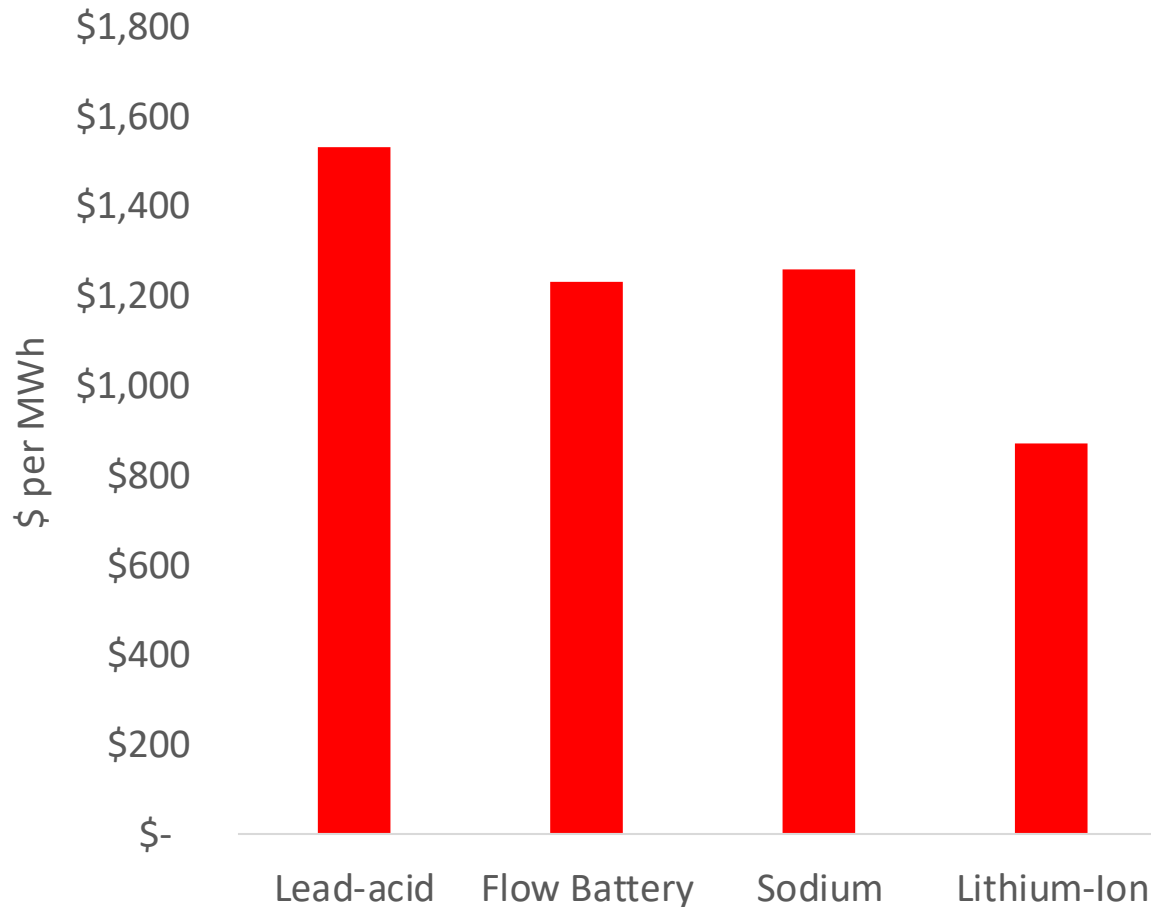
■ Summer ■ Winter ■ Shoulder

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

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/

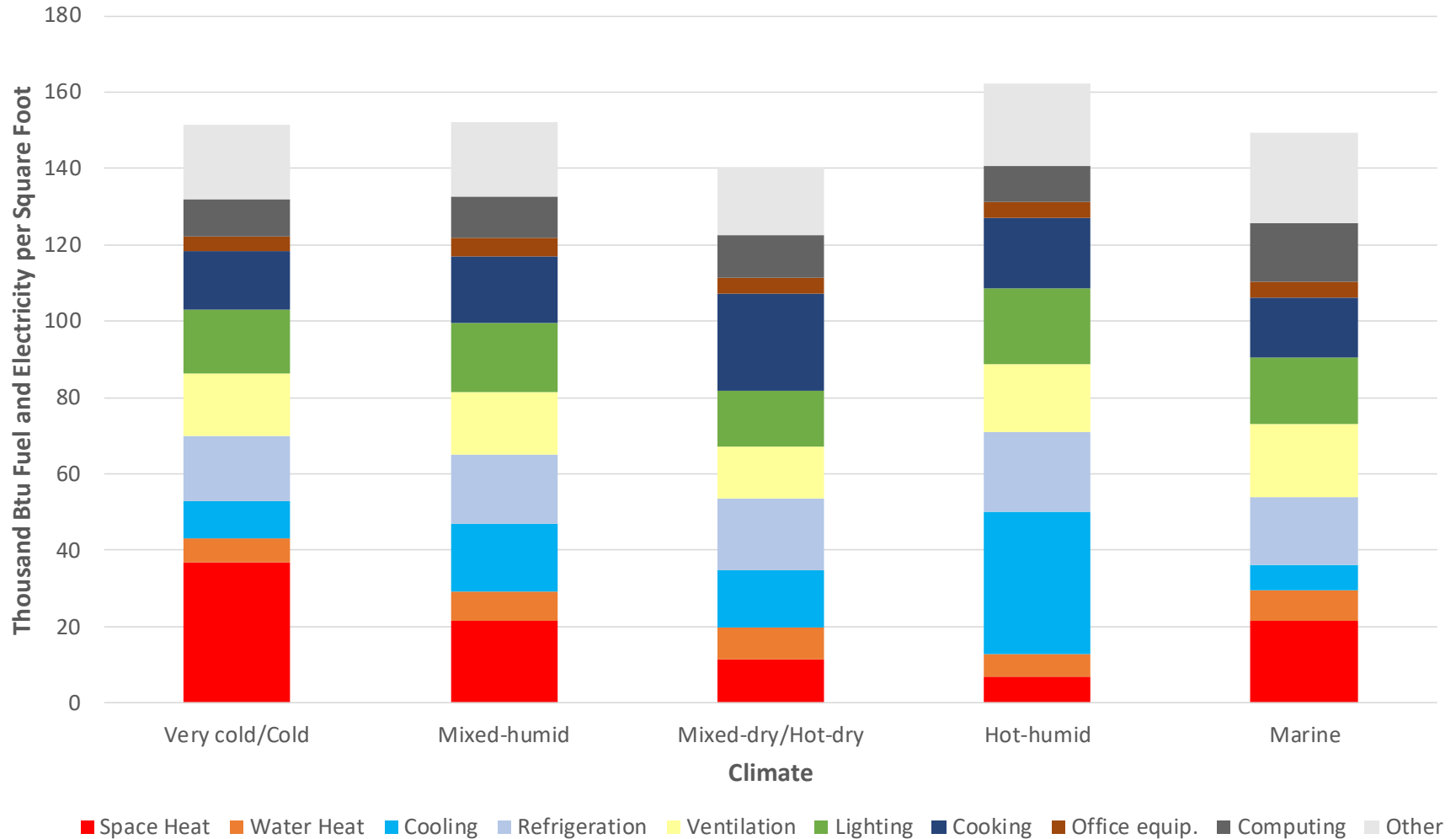


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CHP Integrated with District Energy

- 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

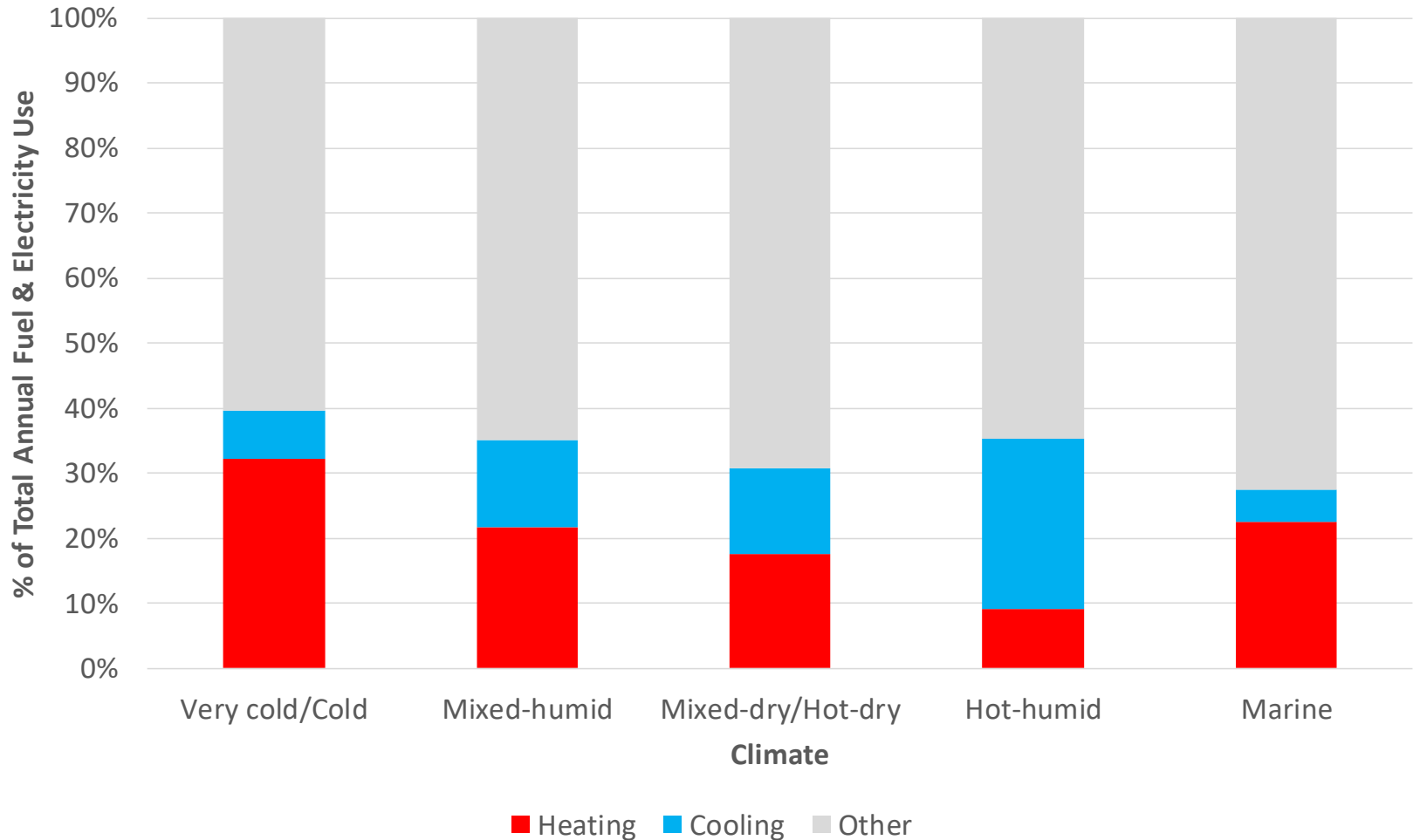


From U.S. Energy Information Administration, 2012 Commercial Building Energy Consumption Survey



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Commercial Buildings Energy End Use

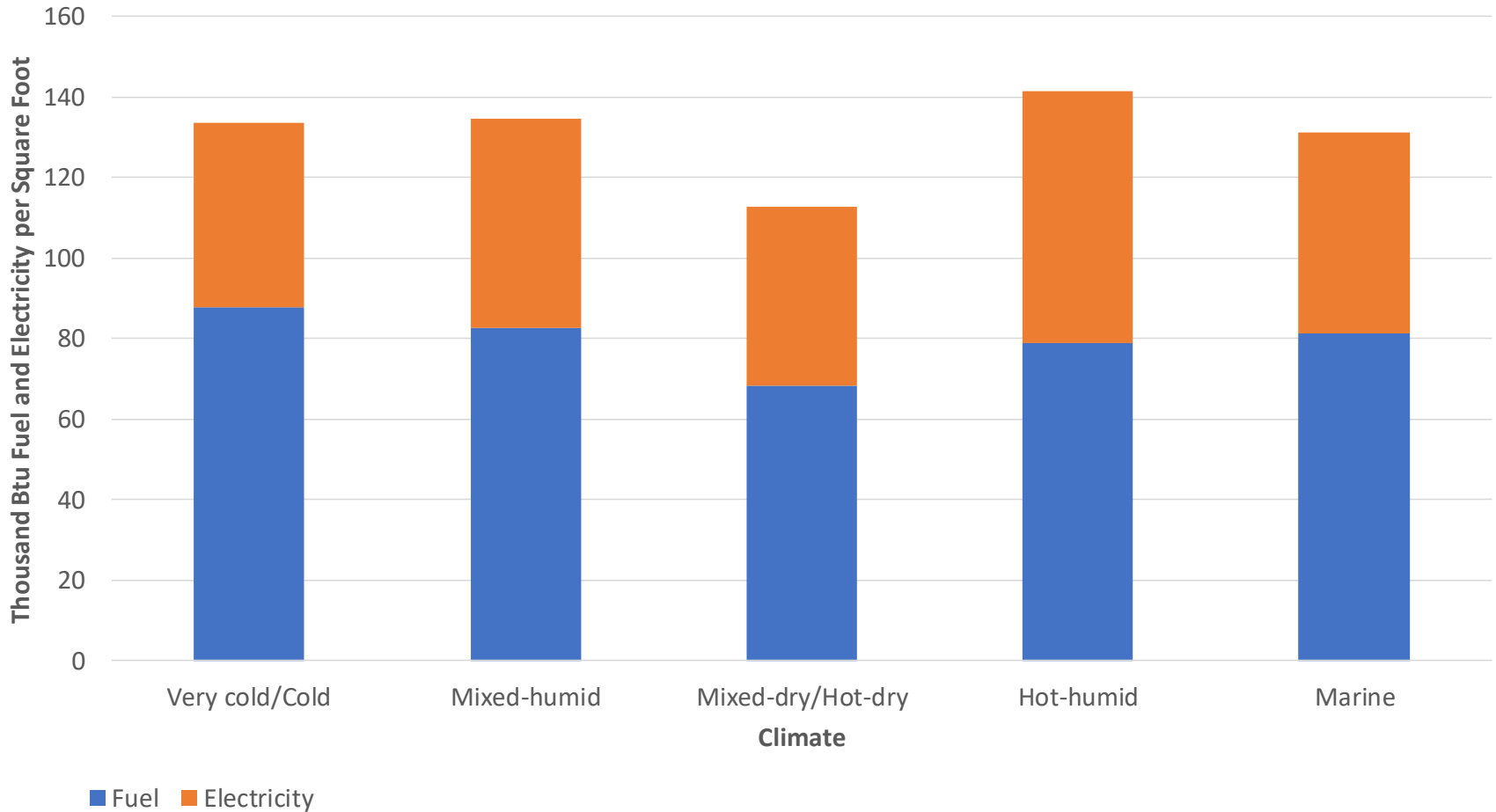


From U.S. Energy Information Administration, 2012 Commercial Building Energy Consumption Survey



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Commercial Buildings Energy Sources



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

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

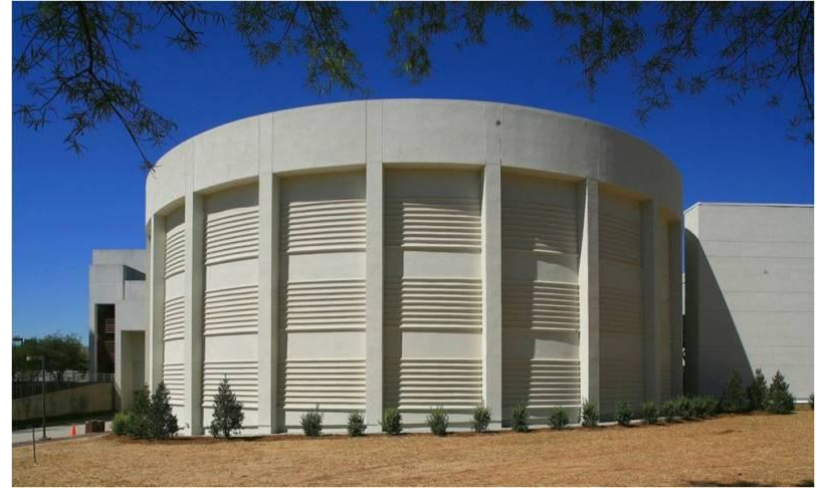
Sewage Heat Recovery

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

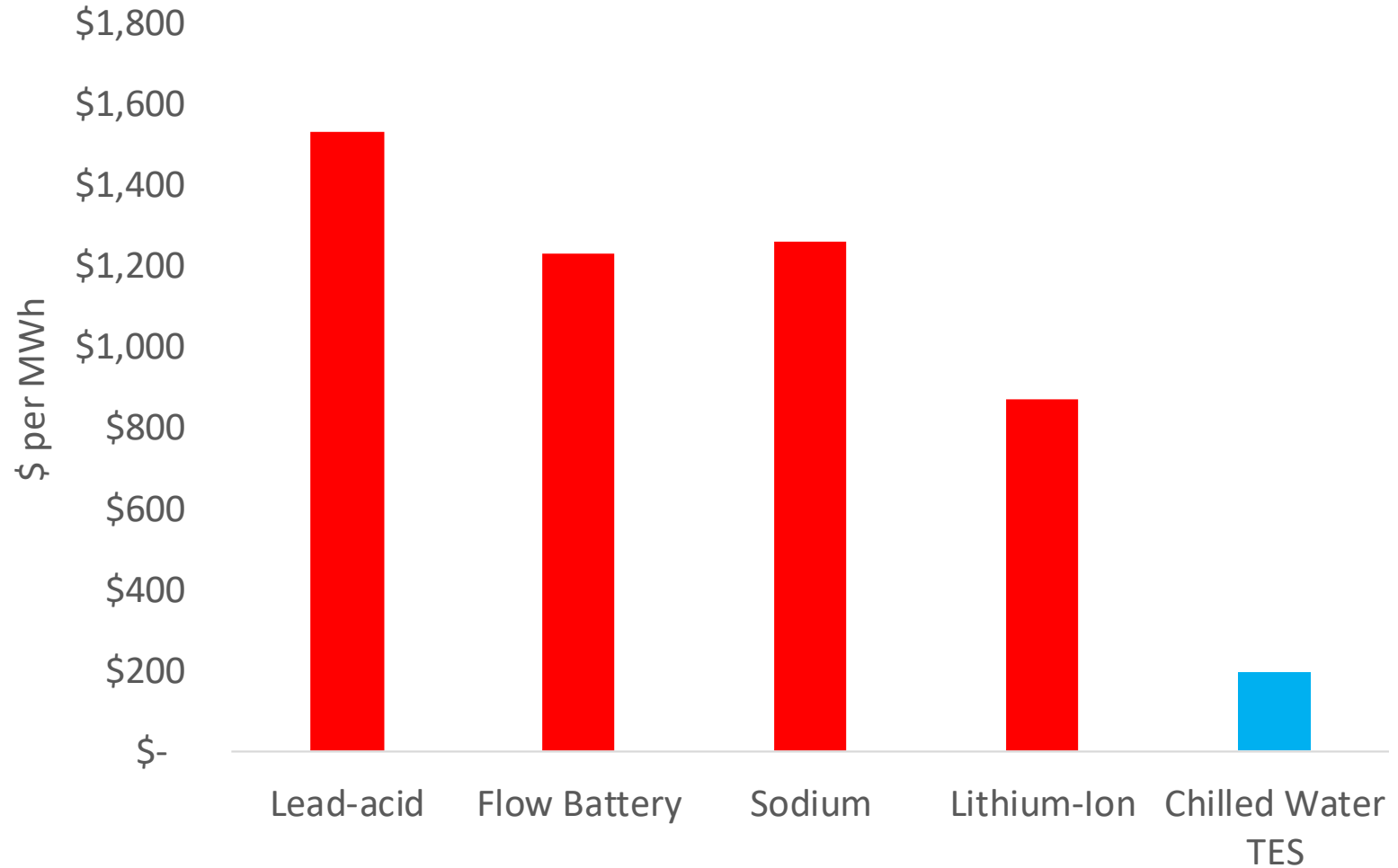


Short Term Thermal Energy Storage

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

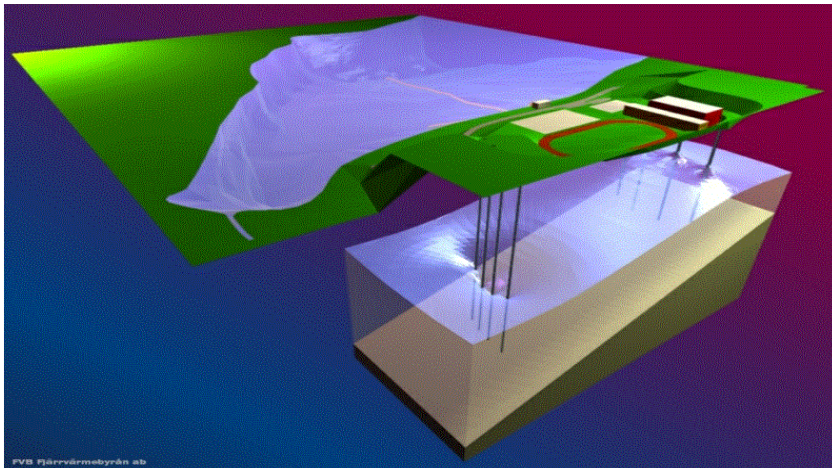
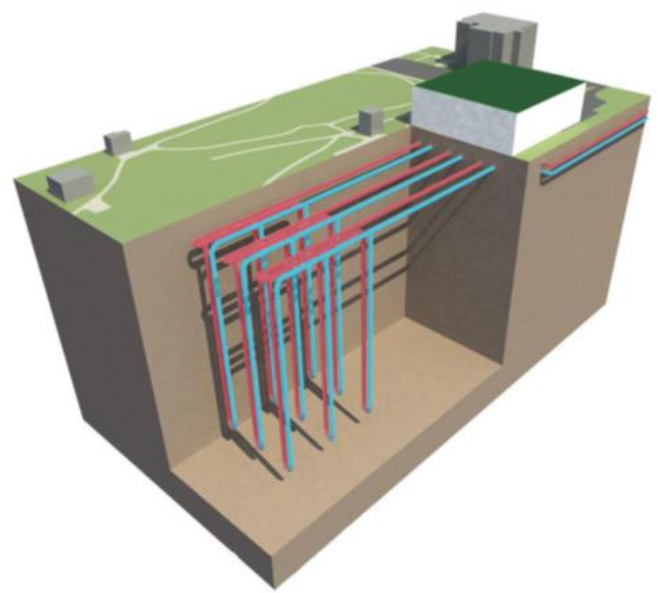


Comparing Chilled Water TES to Battery Storage

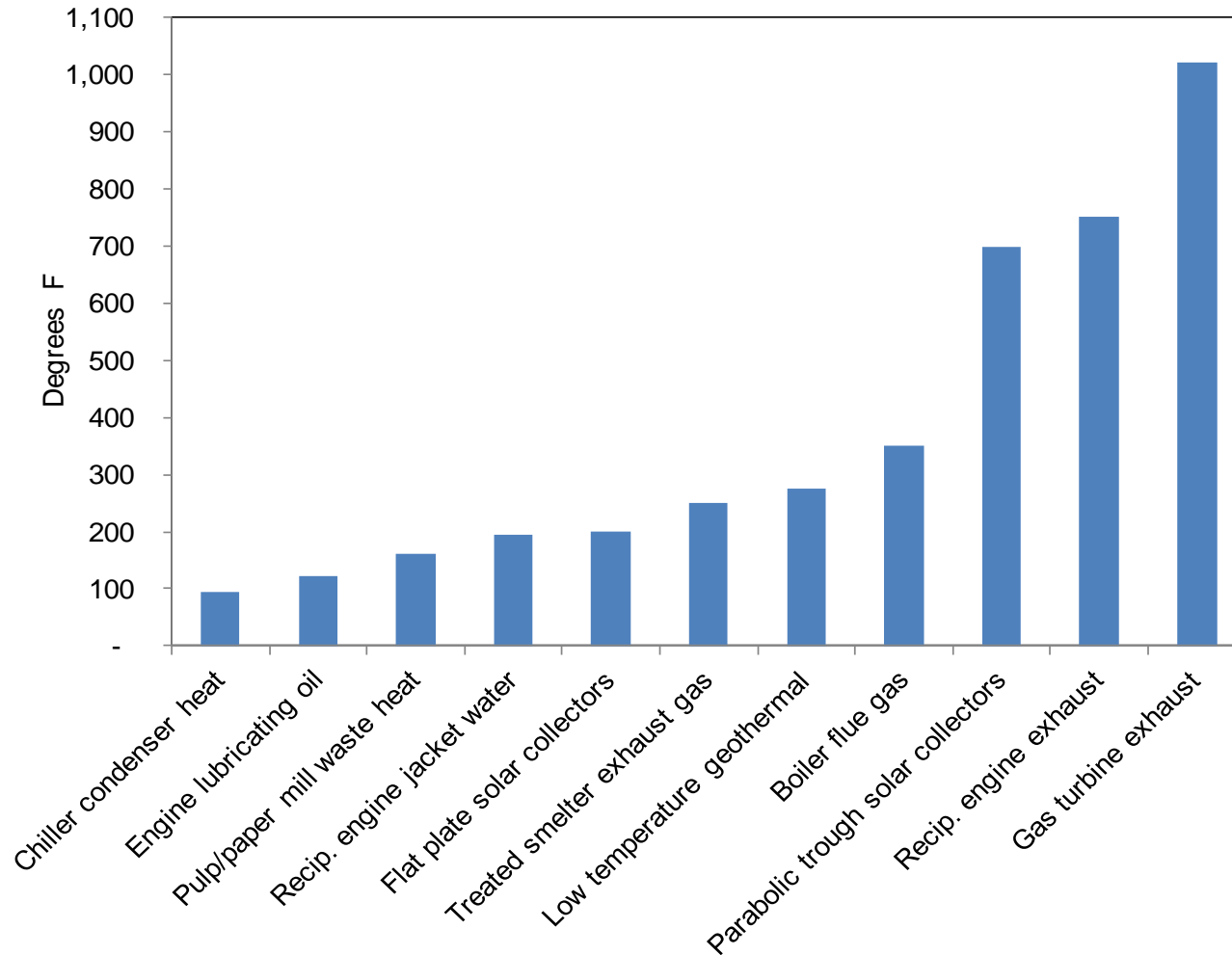


Seasonal Thermal Energy Storage

- Aquifer
- Borehole
- Pits

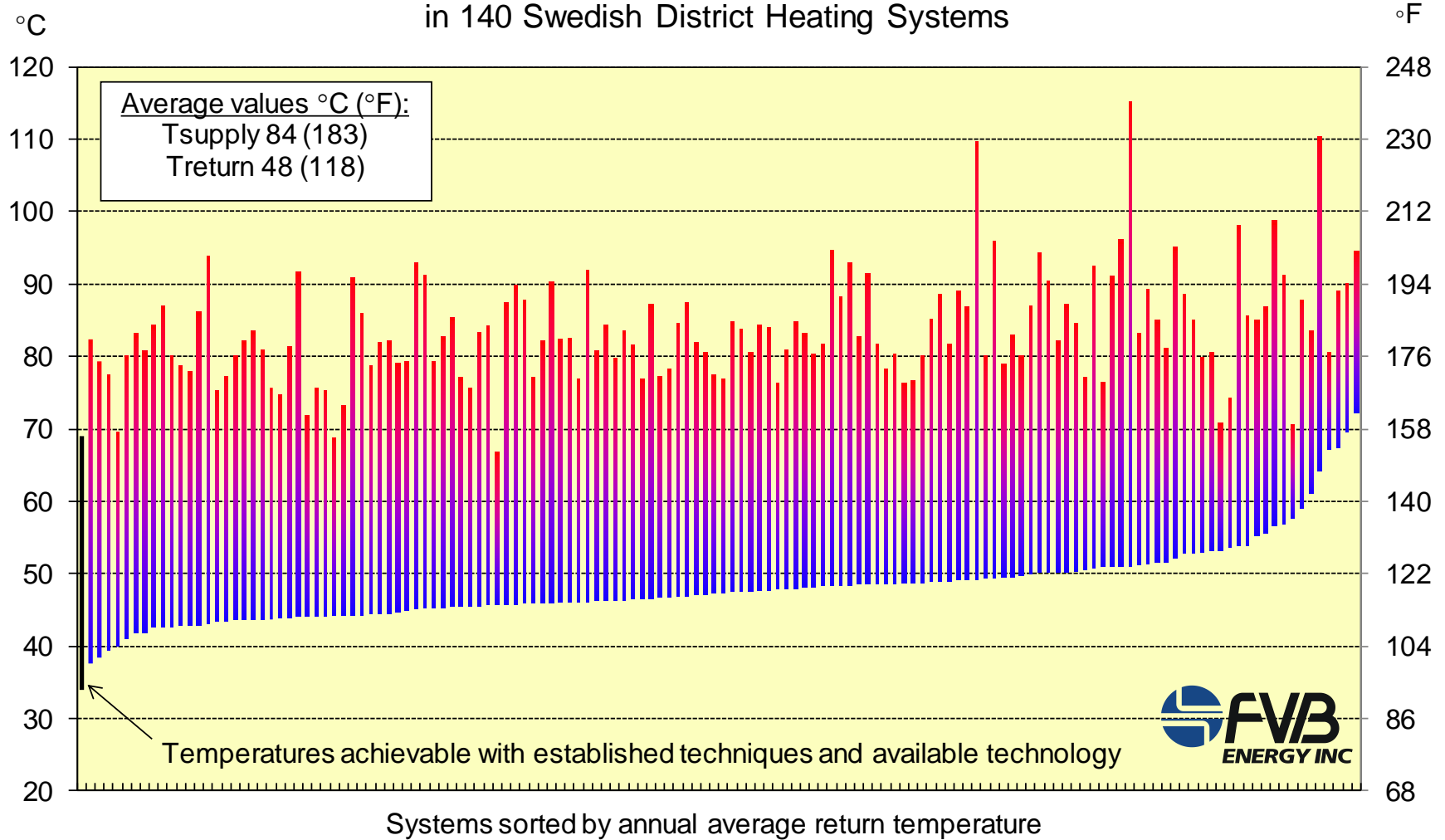


Low District Heat Temps Facilitate Low-Carbon Sources



Temperatures in Operating Swedish Systems

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



Hot Water Piping Technologies



Thanks for your attention!

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