

**Project Title:**

**Fuel-Free Geologic Compressed Air Energy Storage From Renewable Power**

**Task # 6 Deliverable Report**

**For:**

**New Technology Implementation Grant Program**

**582-11-13126-3225**

**Submitted by:**

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**Submission**

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## **Abstract/Executive Summary**

General Compression has completed the procurement, construction, and installation of the GCAES™ and wind turbine. The wind turbine is a Gamesa G97 2.0MW model, and it has been physically and electricity integrated with the GCAES system. General Compression has secured all necessary permits required to deliver electricity to the grid and has connected the project (including both the GCAES™ and wind turbine) to the electric grid. The on-going testing the General Compression has been undertaking with the system, as described in the Task 4 Report, as produced data which provides initial indications as to the commercial viability of the GCAES™ technology.

## **Introduction / Background**

General Compression has developed a near-isothermal compressed air energy storage system to provide a competitive fuel-free bulk energy storage solution. The technology, called GCAES™, consists of a positive displacement compressor/expander module using a bi-directional piston compression system. GCAES™ uses a central electric motor/generator to convert electric energy to hydraulic power to drive multiple compression pistons to produce compressed air; in reverse the compressed air expands against the pistons creating hydraulic power that is converted to electricity by the same electric motor/generator.

Successful commercialization of this GCAES™ technology will allow for increased deployment of renewable energy by eliminating the intermittent nature of stand-alone wind or solar projects. In addition, GCAES™ will enable renewable projects to provide valuable ancillary services that they have been, historically, unable to provide due to the inability to control their production. By providing this increased flexibility and the ability for grid operators and load serving entities (LSEs) to schedule, in advance, the production from a renewable facility GCAES™ will enable renewable plants to compete directly with conventional coal and gas fired facilities. Providing this cost competitive alternative to traditional power generation allows power generators to meet the demand for firm capacity with emissions free technology. In addition to firming renewable generation, GCAES™ has additional potential applications for increasing the efficiency of base load plants by providing shaping services and for various grid applications such as deferral of new capacity or transmission investment and fast-responding ancillary services.

For ratepayers in Texas, GCAES™ has the potential to reduce air emissions by using renewable energy to meet capacity and other requirements traditionally served by coal or natural gas fired power plants. Furthermore renewables paired with GCAES™ can provide a fixed cost alternative that does not expose ratepayers to fuel cost uncertainty. GCAES™ provides a cost complete alternative to allow grid operators and LSEs to diversify their supply mix and insulate ratepayers from cost and regulatory uncertainty.

## **Project Objectives / Technical Approach**

General Compression has eight operational goals and objectives for this project:

- 1) Build and install a commercial unit of the General Compression Advanced Energy Storage (GCAES™) at a demonstration facility being developed jointly between General Compression and ConocoPhillips.
- 2) Integrate the GCAES™ system into an existing cavern formation at the demonstration facility.
- 3) Build and install approximately 2 to 10 MW of wind turbines at the same site.
- 4) Integrate electricity generation from the wind turbine into the GCAES™ system for optimal delivery of wind power to the grid.
- 5) Provide and maintain energy storage and generation services to supply power to the Texas electrical grid over multiple timeframes.
- 6) Work with the Bureau of Economic Geology at the University of Texas (“BEG”) to develop the test protocol to analyze the function of the GCAES™ unit and the wind turbine together as a project so that they respond to appropriate market signals.
- 7) Work with BEG to analyze the further integration of renewables into the electrical grid throughout the state of Texas in order to support the reduction of emissions and create opportunities for existing and future clean energy industry expansion within the state.
- 8) Reduce emissions by displacing base load power generated from fossil fuels with renewable resources thus improving overall air quality in the state of Texas.

## **Tasks**

### ***Task 6: Project objective(s) from Grant Activities (Scope of Work)***

Procure components for, build, and install GCAES and 3-MW of wind turbine(s)

2.6. Task Statement: The PERFORMING PARTY will procure components for, build, and install the GCAES and 3-MW of wind turbine(s) for commercial operation.

2.6.1. The PERFORMING PARTY will competitively procure components for the GCAES. The PERFORMING PARTY will purchase the components per the released final design of the GCAES.

2.6.2. The PERFORMING PARTY will select vendor for purchase of 3-MW of wind turbine(s).

2.6.2.1. The PERFORMING PARTY will contract with the selected vendor for the purchase, commissioning, and installation of the 3-MW of wind turbine(s).

2.6.3. The PERFORMING PARTY will build the GCAES.

2.6.4. The PERFORMING PARTY will take the necessary steps to commission the GCAES including but not limited to control system debugging and calibration, data collection, and post processing.

2.6.5. The PERFORMING PARTY will commission and install the 3-MW of wind turbine(s).

2.6.6. The PERFORMING PARTY will integrate the GCAES and 3-MW of wind turbine(s).

2.6.7. The PERFORMING PARTY will identify and obtain all necessary permits to deliver electricity to the grid from the GCAES and 3-MW of wind turbine(s).

2.6.8. The PERFORMING PARTY will contract to establish a grid interconnection.

2.6.9. The PERFORMING PARTY will collect data on the performance of the GCAES in order to further establish viability of future implementation of the GCAES.

2.6.9.1. The PERFORMING PARTY will collect data to demonstrate dispatchable and firm wind power.

2.6.9.2. The PERFORMING PARTY will collect data to demonstrate ancillary services including but not limited to basic generation time shifting, economic dispatch, frequency regulation, ramp rate control, and steady output control.

2.6.10. Schedule: The PERFORMING PARTY shall complete this task on or before January 31, 2014.

2.6.11. Deliverables: The PERFORMING PARTY shall submit a report to the TCEQ upon completion of this task. This report will include a summary of the installation of the GCAES, including photographs of the specific project site.

***Task 6: Procure components for, build, and install GCAES™ and 3-MW of wind turbine(s)***

General Compression has completed the procurement, construction, and installation of the GCAES™ system. Procurement of the components to implement the retrofit described in the Task 5 report was, to the extent possible, done using a competitive process. In some instances, competitive sourcing was not viable due to a limited number of qualified bidders (e.g., when only one vendor manufactures a needed component) or capacity limitations (e.g., when only one vendor could meet schedule requirements). Procured components were delivered to the site and installed & commissioned by the vendor's staff or by contracted labor. General Compression performed project-level commissioning using its own staff and contracted labor.

General Compression has also completed the procurement, construction, and installation of a wind turbine generator. Before selecting a wind turbine, General Compression (along with partner ConocoPhillips Company) erected a meteorological monitoring station (met station) on land adjacent to the site. This met station gathered data about the wind conditions at the site. These data along with data from long-term reference stations were then used to identify which makes and models of wind turbines were potentially suitable for the site. General Compression then contacted the vendors to determine the cost and availability of several of the suitable wind turbines. Based on these discussions, it was determined that the Gamesa G97 2.0-MW wind turbine was the best combination of performance, availability, and cost. General Compression had originally contemplated installing a three MW wind turbine, however during the procurement process it was determined that the Gamesa turbine could achieve the same project objectives at a lower cost. In addition, at the time of procurement there were a limited number of 3.0-MW wind turbines available in the market and these turbines were not as suitable for the site as the Gamesa turbine. The lower output turbine will not impact the ability for General Compression to achieve the Project Objectives and will reduce the overall cost of the project. The turbine was procured under an Engineering, Procurement, and Construction (EPC) agreement with RES Americas. With this EPC agreement, RES Americas provided all necessary services and labor required to install & commission the Gamesa wind turbine.

As of the writing of this report, the construction activities at the site have been completed and the project is in commercial operation. The project has been interconnected with the electric grid and energy generated by the project is transferred to the local cooperative under a commercial agreement. General Compression is in the midst of a comprehensive operational tuning program that is intended to, slowly over time, increase the demand on and complexity of the project's operation.

### ***Task 6: Objectives vs. Results***

General Compression has procured, built and installed the GCAES™ system and Gamesa G97 2.0MW wind turbine generator. A 2.0MW wind turbine was installed, rather than the 3.0MW wind turbine described in the Scope of Work, due to the lack of commercial availability of 3.0MW wind turbines and the availability of large rotor diameter 2.0MW wind turbines, like the Gamesa G97, which allow for high capacity factors at moderate wind sites (IEC Class III) such as the project site.

- The as-built site plan is submitted as Attachment 1 (Confidential/Proprietary: Inform Applicant and Seek AG Opinion before Releasing)
- The as-built electrical single-line diagram is submitted as Attachment 2 (Confidential/Proprietary: Inform Applicant and Seek AG Opinion before Releasing)
- Technical data about the Gamesa G97 Wind Turbine is submitted as Attachment 3.
- Photographs of completed wind turbine, GCAES™ system, and other project components is submitted as Attachment 4 (Confidential/Proprietary: Inform Applicant and Seek AG Opinion before Releasing)

General Compression has obtained Exempt Wholesale Generator Status and been granted Market Based Rate Authority from the Federal Energy Regulatory Commission (FERC) and has been granted permission to interconnect & operate by the distribution grid operator (Lea County Electric Cooperative).

- Notice of Effectiveness of Exempt Wholesale Generator Status from the U.S. Federal Energy Regulatory Commission (FERC) for Texas Dispatchable Wind 1, LLC is submitted as Attachment 5A (Confidential/Proprietary: Inform Applicant & Seek AG Opinion before Releasing)
- An Order from the U.S. Federal Energy Regulatory Commission (FERC) for Texas Dispatchable Wind 1, LLC's request for Market Based Rate Authority (Docket No. ER13-70-001) is submitted as Attachment 5B (Confidential/Proprietary: Inform Applicant & Seek AG Opinion before Releasing)
- Authorization from the distribution grid operator authorizing the interconnection of the project is submitted as Attachment 6 (Confidential/Proprietary; Inform Applicant and Seek AG Opinion before Releasing)

Finally, General Compression has preformed an initial review of the future commercial viability of the project and GCAES™ technology by assessing the wind resource and collecting data from the GCAES™ system demonstrating basic operational capabilities that will, in the future, enable projects to provide commercial services.

- The Gaines Dispatchable Wind Project production estimate is submitted as Attachment 7 (Confidential/Proprietary; Inform Applicant and Seek AG Opinion before Releasing)
- A discussion of the data collected by the project and the future commercial viability of firm wind and ancillary services products from the project is submitted as Attachment 8 (Confidential/Proprietary; Inform Applicant and Seek AG Opinion before Releasing)

***Task 6: Deadline from Grant Activities (Scope of Work)***

The work required under Task 6, including submission of this report, has been completed on or before January 31, 2014, as required under Section 2.6.10 of the Scope of Work.

***Task 6: Details or attachment of final results/deliverables***

The following documents are submitted as Confidential/Proprietary; Inform Applicant & Seek AG Opinion before Releasing:

- TCEQ Task 6 Report Confidential & Proprietary Attachments (71 pages, dated January 31, 2014) is submitted as Confidential/Proprietary: Inform Applicant & Seek AG Opinion before Releasing.

***Task 6: Technical and commercial viability of the proposed approach***

- A discussion of the data collected by the project and the future commercial viability of firm wind and ancillary services products from the project is submitted as Attachment 8 (Confidential/Proprietary; Inform Applicant and Seek AG Opinion before Releasing)

***Task 6: Scope for future work***

Future work is planned for the design of the next GCAES™ machine. A full design process, from concept development to the ongoing operations and maintenance procedure, is currently underway. A detailed discussion of this future work can be found in Appendix F to the Task 4 Deliverable Report.

In addition, General Compression is working to continually improve its control systems and SCADA software. These improvements are discussed in more detail in Attachment 8 to this report.

***Task 6: Intellectual Properties/Publications/Presentations***

Not applicable

**Summary and Conclusions**

Based on documents provided here and separately as “**Confidential/Proprietary**”: **Inform Applicant and Seek AG Opinion before Releasing**, General Compression believes that it has satisfied all requirements for Task 6.

General Compression has and will continue to prepare and submit quarterly reports and will prepare and submit the final report as required as Task 7.

END OF TASK 6 REPORT