ARIZONA CORPORATION COMMISSION

Arizona Corporation Commission's Inquiry into)
Potential Impacts to the Current Utility Model) Docket No. E-00000J-13-0375
Resulting from Innovation and Technological)
Developments in Generation and Delivery of Energy)

Comments by SustainX: Optimizing Grid Infrastructure with Site-flexible, Fuel-free Compressed Air Energy Storage

EXECUTIVE SUMMARY

SustainX (the "Company") appreciates the opportunity to submit Comments in the above-captioned matter. As the Commission has noted in its Letter, technological innovations across a broad array of fields promise to reshape the current energy utility model. The Commission rightly acknowledges the significant impact of Utility-Scale Storage Technologies.

SustainX, Inc. has developed a site-anywhere, zero-emissions isothermal compressed air energy storage (ICAES™) technology that provides power- and energy-scalable storage for a cleaner, more efficient, and more reliable electric grid. SustainX's solution combines mature, proven industrial components with innovative thermodynamic and control technologies protected by an extensive IP portfolio. The company is ready to start deploying field systems in Arizona.

SustainX's ICAES solution impacts the utility model by providing a new asset class for ensuring flexible and reliable design and operation of the electric grid. Specifically, as described herein, site-flexible energy storage such as ICAES:

- lowers rate-payer costs by enhancing the utilization of existing distribution infrastructure
- increases the penetration of distributed resources by transforming intermittent renewables into schedulable sources of clean energy
- reduces the frequency and impact of outages by providing a flexible and responsive grid asset
- and supports the efficient management of grid assets through low operations, maintenance, and environmental costs

I. BACKGROUND

Wind power installations are increasing around the world, adding supply variability and challenging grid stability. Grid operators are taking a close look at the impact of increasing penetration of highly variable wind power and how energy storage can play a role in stabilizing the electricity network. Although today's level of wind penetration in North America is not yet at a point that creates significant grid instability, utilities and grid operators are paying attention. Based on the growing confluence of industry studies, utility initiatives, regulatory orders and filings, as well as early results from initial projects, the market clearly recognizes that expanding wind power resources will require stabilizing support.

One of the key sources of support can be deployment of grid-scale energy storage systems – and technology developers are racing to provide them. To deliver the greatest benefit, a storage solution must be reliable, cost-effective, and unconstrained by geography. In high-energy applications, such as wind integration (*i.e.*, 4 to 6 hours or more), bulk storage must have a long cyclic life, low initial and O&M costs, and be able to perform many deep charge/discharge cycles without degradation.

Despite advances in chemistry and improvements in cost, utilities have been reluctant to add new technologies without regulatory incentives. Thus, SustainX respectfully requests that the Commission encourage utilities to add energy storage to their systems.

II. ISOTHERMAL CAES

Isothermal compressed air energy storage ("ICAES") captures the heat produced during compression by trapping it in water and storing the warmed air-water mixture in conventional pipelines or fabricated in-ground storage vessels. When energy is needed, the process reverses and the air expands – providing greater efficiency thanks to the presence of heated water in the system (see Figure 1). No fuel is needed to reheat the air and no emissions are produced.

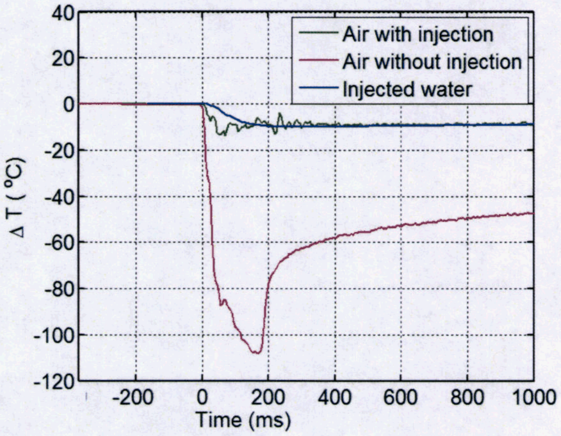

Figure 1. Comparison of non-isothermal air expansion to isothermal air expansion with foam. Air temperature is shown without heat exchange (red) and with foam (green): quarter-second piston stroke (0–250 ms), pressure change from ~200 atmospheres to ~20 atmospheres. Liquid temperature (blue) decreases slightly as heat is transferred to air: liquid and air quickly achieve thermal equilibrium (approach same temperature). Without foam, maximum temperature drop is 108 K; with foam, only 12 K.

SustainX achieves isothermal cycling by combining patented innovations with a design centered on mature industrial components and principles. A mechanical drivetrain utilizes an electric machine and a crankshaft, the latter proven through decades of service in other industries. This efficient mechanical link powers a two-stage, mixed-phase (water-in-air) heat-transfer process within pneumatic cylinders. During piston strokes, a water-based foam is injected into chamber of each cylinder, allowing heat to be transferred from water to air during expansion or from air to water during compression (see Figure 1). The same ICAES power unit provides both isothermal compression and expansion, eliminating the cost of separate compressor and expander subsystems.

SustainX, Inc. has developed the world's first ICAES™ system and is operating a 1.5MW facility in Seabrook, NH. The company is ready to start deploying field systems in Arizona to support the grid modernization objectives that the Commission has identified. The remaining sections of these comments provide examples of two applications that achieve these goals.

III. SCHEDULABLE WIND

The variable nature of wind and solar introduces uncertainty that impacts how grid planners schedule traditional generation and how they utilize their transmission and distribution systems. The frequent need to balance large, unscheduled changes in renewable generation leads to inefficient utilization of both generation and transmission assets. This intermittency limits the penetration of distributed renewable resources into distribution grids, challenges the efficient management of grid assets, and ultimately threatens rate-payer costs for electricity.

As shown in Figure 2, a wind farm may experience rapid shifts in generation nearly equivalent to the rated capacity of the asset. Grid planners must ensure that sufficient spinning reserves are available to balance the decrease in wind output in real-time, while concurrently ensuring that sufficient transmission or distribution bandwidth is available to match supply and demand throughout their balancing area. If sufficient bandwidth is not available, grid operators must either reject renewable energy when it exceeds system limits or over-design the grid infrastructure to accommodate the intermittency. Either approach violates key goals of system modernization – increasing the penetration of distributed renewable resources and increasing the efficiency of managing grid assets.

Pairing renewables with energy storage enables a far different outcome for grid planners. Site-flexible and power/energy-scalable storage can transform variable renewable energy into a firm product that allows for right-sizing and optimal scheduling of transmission, distribution, and generation assets. The green line in Figure 2 represents a firm, 4-hour renewable product that would be delivered to the grid. With a scalable storage asset, the duration of these firm blocks and the percentage of firm wind delivered can be tailored to the unique conditions of that grid region. Scale, response rate, reliability, and site-flexibility are also critical characteristics for such a storage asset.

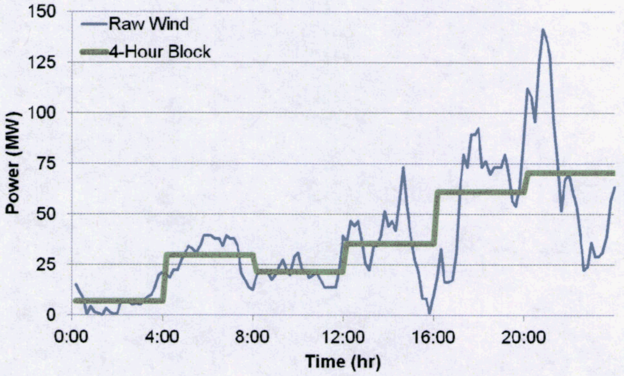

Figure 2. A typical 24-hour period of wind farm output (blue line). The energy levels reflect significant generation peaks and valleys – with a >125 MW swing over a 4-hour period. The addition of ICAES in a potential application (green line) adds certainty to grid operation by firming variable wind energy and transforming it into a predictable, schedulable product. Thus ICAES is able to provide fast-ramping reserve energy, while zero minimum generation allows more wind to reach load and minimize the need for fossil fuel-fired balancing power.

This firm wind energy is somewhat more expensive than raw wind energy. However, the increased costs of the electrical energy can be more than offset by several factors:

- Savings in the capital costs of the transmission and distribution system infrastructure necessary to deliver power to the rate-payers;
- Increased efficiency in the management of grid assets;
- More efficient operation of base-load and balancing generation assets.

SustainX has developed proprietary models to analyze these opportunities and is ready to work with Arizona utilities to identify attractive applications.

IV. NON-TRANSMISSION ALTERNATIVES

Removing the variability from wind and solar has a direct impact on how electric grids are built and operated – but storage need not be linked with renewables in order to benefit transmission and distribution grid planning. Today's transmission and distribution network is designed to meet peak load, which might occur for only a few hours each year. As peak load approaches the rated capacity of the existing T&D network, utilities are faced with the need for inherently lumpy upgrades. In low- and moderate-growth regions, ratepayers will shoulder the costs of an expensive upgrade that will see minimal initial use. Energy storage can provide the same peak load T&D services by leveling the load on the existing network. During periods of low demand, energy can be stored on the customer side of the T&D network. When peak demand is experienced, the storage system can relieve the fully loaded T&D network by providing local capacity. When not acting to meet peak load, energy storage can also provide a variety of energy, capacity, and ancillary services.

The magnitude and duration of peak load events will determine the power and energy requirements of a storage solution. Independent scalability of power and energy enables an optimized solution for a specific location's needs. As load profiles change, additional storage power or energy can be added. If load growth eventually justifies a traditional upgrade of the T&D network, the storage system can be used for other grid services. Freedom from geological constraints is critical for storage as a transmission substitute, enabling it to be sited when and where needed.

Figure 3 presents an example of the additional options made available to grid planners when using storage as a substitute for traditional transmission. Storage can be added in proximity to load to satisfy near-term reliability requirements during peak load occurrences and during contingencies. Unlike the sunk cost of a lumpy line upgrade, the grid planner can continue to monitor conditions on the grid and make more efficient decisions as those conditions change. In the example of Figure 2, the grid planner can make a decision at year 5 to install additional storage in order to meet the growth in peak demand. If peak demand had, in fact, leveled off during that 5-year period, no additional storage would be needed, resulting in substantial savings to ratepayers. The lumpy nature of traditional transmission upgrades and the challenge of siting new lines across multiple rights-of-way and jurisdictions prohibit such planning flexibility.

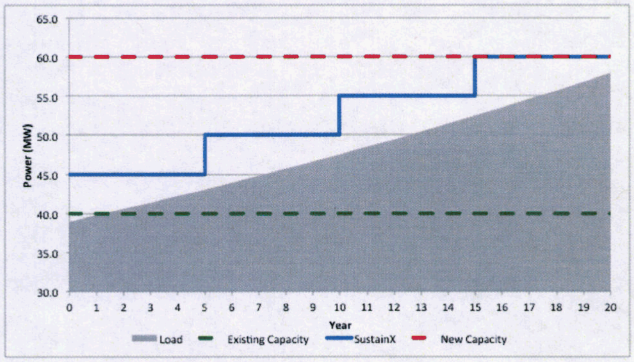

Figure 3. The incremental addition of storage (blue line) enables peak load (gray) to be met by enhancing utilization of the existing transmission line (green). Ratepayers are not faced with cost recovery on a new, higher voltage line (red) that may see limited utilization for several years.

This ability to incrementally meet grid reliability requirements results in direct savings to ratepayers. For example, in the case above, energy storage can be used to avoid a $60M transmission line upgrades at a net savings of at least $20M.

For short line segments and low-cost transmission upgrades, traditional T&D will continue to provide the most cost-effective solution. But grid conditions in densely populated, mature markets such as North America, present an increasingly favorable opportunity for non-transmission alternatives. As seen in Figure 4, high-cost upgrades and slow growth rates present favorable economics for a storage alternative to new lines. Storage also limits the footprint and right-of-way challenges that delay implementation of new lines.

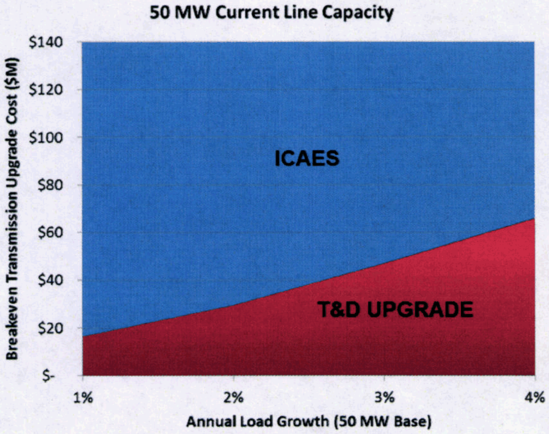

Figure 4. The economics of storage as a substitute for traditional transmission are influenced by the magnitude of the peak load, the load growth rate, and expected cost for the traditional upgrade. In this example, ICAES is installed at 5-year intervals to cover a growing peak load, while a transmission upgrade is installed as one "lumpy" upgrade in Year 0, see Figure 3. For a large window of project costs, the ICAES solution can provide substantial savings to rate-payers. ICAES also gives utilities more flexibility in their grid planning by enabling incremental additions as grid conditions change.

V. CONCLUSION

Storage is a critical new tool in the T&D operator toolbox – and one that is ideally suited to face the challenges of the 21st century grid. A new generation of site-flexible, scalable, fast-responding storage technologies is now coming to market, offering innovative solutions to address grid challenges. Storage removes the uncertainty inherent in wind and solar generation, while boosting utilization of existing infrastructure. Specifically, storage can simultaneously improve and optimize the use of existing and new grid infrastructure, as well as increase the penetration of renewable resources by transforming wind and solar energy into schedulable products. In accomplishing both these tasks, energy stroage can lower rate-payer costs by optimizing the both the generation and delivery of power. And ultimately, a more efficient grid providing more stable sources of energy will be more flexible and responsive, reducing the likelihood of system interruptions and outages.

SustainX looks forward to working with the Commission and the Arizona utilities to use energy storage as a means of maintaining grid reliability in a cost-effective manner.

Respectfully submitted,

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REFERENCES

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