EIC. Solutions.

EIC Isothermal Compressed Air Energy Storage

1.0 Executive Summary

The phenomenal rise of data center construction and related power demand associated with the evolution of artificial intelligence, combined with more extreme weather and increased use of variable renewable energy sources brings a new set of challenges to supplying electricity reliably.

EIC has developed near-isothermal gas compression technology that can directly impact these challenges via energy storage at days to weeks of duration. The unique approach to this proven storage technology allows reasonable round-trip-efficiency with long periods of storage duration and reduces the environmental impact of storage relative to other technologies.

This technology can also be used for compressing other gases for energy reasons or as part of storing, transporting or processing the gases, with substantial energy savings. Compressing and storing natural gas, hydrogen, bio-derived gases and other fuel gases leverage this same efficient technology to support large scale energy storage of combustible gases.

EIC offers the following additional information covering a technical discussion, potential solution sets, and opportunities for collaboration.

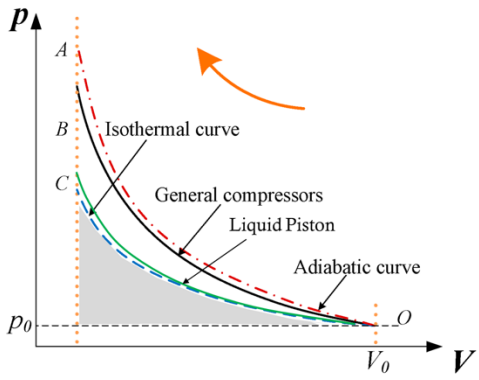
2.0 Technology Discussion

EIC has developed and patented technology that permits compression of various gases to high pressures with limited temperature rise, which offers two significant benefits. The first is in the reduced energy usage of compression relative to conventional machines based on the thermodynamics of near-isothermal compression. The second is that when storing energy in the form of potential energy of a compressed gas, the thermal energy losses of long duration storage are avoided, maintaining the high round-trip efficiency for days or weeks of duration. Few other clean storage methodologies are economical for this mission

statement. Additionally, the large volumes of air required are stored in naturally occurring features below ground, driving the marginal capex of storage toward zero and bringing the overall cost of storage per unit of energy far below lithium-ion batteries.

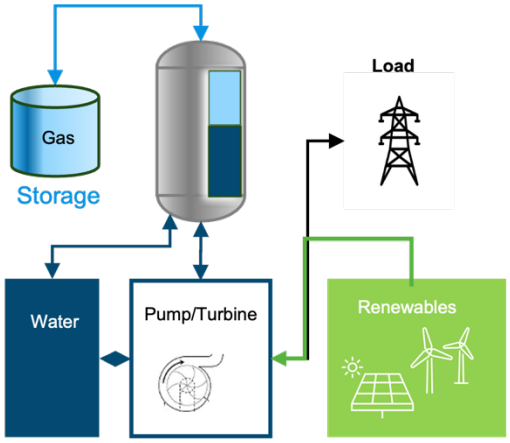
EIC has developed and patented process and equipment for compressing gases with liquid pistons that allows us to approach the theoretical limit of isothermal compression, meaning zero temperature rise from compression. The underlying thermodynamic principles are mature and well understood, and the physical components are variations of common hydromechanical and electric devices in use every day globally. Even liquid pistons have existed for a century, EIC's innovation is around assembling these components to solve a new problem.

Principle: The essential advantage to near-isothermal compression is that by dissipating the heat of compression real-time as it is being created, more of the input energy goes to raising the gas pressure than if the heat builds up during the cycle. This can be observed in the graph of pressure and volume for isothermal (no temperature rise), near-isothermal, conventional and pure adiabatic (no heat transfer out of system) compression. The area under the P-V curve is the work (energy) that it takes to reach a certain pressure, clearly less as the process approaches isothermality (gray shaded area). This is also captured in the thermodynamic principle of exergy, or the mechanically *useful* energy that can be stored and recovered in a system like this.

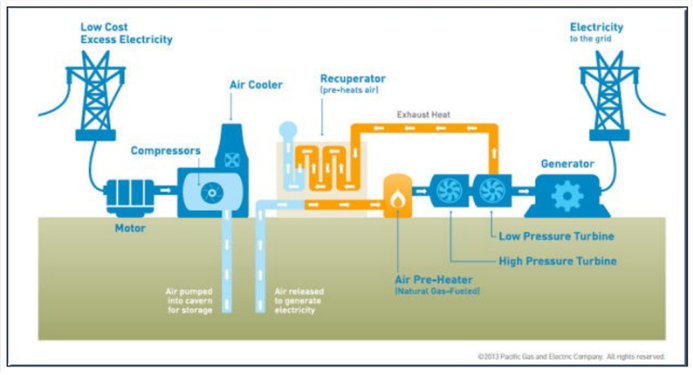


Compression: Conventional compression systems cannot dissipate heat rapidly and can only crudely emulate the process through intercoolers after each stage of compression.

The same amount of heat is discarded but only after it has done its damage. Liquid pistons are the key to near-isothermality, as the liquid itself replaces a mechanical piston or rotating blade. The liquid both enables the high surface area-to-volume ratio of the compression chamber, and also helps dissipate the heat. In the liquid piston system, pumps and hydraulic intensifiers flow water at increasing pressure into closed tubular compression vessels, raising the pressure of the trapped gas as its volume reduces. With just this approach, we can perform high pressure gas compression for a variety of applications with a 10-35% energy reduction, depending on the gas, pressure and flow rate.

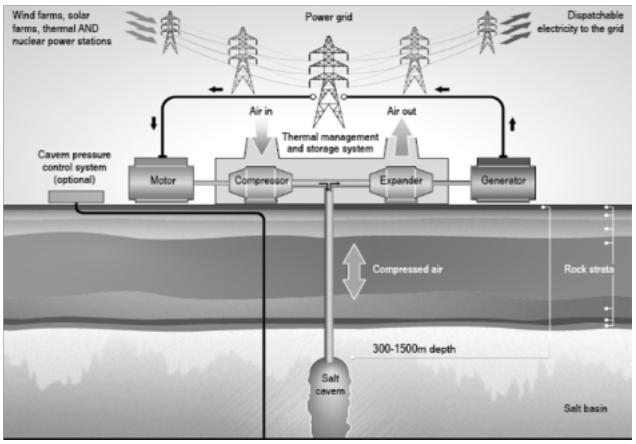


Energy Storage: Beyond simple compression, EIC technology can be used to store energy in the form of the potential energy of compressed gas, air being the most practical. The reason this technology is favorable for long duration energy storage is that the same near-isothermal process that reduces energy consumption also provides the compressed gas at only slightly above ambient temperature. This is important because hot gases will lose thermal energy, and therefore pressure, during storage, whereas the near-ambient discharge air will be less impacted. If the physical storage depth in the earth is deep enough, there will be no losses over time as the air and earth temperature will be equal.

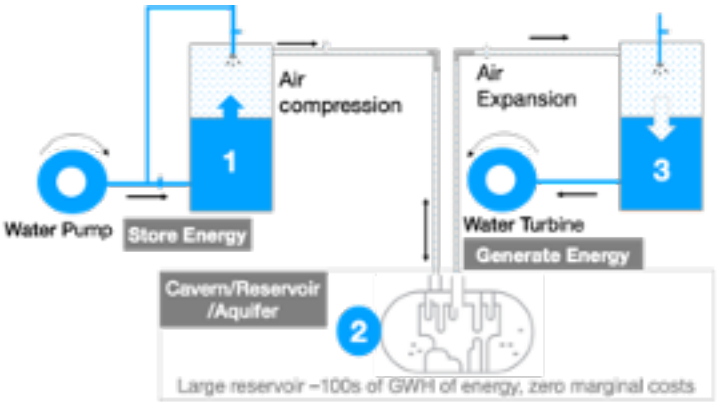


Compressed air energy storage (CAES) has been in continuous use since 1978 at grid-scale levels of power and is regaining momentum with recent Chinese installations and with efficiency improvements from various innovators. The original installations allowed the heat of compression to dissipate during underground storage and were forced to burn natural gas to offset the cooling of expansion, making them inefficient and carbon intensive. This is often labeled diabatic CAES or D-CAES.

EIC. Solutions.

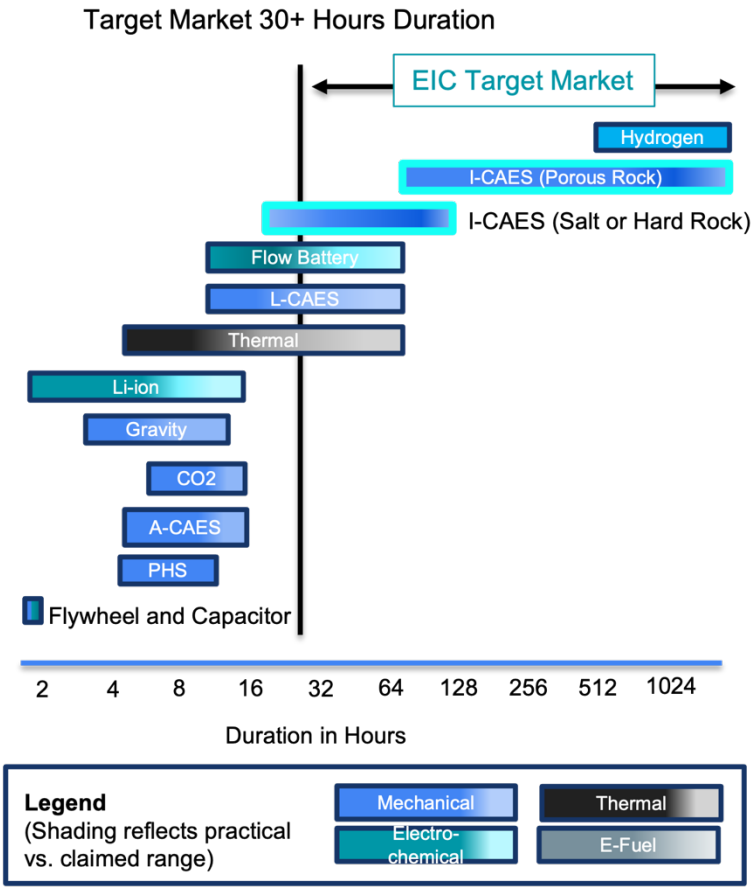


More recent variations from companies such as Hydrostor and Energy Dome (CO2 based) capture and re-use the significant heat generated during compression to offset the low temperatures of expansion during discharging, critical to performance and equipment health. This thermal storage presents a duration barrier however, as storing thermal energy for long periods is costly and challenging. This process is often referred to as adiabatic CAES or advanced CAES, expressed as A-CAES.



By contrast, EIC employs near isothermal compression and in which the heat is moved into the atmosphere real-time and is passively drawn back into the process during the expansion stage to maximize the process efficiency and leverage the atmosphere as our thermal energy storage mechanism. The same equipment is used in both directions, passively using the atmosphere as an infinite sink or source of heat. This makes isothermally compressed air the best low-carbon technology for grid-scale multi-day energy. Green hydrogen has great energy storage capacity, but the current economics are uncompetitive. Hydrocarbons of course are great stores of energy but have the associated carbon impact.

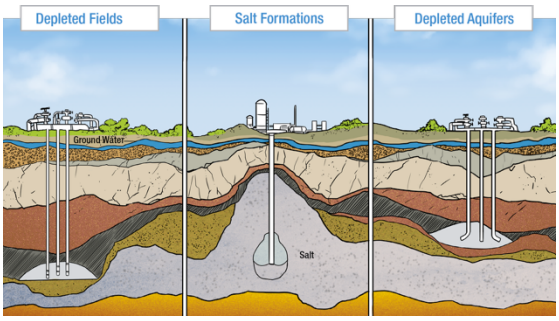
EIC. Solutions.



EIC targets the multi-day or ultra long duration energy storage segment where few clean options exist.

The EIC system has some other inherent advantages over approaches as well. Unlike electrochemical means (batteries), EIC uses minimal rare, or damaging to obtain materials and is essentially air and water (closed loop) operating in largely steel componentry. Toxicity, degradation, end-of-life costs and thermal runaway are not factors and the life is at least twice that of batteries.

CAES Storage:

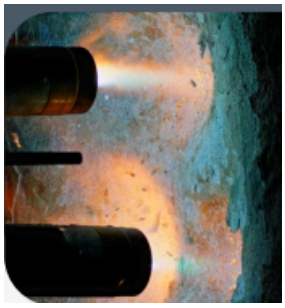


Because large volumes of compressed air are required to store meaningful amounts of energy, storage has typically been underground in a naturally occurring feature. Depleted natural gas fields, aquifers, or other porous rock formations provide vast storage opportunities that can reach weeks of duration but are geographically limited. Depleted natural gas fields are the best candidate in that the geology is well mapped by the previous user, the integrity is proven, and the infrastructure can sometimes be re-purposed to reduce access cost. Access infrastructure cost is driven by depth, permeability, and physical shape, the latter two determining the number of bores required.

The low marginal cost of porous rock containment is important to the economics, since the very low cost of the energy storage component offsets the higher cost of the power conversion component. When this is spread over many hours of low-cost storage the overall economics are unassailable. **The total capex per kilowatt-hour of energy storage can be as low as $25, compared to a lithium-ion battery at $150 per kilowatt-hour and with half of the life.** This is not to be confused with the levelized cost of energy per kilowatt-hour, however that number is derived in part from the cost of storage and so the impact will be similar. Low-cost renewable energy combined with I-CAES LDES can be equal or better than fossil fuel generated electricity in cost and dispatchability. At sufficient depth, higher pressures and geothermal energy transfer increase the round-trip efficiency, at some tradeoff to initial infrastructure costs.

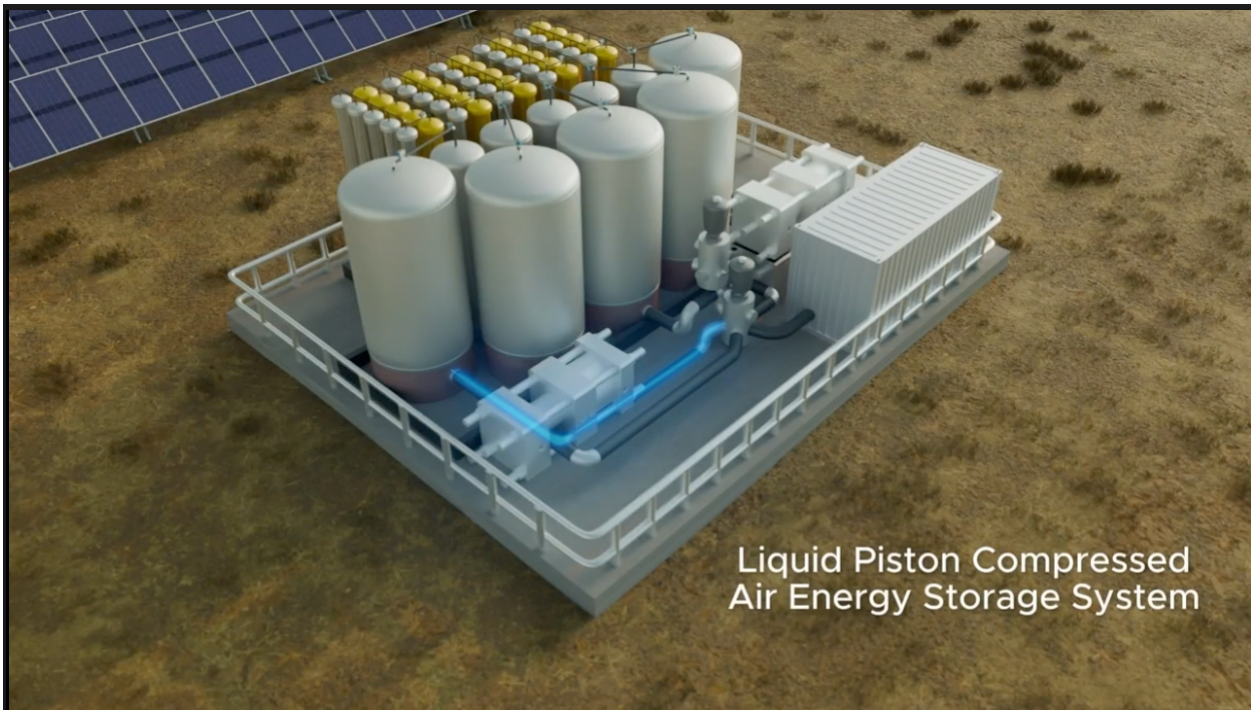
Solution mined salt beds are the most commonly used storage mechanism however they incur costs and complexities and are not available in this specific area.

Hard rock excavations are also possible although more challenging at the depths found at the site and so are included for reference. The recent emergence of technology that uses high temperature plasma (ionized gas) to thermally disassociate any type of rock without contact or concussion provides the speed and cost of subsurface excavation to reduce the cost of these options. EIC has partnered with EarthGrid, the IP holders for this technology.



This technique forces high-pressure compressed air through barrels in which plasma is created by high-amperage DC electricity. The exiting gas has temperatures exceeding 20,000 degrees which spalls off small pieces of rock that can be continuously evacuated to the surface for secondary uses as a concrete additive. Almost any kind of rock can be excavated with this technique, and costs are much lower than for traditional drilling as the speed is higher.

EIC. Solutions.



4. Strategic Considerations

As stated earlier, EIC has great interest in strategic partners where our interests and benefits are shared. There are many options in this area.

4.1 Local manufacturing opportunities – EIC is willing to create local manufacturing for final assembly of modules and installation.

4.2 Subsurface Geology – EIC has several experts available to assess geological suitability and recommend optimal approaches.