Energy And Efficiency Impact Via IcePoint Technology

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, thermal loads like comfort cooling, food cooling, cold storage, and many others dominate our energy consumption. Given these massive electrical loads, this sector above all others has the potential to serve as an energy storage asset for the grid, enabling flexible energy consumption. Rebound's solutions, powered by IcePoint technology, can make that happen. IcePoint technology represents an entirely new way to approach demand response, TOU rate mitigation, and energy storage. Unlike today's grid storage assets, systems powered by IcePoint generate only a small fraction of their value from arbitraging TOU rates or demand charges; instead, they achieve ROIs of 2-4 years by generating value using agile cooling. Taking different forms for every market vertical, agile cooling unlocks a combination of additional revenue, lower capex, higher customer retention, greater productivity and lower labor costs. In every case, 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 technology can reduce storage costs by 90% compared to today's cheapest energy storage options.

Once rolled out across the HVACR spectrum, IcePoint enabled products could create multiple TWh of long duration diurnal energy storage for the electrical grid.

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 product using IcePoint technology, has a proven LCOS of $120/MWh.**

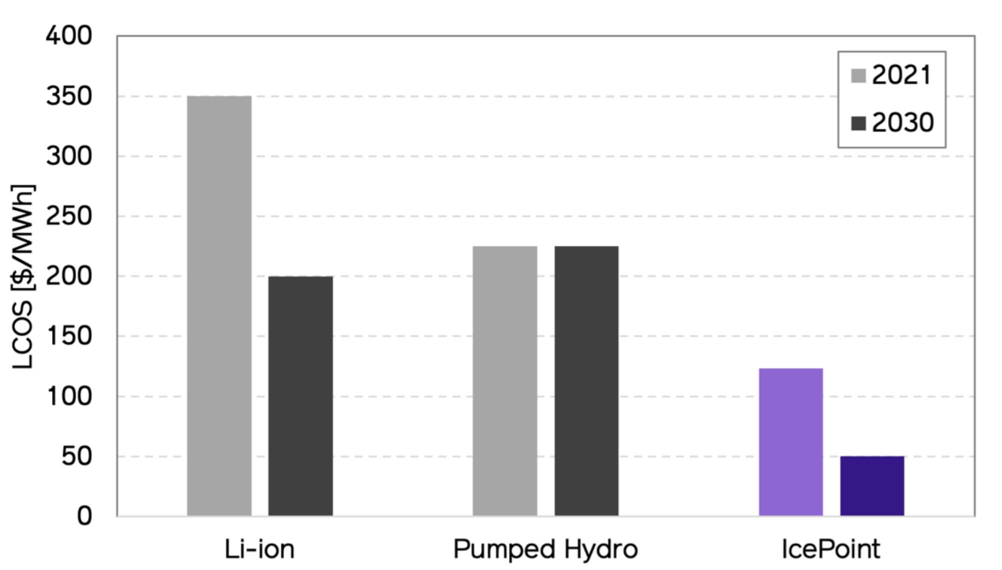

Figure 1: Current and 2030 LCOS values in a renewable integration role.

IcePoint technology achieves such low storage costs by taking a fundamentally different approach to energy storage: it generates revenue for the customer primarily as a superior refrigeration and dehumidification asset, with energy storage as a secondary benefit. Powered by IcePoint technology, this product introduces 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 innovative heat pump cycle is known as the freeze point suppression (FPS) cycle. The primary value of FPS cycles comes from matching customer thermal transients and offering moisture control within refrigerated spaces. Additionally, because these cycles use affordable and easily stored brine and icebased refrigerants, they can be scaled up to provide grid storage at a very low cost. The energy storage cost with IcePoint technology is limited to the incremental cost of adding extra thermal capacity to the system, which is significantly lower than stand-alone energy storage solutions like Li-ion, PHES, and Vanadium flow batteries. This extra capacity mainly involves a larger tank and more brine, both of which are inexpensive.

IcePoint is a is fully developed technology stack that is ready to scale, with the first full-scale commercial system installed in 2023, successfully demonstrating the value of agile cooling and moisture control. Figure 2 shows the unit in operation at the customer site.

Figure 2: the first full-scale product powered by IcePoint technology in operation.

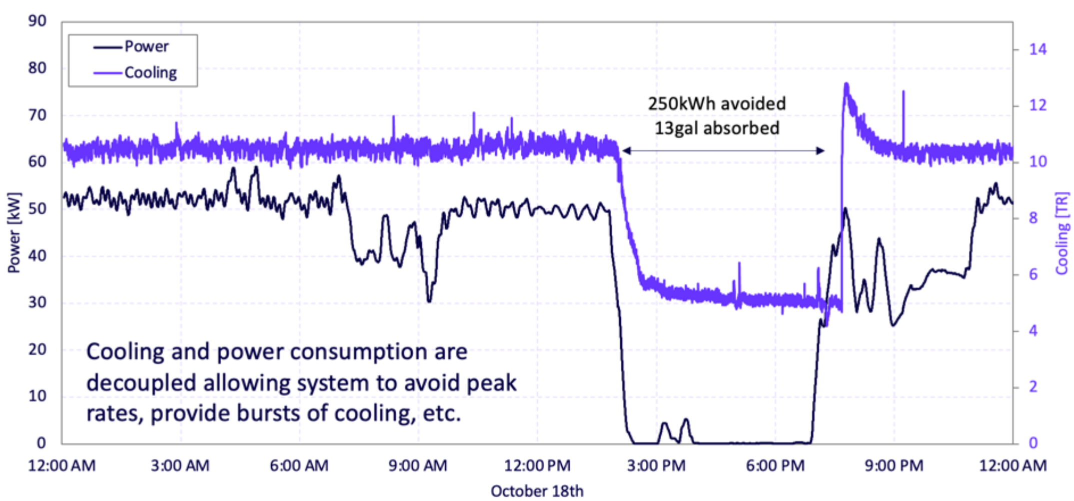

Figure 3: Demand response performance showing system reduce power consumption to near zero for entire 5 hour period while still providing value.

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 the product has the capacity to provide long-duration energy storage to the grid at thousands of existing facilities.

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

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

Powered by IcePoint technology, this solution delivers five key value adds, while stand-alone energy storage systems are typically limited to mitigating peak rates and demand charges. As a result, the IcePoint enabled product offers more than 10 times the value. For large industrial customers, stand-alone energy storage systems often have a payback period exceeding 10 years, whereas systems powered by IcePoint technology can achieve payback in just 2-4 years. Table 1 illustrates a comparison between systems using IcePoint technology and traditional chemical and thermal batteries, highlighting this distinction.

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**

This system represents just one product Rebound is currently bringing to market that is powered by the IcePoint technological stack. Additional products with similar paybacks and value-focused integrations are being rolled out in the pool, comfort cooling, food processing, and agricultural space.

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 consumer today pays more than 2X higher rates during the more expensive peak periods and about 50% 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, a 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 (and quick project ROI!).

THE FUTURE OF ENERGY STORAGE

Yes - batteries are a solution but thermal storage can be THE cost-effective solution. 1000's of MWhs can be created across the country by converting medium and large scale HVACR loads to thermal batteries that run on ice. 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 enabled systems are 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.

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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