Energy And Efficiency Impact Via IcePoint Enabled Cold Chain Facilities

Rebound Technologies
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SUMMARY
The decarbonization of our electrical infrastructure and move from fossil fuels is already proving to be painful. One obvious solution is to install trillions of dollars of batteries in massive green-field construction projects across the country. While this solution is easy to understand, it is brute force and environmentally costly. There is a far simpler solution: create flexible energy consumption.

Throughout the United States, there are thousands of cold chain facilities with energy consumption on the MW scale. Given their massive electrical loads, each of these facilities has the potential to serve as an energy storage asset for the grid, enabling flexible energy consumption. Rebound's IcePoint can make that happen. IcePoint represents an entirely new way to think about demand response, TOU rate mitigation, and energy storage. Unlike today's grid storage assets, IcePoint units generate only a small fraction of their value from arbitraging TOU rates or demand charges; instead, they hit ROIs of 2-4 years, by increasing customers productivity, operational efficiency, and profit through better temperature fluctuation control and dehumidification. This value covers the capex of the system meaning customers only pay for the incremental cost of adding storage to the system. By adopting this new approach to energy storage, IcePoint can hit storage costs 90% lower than today's cheapest forms of energy storage.

Once rolled out across cold storage, food processing, and food retail markets IcePoint can enable more than 800GWh (100X more than today's installed batteries) of energy storage at a cost far below batteries and even pumped hydro.

INNOVATION AND IMPACT

The current (and decreasing) costs of renewables will drive massive adoption over the next 30 years necessitating significant investments in grid storage and flexibility. To capture the value of low-cost renewables, 600-1200 GWh of an equally low-cost storage technology is required[1,2]. To be implemented, this storage technology should have a levelized cost of storage (LCOS[3]) well below that of pumped hydro energy storage (PHES) in a 4-12 hour diurnal arbitrage scenario. To date, no such technology is on the horizon.

PHES, the only 4-12 hour storage technology deployed at scale today, has an LCOS of $225/MWh and is not projected to see any meaningful LCOS cost reduction in the next 10 years[4]. Li-Ion batteries, despite their recent cost reductions, have a LCOS of $350 /MWh today and are expected to reach an LCOS of $200/MWh by 2030[4]. Cost for all three systems are shown in Figure 1. **The first commercial scale IcePoint unit, which is currently operational, has a proven LCOS of $120/MWh.**

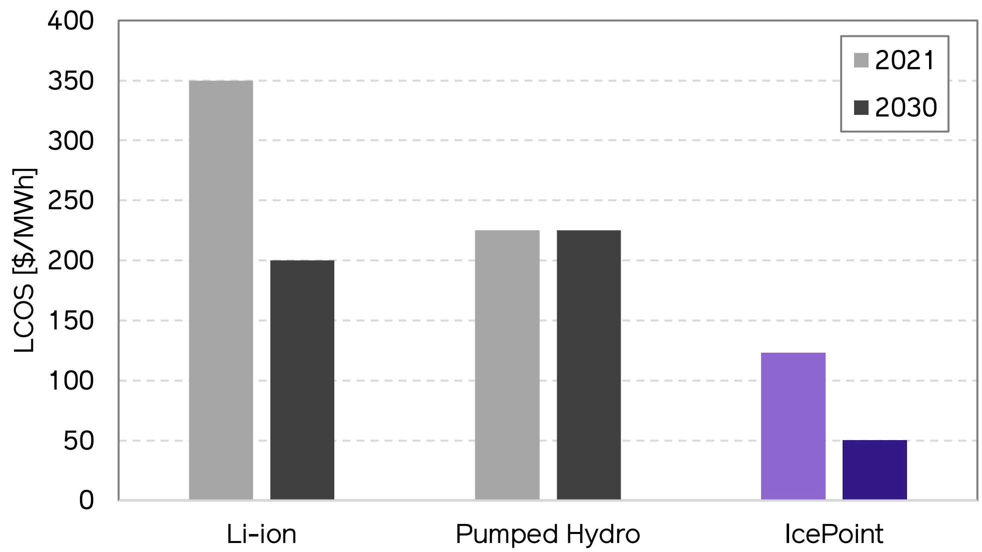

Figure 1: Current and 2030 LCOS values in a renewable integration role.

IcePoint achieves such low storage costs because it takes a fundamentally different approach to energy storage: it generates revenue for the customer primarily as a superior refrigeration and dehumidification asset and secondarily as an energy storage asset. It represents a new form of refrigeration heat pump that uses brine-ice mixtures to provide low temperature refrigeration to the cold storage, food processing, and food retail markets. This new heat pump cycle is called a freeze point suppression (FPS) cycle. The primary value of FPS cycles is derived from matching customer thermal transients and providing moisture control within the customer's refrigerated space. However, since these cycles use cheap and easy-to-store brine and ice-based refrigerants, they can be scaled up to provide grid storage at a very low cost. Thus, IcePoint's energy storage cost is only the incremental cost of adding additional thermal capacity to the system and has a significantly lower potential cost then stand-alone energy storage solutions like Li-ion, PHES, and Vanadium flow batteries. The additional capacity consists predominantly of a larger tank and more brine both of which are cheap.

IcePoint is a fully developed technology ready to scale. In 2023 the first full-scale commercial system was installed at a customer site and demonstrated the value of both agile cooling and moisture control. Figure 2 shows the unit in operation at the customer site.

Figure 2: the first full-scale IcePoint system in operation.

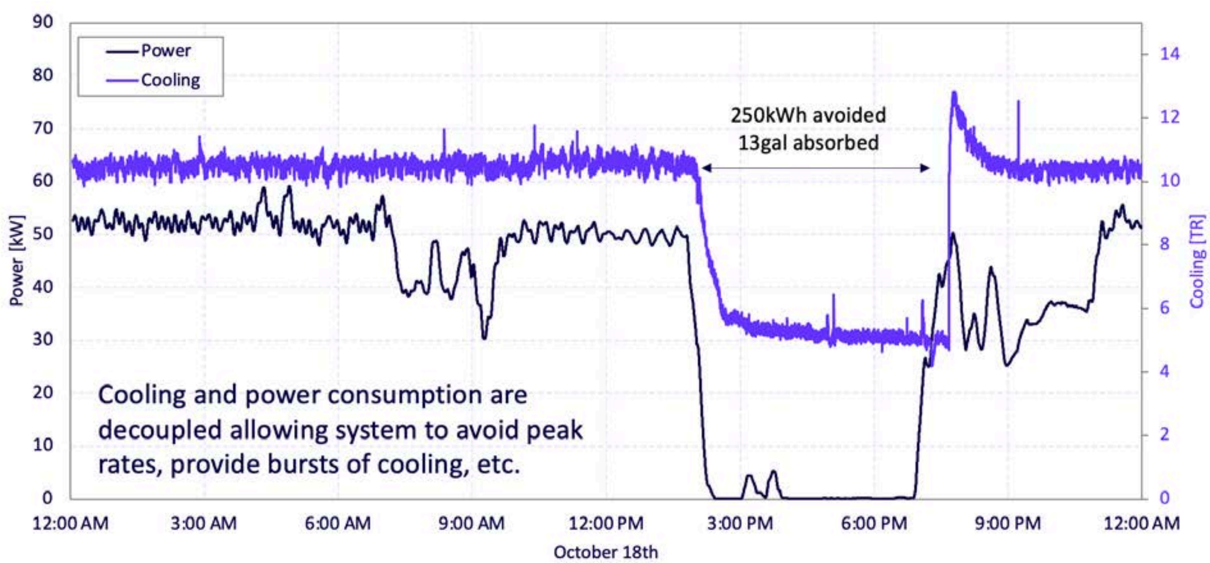

Figure 3: Demand response performance showing system reduce power consumption to near zero for entire 5 hour period while still providing value.

During the commissioning phase the system hit all its major goals: cooling below -10°F, moisture absorption rates above 8GPH, and 5-hour demand response performance. Although the system was initially designed to provide 3 hours of 100% capacity demand response load shifting, its inherent flexibility allowed Rebound to extend the load shifting period to 5 hours by decreasing the load by ~50% during those hours. Figure 3 shows an example of one such day where cooling and moisture management are still provided despite energy consumption dropping to near-zero. This data shows IcePoint has the capacity to provide long-duration energy storage to the grid at thousands of existing facilities.

What is more, a major benefit of IcePoint over stand-alone grid storage is that customers are motivated to purchase IcePoint for reasons other than energy savings. Instead, customers install IcePoint because it:

1. Provides agile cooling that matches facility refrigerant loads
2. Decreases labor costs by more effectively utilizing existing staff
3. Manages moisture in refrigerated spaces
4. Increases the throughput (and revenue) generated by fixed assets such as blast freezers
5. Mitigates peak rates and demand charges

IcePoint delivers these five values adds whereas stand-along energy storage can only be used to mitigate peak rates and demand charges. As such, IcePoint delivers more than 10X the value. For these large industrial customers stand-alone energy storage systems have a payback far greater than 10 years where IcePoint can offer payback periods of 2-4 years. Table 1 shows a comparison of IcePoint to a chemical and thermal battery to make this distinction clear.

Table 1: Comparison of IcePoint to Li-ion batteries and ice banks Sources: 4,5

	Li-ion	HVAC Ice Banks	**IcePoint**
Product life [years]	< 10	> 20	**> 20**
Non-energy value add?	No	No	**Many**
Storage capex [$/kWh$_e$]	625	600	**260**
LCOS [$/MWh]	350	579	**120**
US capacity [GWh]	No limit	1900 (summer only)	**800**
ROI	10-20 years	16-28 years	**2-4 years**

BETTER THAN EFFICIENCY

Over the past 50 years significant emphasis has been put on efficiency as a solution to both utility costs and environmental issues. While this paradigm was well suited for the 1970s when utility rates and carbon intensity were largely time-independent, it no longer is the easiest way to decrease operational costs and environmental impact. As the time-dependence of energy cost and carbon intensity have become more extreme, the ability to shift when energy is consumed has become a superior way to decrease costs and increase sustainability.

A typical industrial consumer today pays more than 2X higher rates during the more expensive half of the day and about half of that customer's bill is determined by a time dependent peak demand charge. All told, about 75% of a customer's utility is generated in 25% of the hours of a month. Efficiency decreases these costs evenly in both peak-rate hours and off-peak-rate hours whereas storage focuses specifically on the highest-cost hours.

For example, an industrial customer with the ability to shift 6 hours of energy consumption from high-cost hours to low-cost hours while also strategically decreasing peak demand, could lower utility costs by more than 50%. Achieving this same savings via higher efficiency would require a doubling of efficiency, a feat that is not physically (let alone economically) possible with today's HVACR technology.

This distinction becomes even more pronounced when looking at the environmental impact of efficiency vs storage. In the past decade the time-dependence of electrical carbon intensity has changed dramatically as massive amounts of solar and wind have been deployed. This change is only accelerating as the cost of these carbon-free generators continues to plummet. If a facility can selectively consume electricity during low or no carbon intensity, it can decrease its environmental impact more effectively than by consuming fewer overall kWh.

Using gap analysis as a proxy, it is possible to estimate that most industrial customers would need roughly 10-20% coverage by storage to reliably use exclusively carbon-free energy like wind, solar, hydro, and nuclear.[6] Thus, with six hours of storage (25% coverage), an industrial customer could not only use carbon free energy sources for their own supply but add surplus storage to the grid, lowering the carbon intensity of other customers with no storage. So, whereas a doubling of efficiency would halve the carbon footprint of an industrial facility, six hours of storage eliminates the facility's carbon footprint and enables a lower overall carbon intensity on the grid where the facility operates.

To put it bluntly: We must stop chasing the diminishing returns of efficiency gains and focus on energy storage, the easier path to sustainability impact.

THE FUTURE OF ENERGY STORAGE

Yes - batteries are a solution but thermal storage can be THE simple and cost-effective solution. 1000's of MWhs can be created across existing facilities by converting them to thermal batteries that run on ice and salt. Instead of paying for an expensive and low-value battery solution, customers buy a high value plant optimizing thermal asset that provides energy storage value at a much lower cost.

While it may seem counter intuitive, IcePoint is the more natural of the two: as peak rates and demand charges go up, customers will naturally look for alternatives. They will not care, in the end, if their solution stores energy in electrons or in ice crystals: they will only look for price relief at the fastest ROI. IcePoint and other technologies like it will always beat out stand-alone energy storage technology because of the multifaceted impact beyond storage.

The idea of IcePoint transcends the cold chain. It can be applied to any thermal technology in any market that sees price signals encouraging storage. In that regard, 800GWh is just the tip of the impact iceberg. There is a future where systems like IcePoint **enable lower first costs** across any thermally focused market and enable energy generation and distribution that is cheaper and more reliable than today.

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[1] Mai, T.; Sandor, D.; Wiser, R.; Schneider, T (2012). Renewable Electricity Futures Study: Executive Summary. NREL/TP-6A20-52409-ES. Golden, CO: National Renewable Energy Laboratory

[2] The 2035 report: Plummeting Solar, Wind, And Battery Costs Can Accelerate Our Clean Electricity Future, (2020) Goldman School of Public Policy

[3] LCOS values in this document are calculated using the “Energy Arbitrage” application which is most appropriate for integrating renewables.

[4] Schmidt et al., Joule 3, 81–100 January 16, 2019 a 2018 Elsevier Inc.

[5] Sara Hoff, Alexander Mey (2020) Utility-scale battery storage costs decreased nearly 70% between 2015 and 2018

[6] Pierpont et al., Climate Policy Initiative, April 2017, Flexibility: the path to low-carbon, low-cost electricity grids