TMCES

Agile Cooling and customer-centric value props for thermal energy storage system

What is Agile Cooling?

Agile cooling is possible when both energy and power are decoupled from time:

Decoupling Energy and Time

"I consumed 300kWh between 3-4am and reduced my load by 300kWh between 3-4pm"

Current TES is good at this.

This has LOW value for customers

Decoupling Power and Time

"I charged my thermal battery at 25TR but discharged it at 250TR"

Current TES is bad at this.

This has HIGH value for customers

What is Agile Cooling?

High-power-density GPU-based racks require 5-15 minutes of backup cooling to bridge the power failure to chiller startup.

Customer Value Opportunity

- 2-4X lower footprint than chilled water
- Chilled water incumbent is expensive and low-density
- Additional grid interconnect value
- Huge market (>50GWh)
- Entry point into datacenter market (>500GWh)

28X Faster Discharge Required

Typical Discharge Rate: 700TR
Typical Charge Rate: 25TR

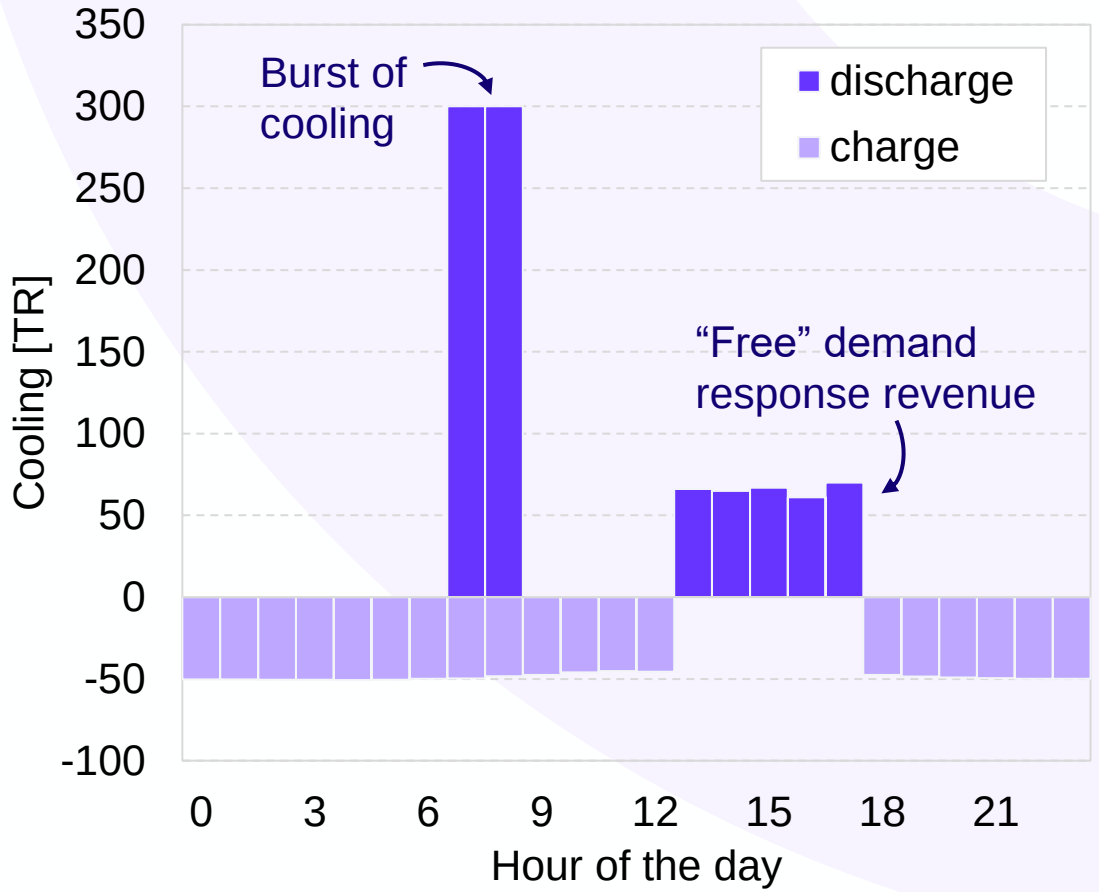
Current industry solution requires large chilled water tanks, as no ice-based thermal energy storage system is sufficiently agile.

What is Agile Cooling?

Every day, food processors clean their equipment using hot water but cannot begin operation until spaces are returned to cool and dry conditions. This creates a significant bottleneck to revenue

2X lower capex solution

An Agile solution provides 300TR of cooling during recovery, but charges at a rate of 25-50TR. For food processors, this solution not only generates significant additional revenue each year, but is the **lowest capex, opex, and total cost solution.**

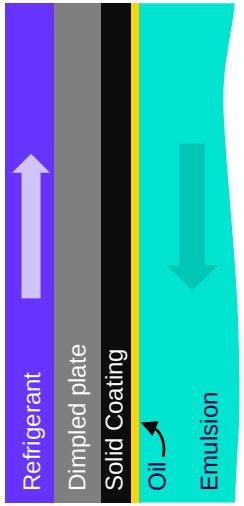


One Example of Agile Cooling

To make an ice maker for ice banking, one must make extremely thin ice that harvests quickly without losses.

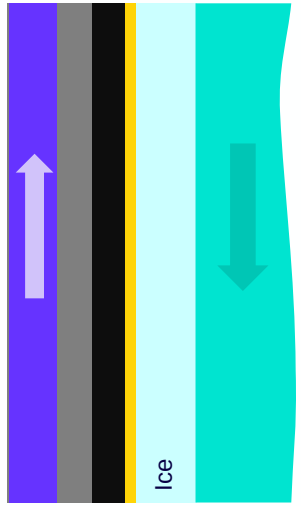
Coating (<1min)

A solid coating pulls chemically matched oil from an emulsion



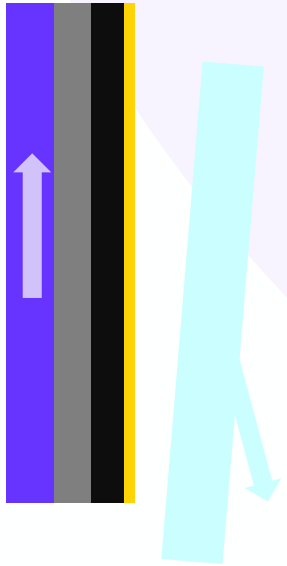
Growth (6min)

Ice forms on top of a micron scale hybrid coating



Harvest (<1min)

Emulsion flow is curtailed, ice sub-cools and falls off. No losses.



Real-time harvest. Emulsion stops, refrigerant continues to flow, ice pulls away and falls off.

One Example of Agile Cooling

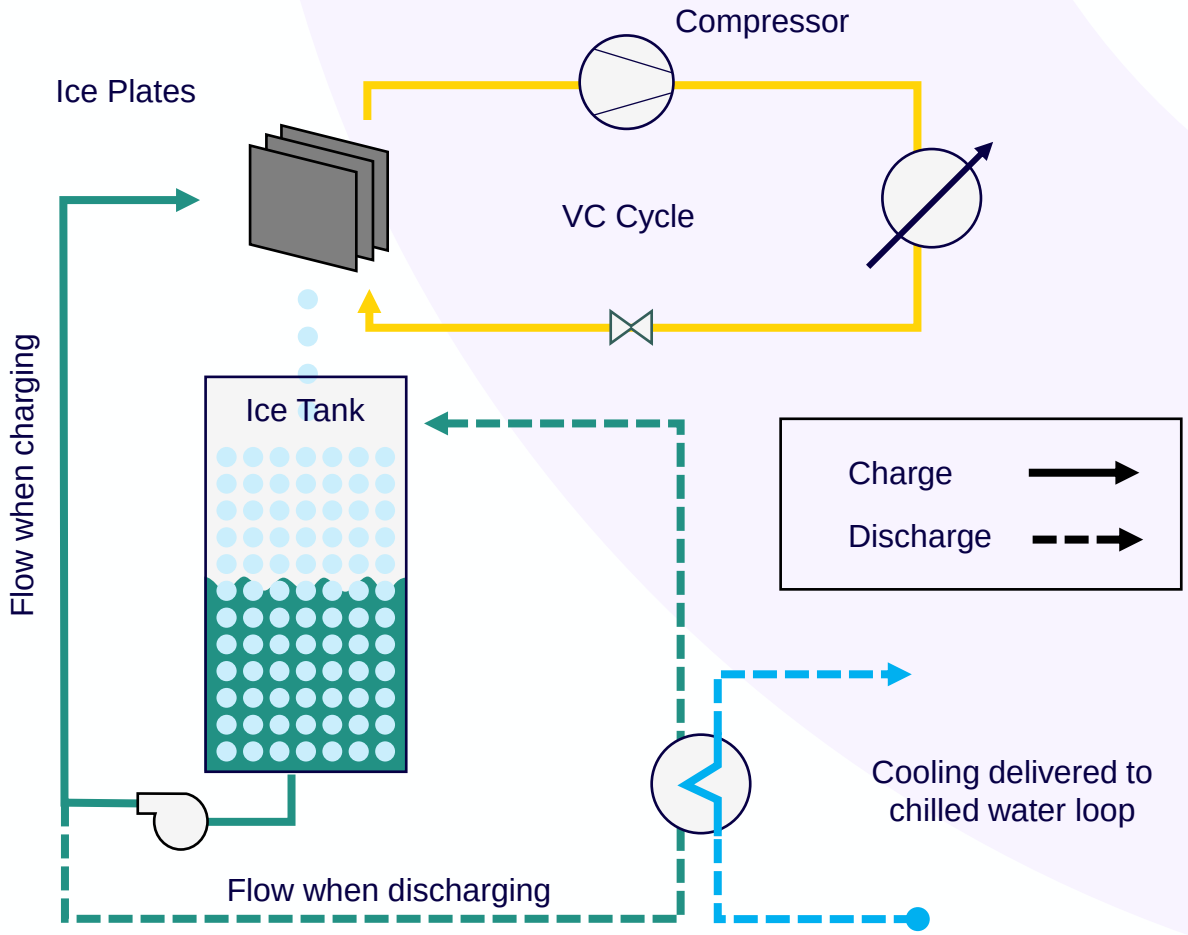
Key to achieving Agile Cooling is the generation and storage of **high surface area**, **low pressure drop** ice pack.

Charge

Ice is formed in 1/8”-1/4” sheets, leading to a surface area to volume ratio >20X larger than 3” ice on coil.

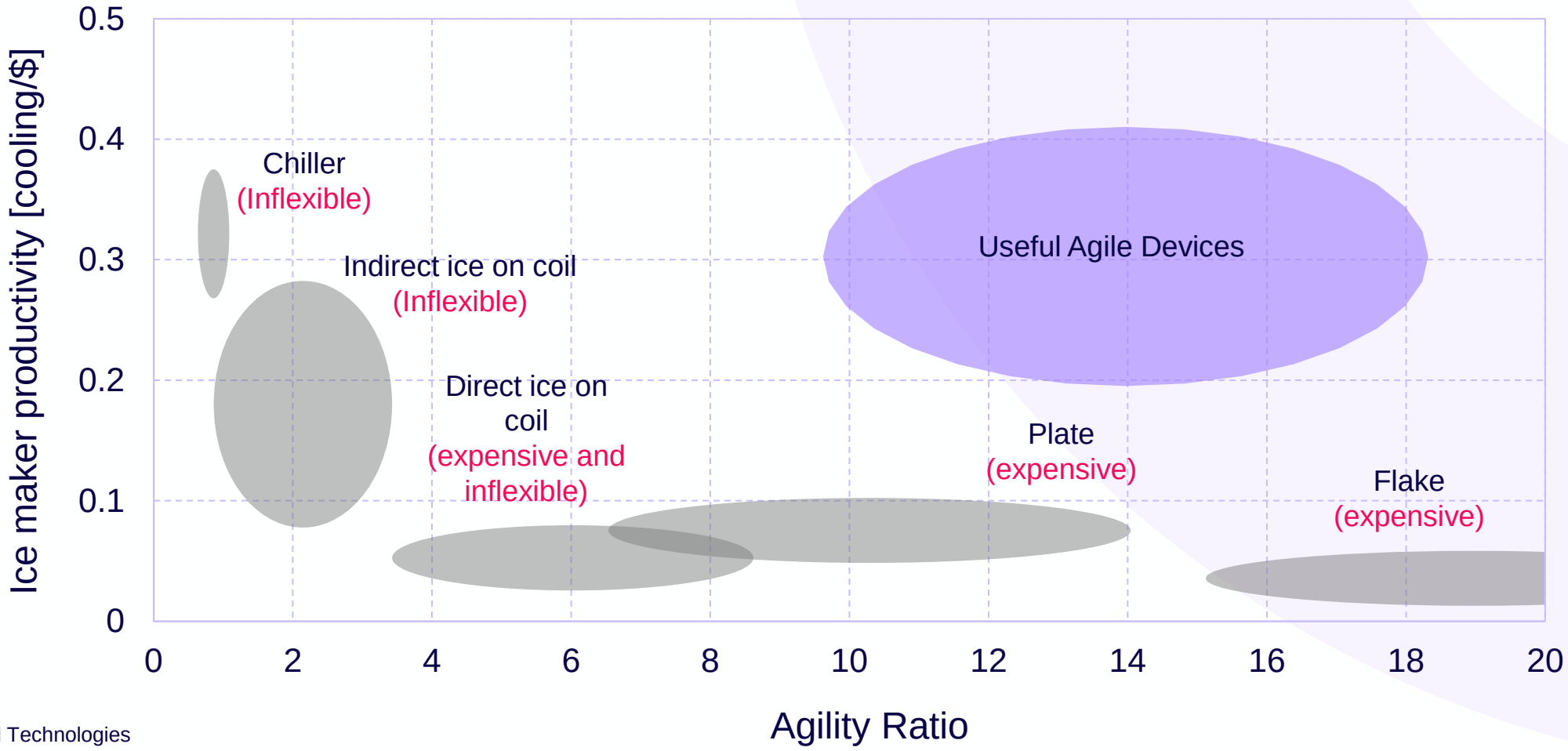
Discharge

Low pressure drop packed bed allows for flow without tunneling. Even access to all ice surface area is essential to achieve Agile Cooling.



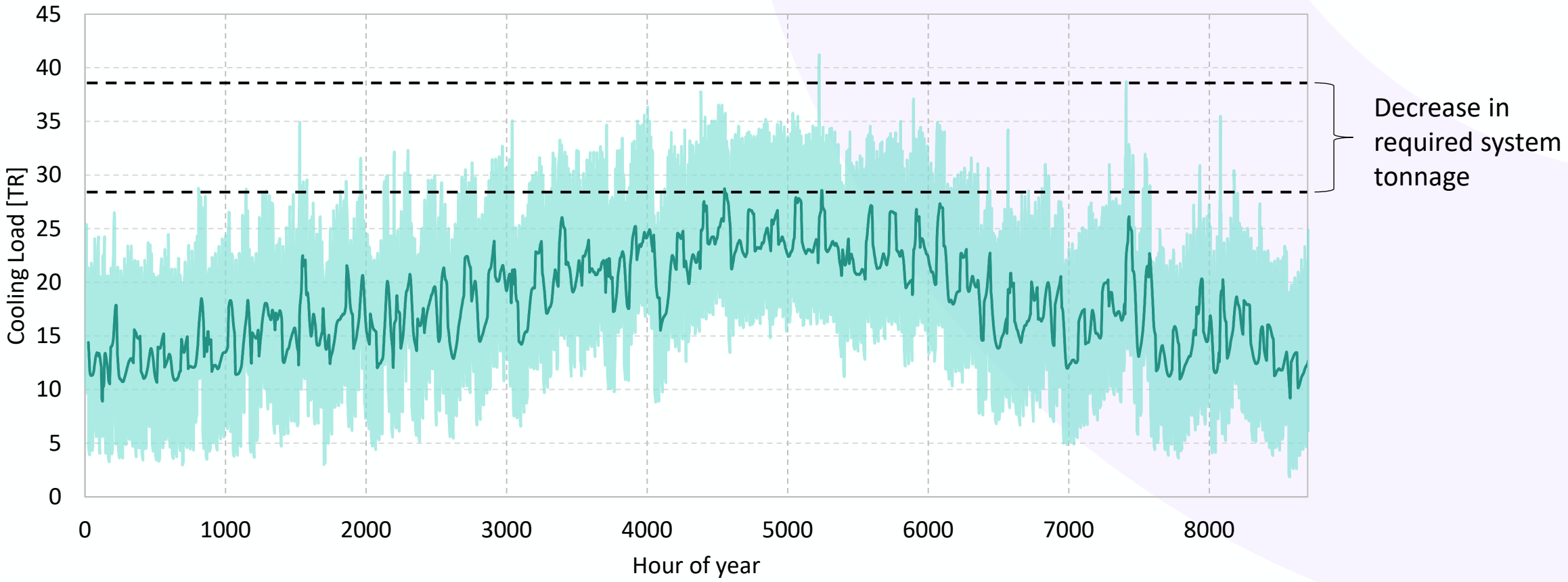
Usefulness Requires High Productivity

Other devices exist to that can make Agile storage media, but these devices have low productivity (high cost) and thus cannot compete in the market.



Rec Center Pool Example

Swimming pools have a volatile load (especially when pool covers are used), which can be arbitraged by Agile systems.



Rec Center Pool Example

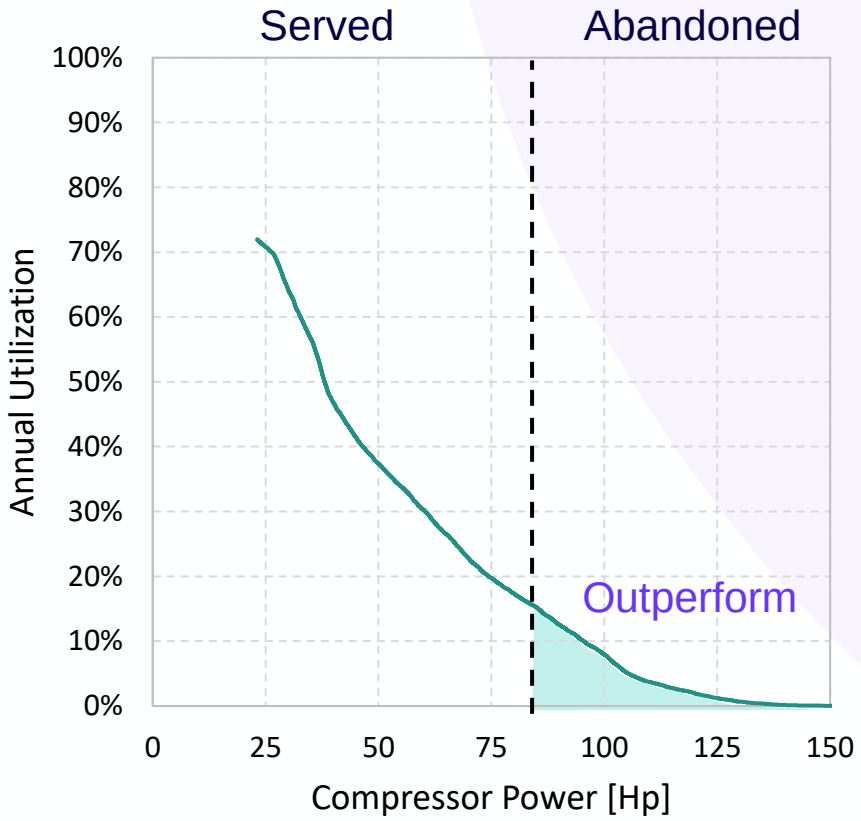
Swimming pools have a volatile load (especially when pool covers are used), which can be arbitraged by Agile systems.

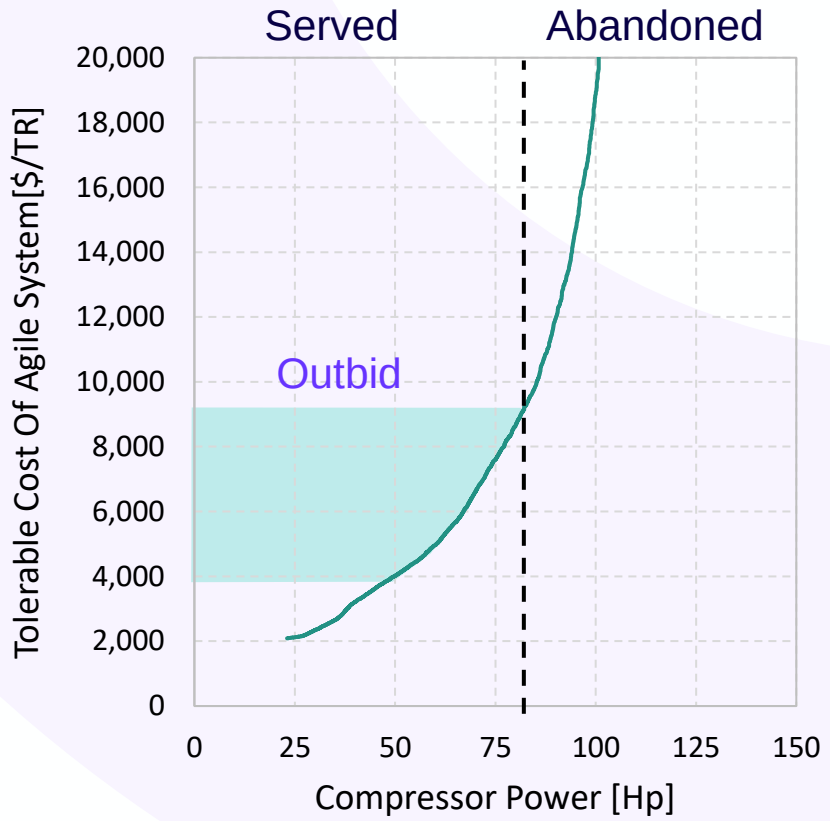
Annual Utilization:

$$= \frac{Hours\ at\ or\ above\ power}{Hours\ in\ year}$$

Tolerable Cost:

$$= \frac{Capex\ /\ Capacity}{Utilization}$$



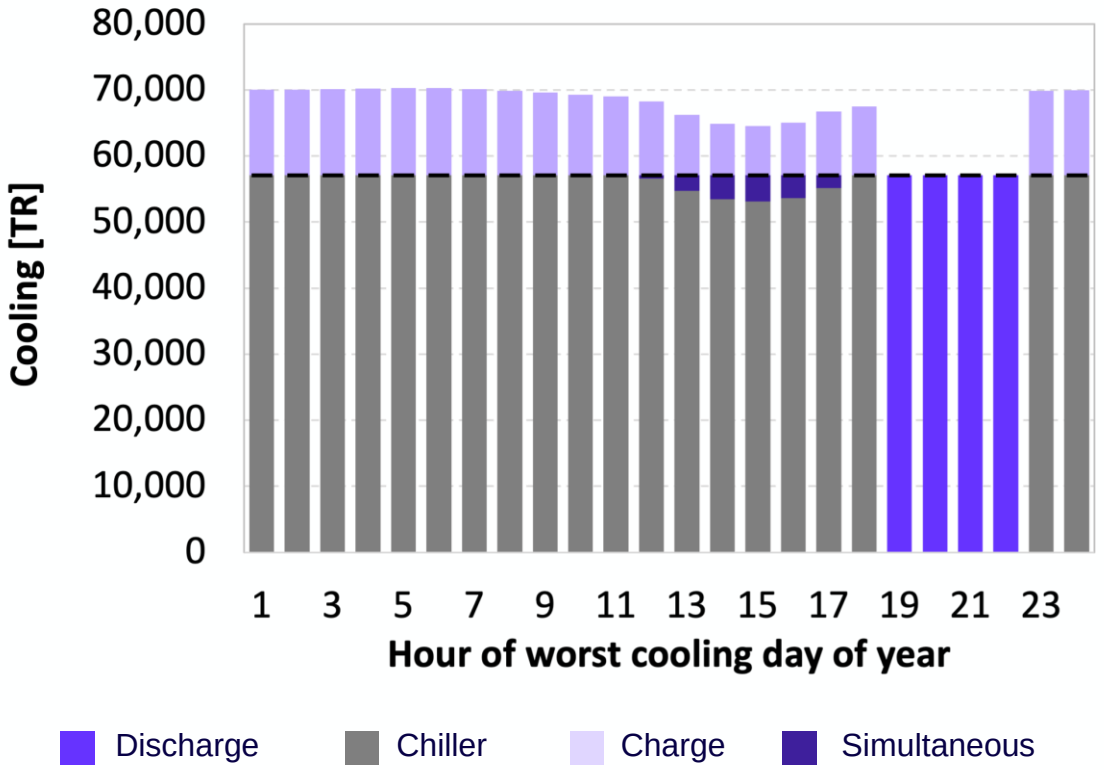


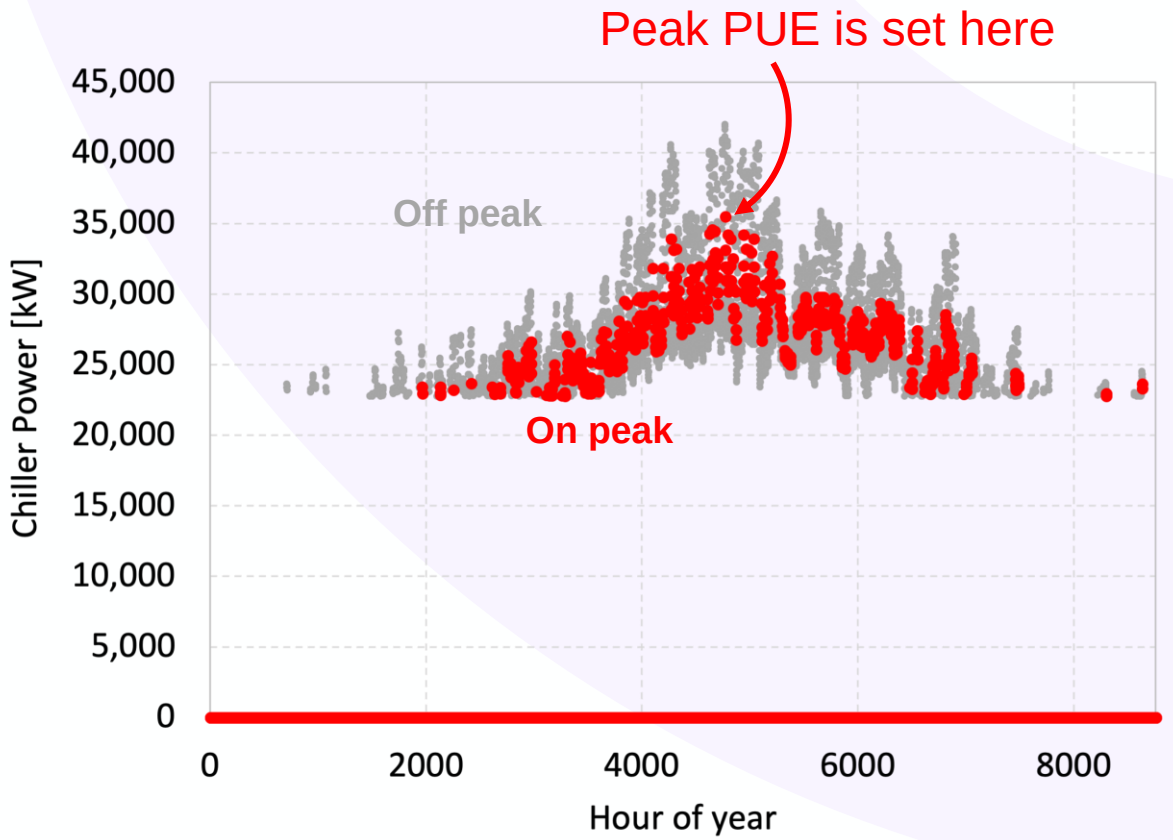
Storage enabled systems can outperform and outbid conventional systems

Data Center Interconnect Example

Data center expansion is demand-constrained, not energy-constrained. Example is 200MW IT load in Texas

6X Faster Discharge Required

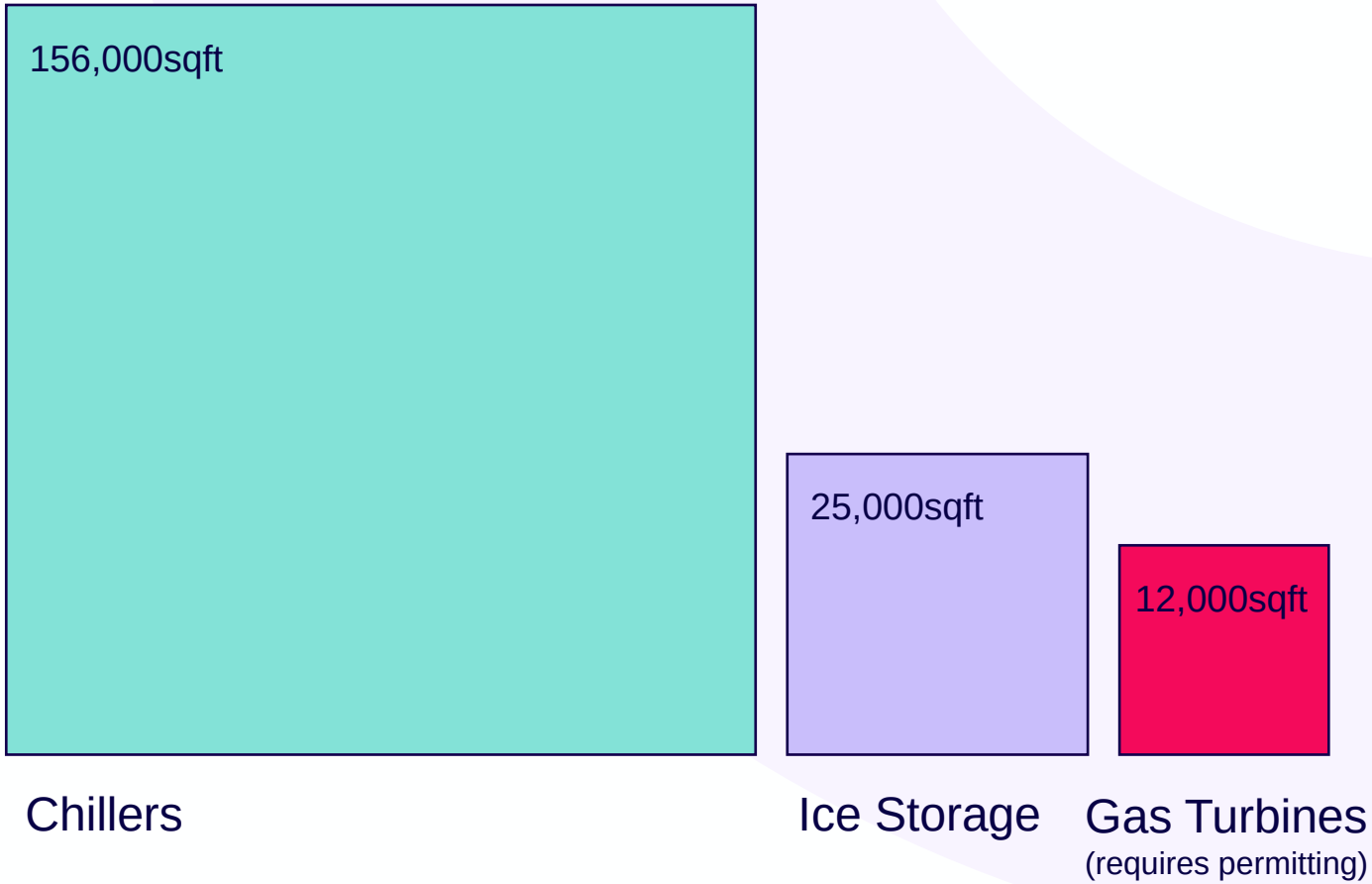




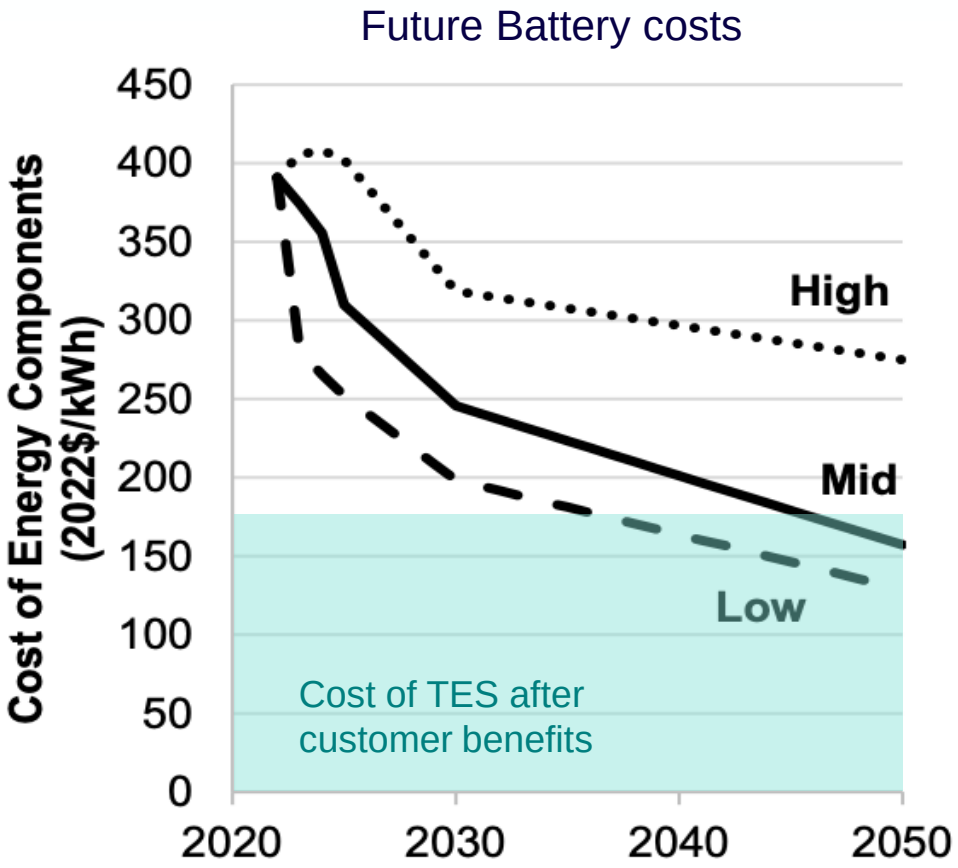
Data Center Interconnect Example

Agile systems at data centers offer the lowest first cost peak power, the cheapest access to additional IT power, at a reasonable footprint.

	Agile solution
Curtailed load	Up to 36MW
Energy savings	$1.5MM/yr
Agile system cost	$40MM
Annual value of Curtailed IT	**$20MM**
Cost of “peak power”	**$1000/kW (50% lower than Turbines)**



Bringing it Back to the Grid



Agile Systems aren't about the grid…

- Higher performance
- Superior comfort
- More revenue
- Lower upfront costs
- Lower total cost of ownership

…but they can have a HUGE impact.

Contact:

Russell Goldfarbmuren
Russell@rebound-tech.com