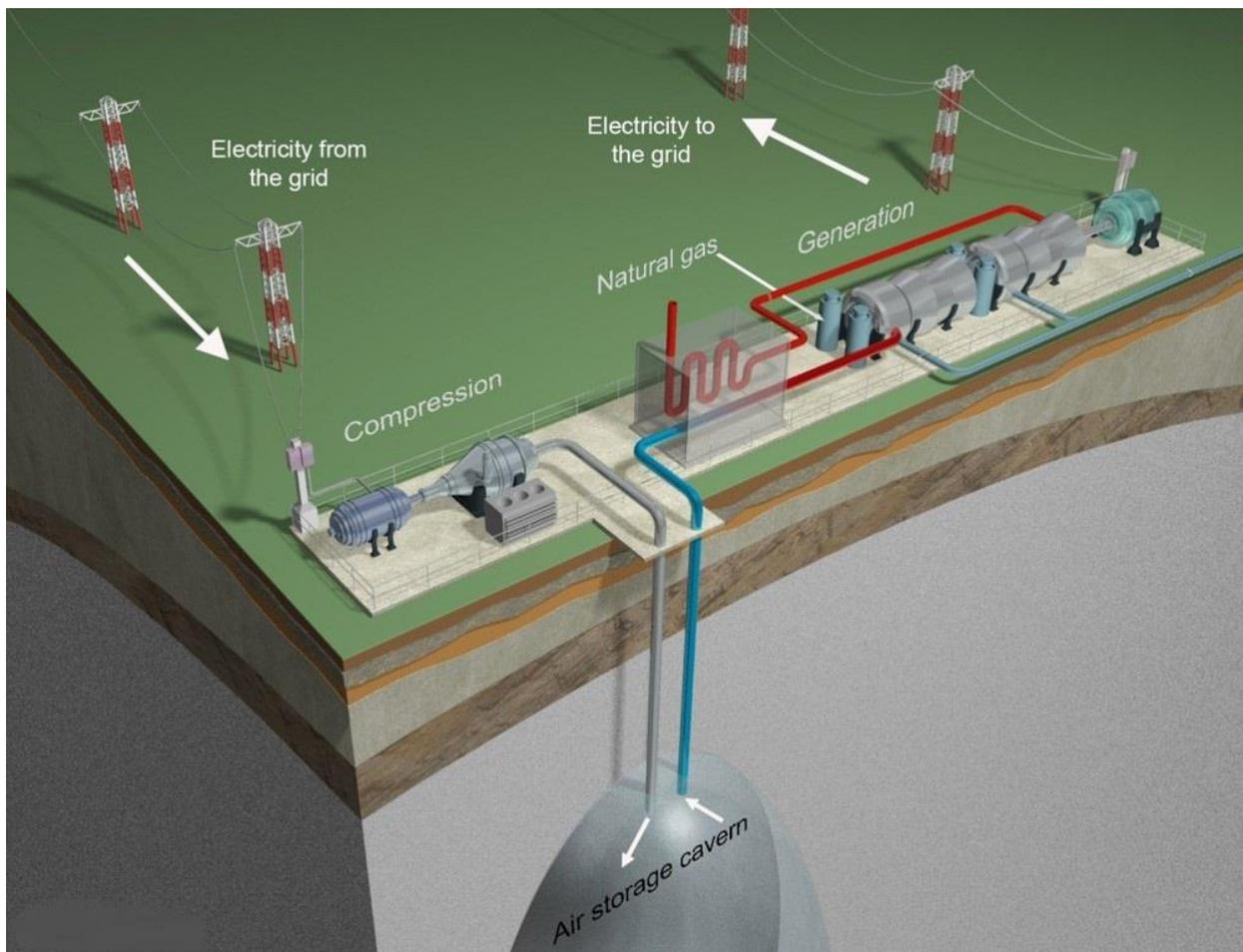




## ***Magnum's Compressed Air Energy Storage (CAES) Project***



***2016 Request for Information***

## **PROJECT BACKGROUND**

The Western electric industry is undergoing an unprecedented evolution; many would say it is undergoing a revolution. Magnum CAES' (MCAES) compressed air energy storage project will support the Western region's aspirations and goals to deploy ever higher percentages of cost effective renewable energy. The MCAES project will allow stakeholders to cost effectively meet, and even exceed, these sustainable energy ambitions. The project will also help to assure the continued economic, reliable and secure operation of the Western grid.

Because of the project's location and operational capabilities, several renewable project developers have approached MCAES to discuss a collaborative approach to providing an enhanced renewable energy offering to Western utilities. Rather than wait for an evolution of the industry, Magnum is proactively taking the bold initiative to collaborate with one or more renewable energy developers to support the development of a combination renewable energy and storage offering. Magnum believes that this combination will enable renewable electricity production that better fits the needs and aspirations of end-use electric customers by maximizing the environmental and economic value of these renewable projects.

*How would renewable projects benefit from a collaboration with MCAES?* To begin with, it will give participants a chance to get smarter about the opportunities and challenges facing bulk energy storage in the West, and specifically how best to integrate the MCAES project's unique capabilities with the needs of developers, customers and transmission grid operators. The MCAES project will enhance the economic and environmental value of renewable projects while helping to mitigate project risks, thus differentiating theirs from other projects.

We firmly believe that this approach will result in a degree of renewable development that might not happen otherwise.

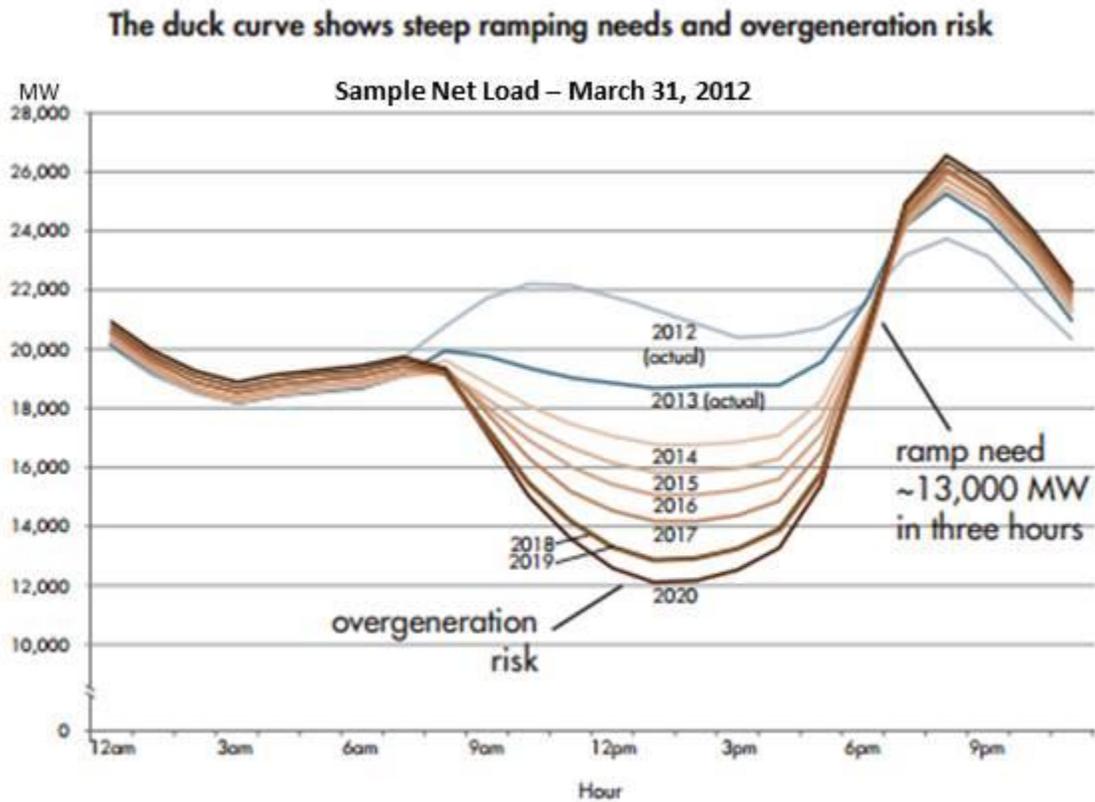
The creativity of renewable project developers and Magnum's commitment to the future will allow the combination to discover better ways of meeting stakeholders' needs.

In short Magnum is looking to the future of grid scale renewable energy storage in the West and is looking for potential renewable partners to embark on this journey with us.

### **What is the Potential Joint Opportunity?**

Utilities in the Western United States are responding to a dramatic change in business exigencies. They must respond to many unprecedented societal, regulatory, and operational demands; as well as changing expectations of the customer. Among these challenges: increases in renewable energy generation (both distributed and utility scale), environmental compliance requirements, the development of the Western Energy Imbalance Market and potential changes to a broader form of Western Independent System Operator structure. The California Independent System Operator and the Western Electric Coordinating Council must plan for the real-time impact of the increased penetration of variable, somewhat unpredictable, renewable

resources on the reliability of the Western Grid. The challenge is best shown by the well-known California “Duck Curve.”



(from the California Independent System Operator)

This curve was produced under the assumption that renewable energy would provide 33 1/3% of California’s electric energy by 2020. That requirement has been increased to 50% by 2030. Recent experience shows that the impact shown in the graph above for 2020 has already arrived. The MCAES project can be instrumental in helping to mitigate the impacts shown above through grid scale renewable energy storage. Additionally, CAES up and down ramp rates are faster than most other grid level technologies that provide ancillary services.

Nearly every other state connected to the Western grid has requirements and aspirations to increase the use of renewable energy, distributed energy resources, and energy efficiency approaches while lessening the environmental impact of electricity production and consumption. The location of Magnum’s CAES project could not be better situated to provide an array of valuable services to western energy entities striving to deal with these changes.

## MCAES Project Description

The project is being developed using the only known “Gulf Coast” domal salt deposit in the Western United States. The salt dome is near the town of Delta in Millard County, Utah.



<b>Generator Capacity</b>	160 MW output
<b>Heat Rate</b>	4,227 Btu/kWh (HHV basis)
<b>Storage Duration</b>	48 hours or ~7,680 MWh without recharge
<b>Compressor Capacity</b>	Up to 160 MW input
<b>Equipment</b>	One Dresser-Rand four-stage compression train One Dresser-Rand three-stage expander turbine generator train
<b>Cooling</b>	TBD – air/water/hybrid
<b>Owner’s Engineer</b>	TBD
<b>Gas Supply</b>	TBD
<b>Long-Term Maintenance</b>	Siemens
<b>Operator</b>	TBD
<b>Electric Interconnection and Transmission</b>	HVAC & HVDC at the Intermountain Power Plant Substation
<b>Substantial Completion</b>	4 <sup>th</sup> quarter 2021

The current design of the first MCAES project will use up to 160 MW of renewable electricity to compress air and store it in a deep underground salt cavern. The energy will be returned to the grid, through a highly flexible, 160 MW natural gas fueled generator, which, when augmented

by compressed air, will have a heat rate of about 4227 MMBtu/MWh. The volume of the salt cavern, at approximately 4 million barrels, will allow the generator to operate for 48 hours before cavern recharging is required. This results in approximately 7,680 megawatt-hours (MWh) of storage from one cavern charge. Also, because the two major industrial components of CAES technology can run independently, the project can provide up to 317 MW of ancillary services to the grid.

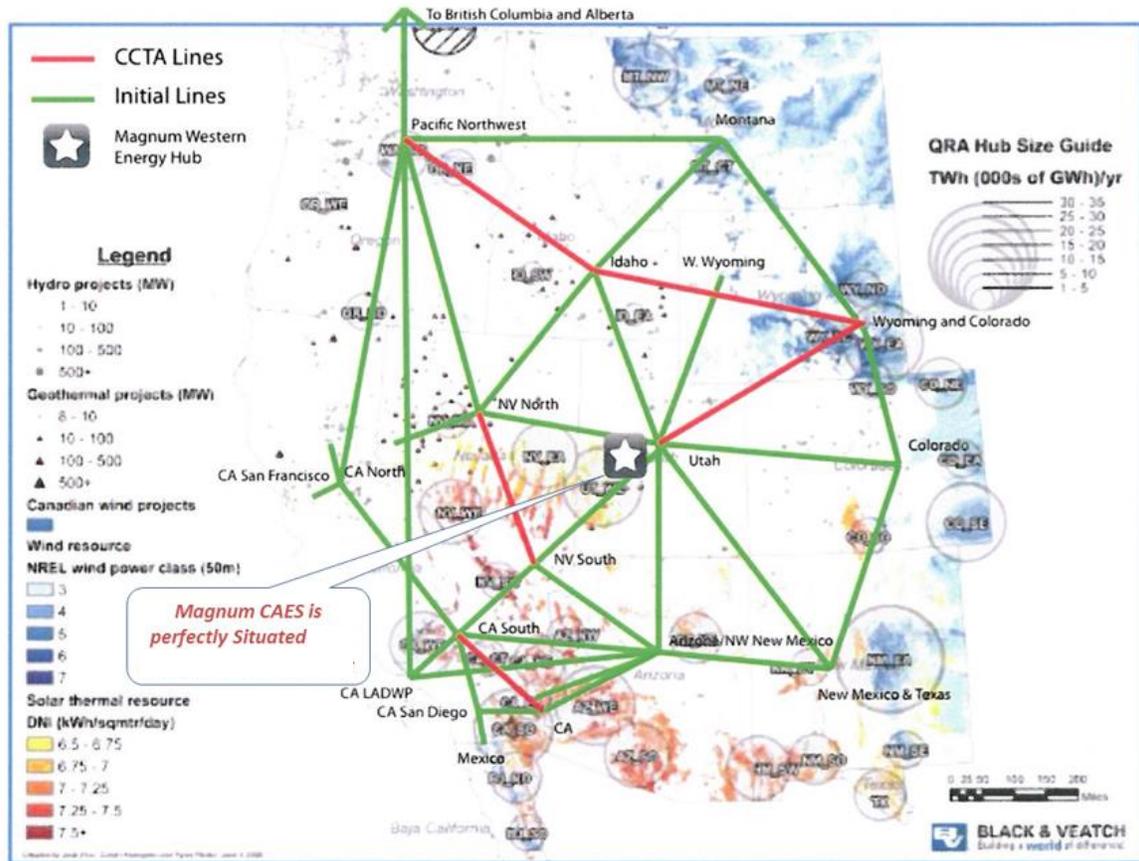
MCAES will provide the balance of plant infrastructure to bring the CAES project to commercial operation. This infrastructure includes the required: permits, water, brine pond, cooling, selective catalytic reduction, natural gas fuel, CAES Compression and CAES Generation Substations, control buildings, and Western grid interconnection.

**This request for information does not specify the amount or kind of renewable energy that the respondent wishes to propose as electricity to power the CAES project compressors. The expectation is that a respondent will have specific storage, arbitrage or other needs related to the size of the renewable project, its potential off-taker and the developer's assessment of the best way to use CAES' capability to maximize the flexibility inherent in CAES technology. This also means that more than one project could provide "renewable compression electricity" to Magnum's CAES project; therefore, exclusivity might not be possible, depending on the size of the renewable projects under consideration.**

Fortunately, one cavern can potentially support more than one 160 x 160 MW CAES project and the cavern size can vary per renewable project needs; therefore, the current CAES design can be customized to some degree to match the respondent's needs and business opportunities. The salt dome is large enough to provide caverns to support 10 or more similar CAES projects in the future.

An interconnection to the Western electric grid through the IPP substation or other existing and proposed transmission line interconnections will allow a combination CAES and renewable energy offering to gain access to Western electricity customers and markets. As shown below the CAES project is ideally located to provide access from many large, high value renewable energy zones to electricity consumers throughout the west.

# Magnum CAES – Future Heart of the Western Grid



WECC Common Case Transmission Assumptions (CCTA)

The size of the circles above shows the magnitude of the renewable energy capacity, by type, in the Western United States as determined by Black & Veatch under the Western Governors Association’s sponsorship. The green lines represent existing transmission paths and the red lines planned or recently completed paths as used by Western Electricity Coordinating Council planners.

The Delta location is at the hub of a “wheel of renewable opportunity.” However, not only is it a hub for storage and generation, but the salt dome is ideal for natural gas storage too. Creating a true western energy hub to the benefit of all Westerners.

## CAES Adds Value to Renewable Energy Projects

A partnership with MCAES will allow the respondent to make an integrated offering to Western electric entities that will allow the renewable project to:

- Reduce the probability of the curtailment of valuable renewable energy, along with the associated loss of its environmental attributes
- Arbitrage renewable generation through storage to maximize the economic value of renewable energy
- Firm and shape delivery to the grid to maximize economic and environmental value
- Provide the following ancillary services:
  - Voltage regulation via automatic generation control
  - Spinning and non-spinning reserves
  - Regulation up and regulation down
  - Ancillary services are provided with very low fuel burn and hence low greenhouse gas emissions
- Magnum has already developed significant components of the infrastructure required to construct and operate a CAES plant at the site, and has a history of successfully solution-mining four large underground caverns at the site
- Differentiate the project from similar projects in the same area
- Reduce the risk of inadequate availability of transmission capacity

Unlike other grid-level, bulk storage technologies, some combination of these capabilities can be provided simultaneously because the CAES compression and generation functions operate independently.

## Non-binding, Non-exclusive, Request for Information

MCAES is interested in working with existing and proposed renewable energy projects to enhance the value of those projects by providing storage, arbitrage and ancillary services for them. MCAES invites your company to participate in a 40 day, non-binding request for information process whereby expressions of interest are being sought for the respondents to propose delivery of electricity from renewable energy projects to power the compressors at the Delta, Utah CAES project.

This 40 day RFI will run from **8:00 a.m. Mountain Standard time on Monday, November 7, 2016 through 5:00 p.m. Mountain Standard time on Friday, December 16, 2016.**

*Magnum will enter a non-exclusive, confidentiality agreement with each respondent to protect the commercially sensitive information that might be shared by both parties.*

## Summary

The intent of this RFI is to solicit information and input from renewable project developers on how to best work together to provide the renewable energy and energy services the Western United States is going to need. MCAES' intent is to use this RFI: to learn more about the future from other developers, to assess mutual development opportunities and to further explore if there is a commercial structure that will support a compelling market offering to Western utilities, or other energy sector entities. Because of the location and unique nature of Magnum's salt dome, CAES with dedicated renewables can create an unprecedented storage, transmission and generation asset, which cannot be duplicated elsewhere in the West.

A Request for Information Form and other information can be found on the MCAES website at <http://westernenergyhub.com/caes.php>. A completed MCAES Request for Information Form should be emailed to Richard Walje at [rwalje@westernenergyhub.com](mailto:rwalje@westernenergyhub.com) by 5 p.m., Mountain Standard Time, on December 16, 2016.

Magnum Compressed Air Energy Storage, i.e. Magnum CAES, is wholly owned by Magnum Development, LLC, a Haddington Ventures, LLC portfolio company. Haddington principals have been involved in compressed air energy storage businesses since the early 1990s. A list of Haddington's active and realized investments can be viewed at [www.hvllc.com](http://www.hvllc.com).

Thank you for your interest in the Magnum CAES project.

## Magnum CAES, LLC