Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title:
BULK ENERGY STORAGE FOR NORTH DAKOTA WIND ENERGY INTEGRATION

Applicant:
DAKOTA SALTS, LLC

Principle Investigator(s):
DAKOTA SALTS, LLC &
ELECTRIC POWER AND RESEARCH INSTITUTE
SCHLUMBERGER
TETRA TECH

Date of Application:
December 2009

Amount of Request:
$ 225,000

Total Amount of Proposed Project:
$ 570,000

Duration of Project:
8 MONTHS

TABLE OF CONTENTS

Please use this table to fill in the correct corresponding page number

ABSTRACT

Objective:

The objectives of the proposed project are to (1) perform an advanced subsurface geo-mechanical feasibility study to characterize North Dakota's salts for their utilization for Bulk Energy Storage (BES) and (2) perform a cost-to-benefit analysis for installation of a Compressed Air Energy Storage (CAES) power plant for wind integration service in North Dakota. This will include plant performance and operating cost specifications, expectations for plant capital costs and optimal dispatch of the power plant.

Expected Results:

The North Dakota BES feasibility study will provide the total value proposition for BES in North Dakota which is a vital step in stimulating investment in plant construction for wind integration in North Dakota. Bulk energy storage installations will reduce the challenges caused by increased wind penetration, enhance continued increases in wind penetration levels, improve system efficiency and economics; thereby, encouraging continued and aggressive renewable investments.

The proposed project objectives will be coordinated through Dakota Salts while collaborating with the world's leading experts in identifying and preparing the technical pre-steps associated with integrating Wind Energy into Bulk Energy Storage. Dakota Salts fully intends to further enter the construction phase of a BES power plant along with our collaborating partners as soon as the technical and economic feasibility studies have been finalized. Further, we believe the combined wind-CAES technology described in this study will be a long term strategic asset to the North Dakota Wind Industry.

Duration:

Completion of the Feasibility Studies should conclude within 8 months.

Total Project Costs:

Total project cost for the associated feasibility study will be approximately $ 570,000.

Total Application Amount Requested from NDIC: $225,000.

Participants:

All efforts are collaborative contractual engagements through Dakota Salts, including the Electric Power and Research Institute (EPRI), Schlumberger and Tetra Tech. The responsibilities and qualifications of the participants are further defined throughout the application proposal.

PROJECT DESCRIPTION

Overview:

Since mid-2008, Dakota Salts, LLC (Dakota Salts) has been coordinating expertise and efforts to capture the value of North Dakota's large bedded salt deposits for the purpose of solution mined Salt Cavern and Compressed Air Energy Storage (CAES) solutions. Dakota Salts has collectively established a confluence of interested parties that are working together in the realm of Wind Turbine Energy, Salt Cavern CAES and Energy Transmission Infrastructure with the aim of assisting North Dakota in being one of the United States' greatest resources for renewable energy technology and renewable energy storage.

When signing the economic recovery plan into law, President Obama also singled out North Dakota and how the lack of transmission in the state affects the nation, saying "It also means that places like North Dakota can produce a lot of wind energy, but can't deliver it to communities that want it, leading to a gap between how much clean energy we are using and how much we could be using."

Dakota Salts is the first to pioneer Wind energy storage efforts in the region setting where a comprehensive renewable energy solution is possible via wind and CAES: North Dakota. Dakota Salts has engaged the world's leading expertise surrounding successfully building and operating CAES plants to comprehensively launch a feasibility study and subsequent plant construction. State assistance via the North Dakota Renewable Energy Council Initiative will be allocated toward in-depth feasibility studies for the direct purpose of integrating wind utility into energy storage technology in North Dakota via CAES and integrating wind-CAES solutions into existing electrical infrastructure.

A Wind CAES solution in North Dakota requires that the two feasibility objectives below are carefully coordinated as variables from one may affect the other. The Project Participants collectively combine the leading expertise that is required in preparing and conducting the technical and economic feasibility pre-steps associated with integrating Wind Energy into Renewable Bulk Energy Storage and further executing the construction phase of a Wind CAES power plant post this feasibility study.

(1) Perform an Advanced Subsurface Geo-mechanical Feasibility Study Characterizing North Dakota Salts for its Utilization in Bulk Energy Storage

North Dakota is the beneficiary of the proper geological and regional setting that allows high wind turbine efficiency and wind storage capability via salt cavern CAES. The depth at which North Dakota's salts are deposited introduces geological and geo-mechanical considerations that are unique to North Dakota. Thereby, the necessity to carefully coordinate and balance deep salt caverns and/or shallower horizontal storage caverns for CAES technology and the implementation of new technologies in salt cavern generation is a consideration that must be completed to address bulk energy storage solutions in North Dakota.

(2) Perform a Cost Benefit Analysis for a Compressed Air Energy Storage (CAES) plant for Wind Integration in North Dakota

In North Dakota electrical service territories, there is a need to take advantage of renewable energy generation (in particular, wind generated energy) and to more effectively follow the daily increase and decrease of power requirements providing improved system reliability and efficiency. The objective of the economic study is to perform a cost-to-benefit analysis for installation of an bulk energy storage (BES) power plant for wind integration service in North Dakota. This will include plant performance and operating cost specifications, expectations for plant capital costs, and optimal dispatch of the power plant.

Combined Project Methodology:

Dakota Salts' collaborative effort combines the world's leading subsurface and surface expertise in renewable bulk energy storage. Our project partners include:

- Electric Power and Research Institute (EPRI), the foremost expert in CAES technology;
- Schlumberger, one of the foremost experts in subsurface characterization;
- Tetra Tech, the foremost expert in subsurface storage permitting and environmental impact.

Together, we're working collaboratively to apply advancements in technology to successfully implement CAES in North Dakota.

The starting point of the CAES initial evaluation study will be based on the details provided via advanced solution mining and salt cavern generation technical and feasibility consideration by Schlumberger and others, who shall report our expected physical characteristics including the expected physical volume, the minimum working pressure, the maximum working pressure and the geological details of the overburden. Such detail will be maneuverable according to the needs of CAES while balancing such with the technical challenges of North Dakota's salt. By running numerous geo-mechanical models and applying theoretical technical methods, an optimum geological setting for CAES in North Dakota can be identified.

Advancements in solution mining practices and drilling practices are already in consideration to identify novel approaches to capture the full resource of North Dakota's salt deposits for the purpose of alternate energy generation. The study will include the following considerations.

(1) A geo-mechanical study of a solution-mining cavern and cavern field in order to optimize the cavern geometry and layout to maximize size while maintaining cavern stability, thus minimizing disruptions to operations through cavern collapse or damage to surface infrastructure because of ground subsidence.

(2) Provide CAES cavern assessment of performance and stability of the cavern during CAES operations. Performance and stability issues include cavern connectivity, cavern closure, surface subsidence, and potential for spalling in the cavern roof and/or walls, and roof collapse.

(3) In the development of new caverns, the size, shape, and locations maybe optimized by evaluating a series of geo-mechanical models. For the North Dakota cavern field, solution mining simulations will be performed to identify potential cavern geometry, including investigation of horizontal salt cavern generation in shallower, bedded salts.

(4) Determination of an allowable operating pressure range in a cavern that will ensure cavern stability and provide acceptable performance for a CAES facility, which provides the groundwork for subsequent movement into a detailed CAES unit design.

(5) The generic performance of a BES plant operating in North Dakota will be specified including ranges for heat rate, ranges for energy ratio, capital costs, variable and fixed O&M costs, up and down ramp rates, maximum discharge capacity, switchover time, etc, for a generic plant representing known compression based energy storage systems.

(6) The economic optimization will utilize hourly on/off peak electricity price data. Hourly variation of electricity prices will be presented for typical representative

weeks from different seasons and years with characteristic fuel prices, wind penetration levels, and electricity price variations on/off peak.

(7) The EPRI Dynatran software code will use this data, and plant characteristics, to determine optimal charging and discharging of the BES plant, CO_2 emissions and savings, and plant capacity factor.

(8) EPRI Dynatran modeling will assist in determining the size of a potential BES plant in terms of its MW capacity, and hours of discharge capacity, to produce maximum economic value to the potential host utility for a BES plant.

(9) The detailed CAES unit design and financial model will take into consideration the advantages and disadvantages of applying CAES at significantly greater operating pressures and depths than previously accomplished.

(10) Application of CAES in deep salt and the associated learning, impact, and real incentive not only captures the North Dakota wind and salt resources, but widens the scope of potential CAES applications.

(11) In addition to capturing this data, the purpose of this feasibility study is to address and overcome the technical issues associated with CAES application in North Dakota and move forward into the construction phase as rapidly as the permitting process allows. Therefore, all feasibility studies will be comprehensive enough to immediately move North Dakota CAES into project financing, permitting and project coordination and installation.

Anticipated Results:

The proposed study is to answer each of the above mentioned technical and economic considerations, which will provide the total value proposition for bulk energy storage in North Dakota. This is the first and most vital step in stimulating investment in plant construction for wind integration in ND.

Bulk energy storage installations will reduce the challenges caused by increased wind penetration, enhance continued increases in wind penetration levels and improve system efficiency and economics; thereby, encouraging and spurring additional wind energy investment. Further, part of the benefit of bulk storage is derived from a latent value in storage in the electrical system, independent of wind penetration.

Facilities:

The proposed project is principally an engineering feasibility study, whereby, the required facilities are satisfactorily provided by pre-established facilities available to EPRI, Schlumberger, Tetra Tech, Dakota Salts, and other vendors as required. Each of the principle investigators experience and in-house capabilities are discussed through the project description and grant application.

Primary Resources:

Dakota Salts expertise is in salt exploration and development, with geological, geophysical, land, law, and legal expertise in the realm of power generation and subsurface mining. Dakota Salts efforts and business interests in North Dakota are ongoing.

The EPRI CAES R&D team has extensive experience with optimal economic dispatch modeling and strategic planning for all types of energy storage technologies. EPRI has developed and refined in-house software for optimal dispatch/charging of storage plants to determine the total value proposition for plant construction. EPRI has dedicated their principle CAES expertise to the North Dakota CAES effort.

Schlumberger has over 65,000 employees and is the world's largest subsurface characterization and engineering firm, with 25 R&D facilities around the world, Schlumberger places a strong emphasis on developing innovative technology that adds value for customers. Schlumberger consistently invests more in R&D each year than all other subsurface characterization companies.

Schlumberger has dedicated their principle lead expertise in salt characterization and mining to the North Dakota CAES effort. Tetra Tech is one of the top ten design and environmental firms in the nation with over 10,000 employees and has been providing the energy industry with sound technical solutions for over forty years. Tetra Tech has dedicated their principle CAES, storage, permitting, and environmental impact expertise to the North Dakota CAES effort.

Techniques to be Used, Their Availability and Capability:

In addition to the primary resources available by the project participants; some additional techniques and resources available to the project include an in-house EPRI software program for optimal dispatch/charging of storage plants. This is an effective tool for determining the total value proposition for storage plants. This software, and earlier versions, has been used extensively with US utilities. In addition, EPRI has built current demonstration projects in other regions that have involved economic analysis for advanced compression based plants for 15+ utilities.

Schlumberger has developed a series of down-hole wireline logging tools that are directly applicable to CAES evaluation. Innovative down-hole logging tools such as: magnetic resonance, natural gamma ray spectroscopy, multi-component sheer sonic, resistivity borehole imaging and modular testing tool have the potential to significantly reduce the effort needed to characterize a potential CAES resource. In the event that a salt exploratory hole is drilled, Schlumberger will selectively utilize these tools to aid in the evaluation of the suitability salt deposit for CAES storage.

The data collected by Schlumberger will be utilized by EPRI to assist in understanding the cavern size development potential and CAES injection and withdrawal rates. Further, in the event of a core extraction, laboratory testing can be utilized to determine the mechanical properties of the salt and nonsalt units. Rock properties determined from laboratory testing are an important input to the geo-mechanical analysis effort.

The tests required to determine the necessary properties include:

- Quasi-Static Compression Test: The quasi-static compression test is used to determine (1) the ultimate compressive strength, (2) Young's modulus, and (3) Poisson's ratio for the salt and nonsalt units.
- Brazilian Indirect Tension Test: The Brazilian indirect tension test is used to determine the apparent tensile strength for the salt and nonsalt units.
- Constant Mean Stress Test: The constant mean stress test is used to determine the dilation limit of salt.
- Confined Creep Test: The confined creep test is used to determine the deformation that occurs through time when a constant stress difference (axial stress minus confining pressure) is applied to the specimen. Creep is the principal deformation mechanism in salt surrounding a storage cavern.

Environmental and Economic Impacts while Project is Underway:

Dakota Salts and the proposed participants in the following study have meet with and are in communication with the principle utility providers, wind power generators, and transmission providers. The execution of this project will draw additional attention from each power interest currently operating in North Dakota. As Dakota Salts and the project participants continue to solicit CAES interest to North Dakota power interests, the proposed project will continue to generate real partnership and intellectual collaboration amongst North Dakota's renewable power interests.

Dakota Salts does not envision any negative adverse environmental impacts while this project is underway and together with our project paticpants', we fully intend to engage the relevant parties on further environmental reviews and consultation as appropriate.

Ultimate Technological and Economic Impacts:

The only economical BES options are likely pumped hydro (PH) and compressed air energy storage (CAES). CAES is a renewable energy solution with large scale, cost competitive power generation costs. A single cavern has the capability to generate up to 120 MW, and with minimal surface facility investment, a second cavern can enable up to 360 MW per module. There is no limit to the number of CAES modules that can be built, making CAES power plants a necessary, complimentary alternative energy source to wind.

CAES avoids the pitfalls of PH, namely, high costs per kW capacity, multi-billion dollar investments, permitting difficulties and lengthy build times. Figure 1 below compares various energy storage technologies in terms of total yearly costs of ownership (operating & capital) versus average daily discharge capacity in hours.

Typically, compression based technologies are the lowest cost BES options for wind integration. It should be noted that the costs below for battery technologies do not include battery replacement costs which are significant, as most battery systems would have to be replaced 3 or 4 times in the 35 year life of a compression based plant.

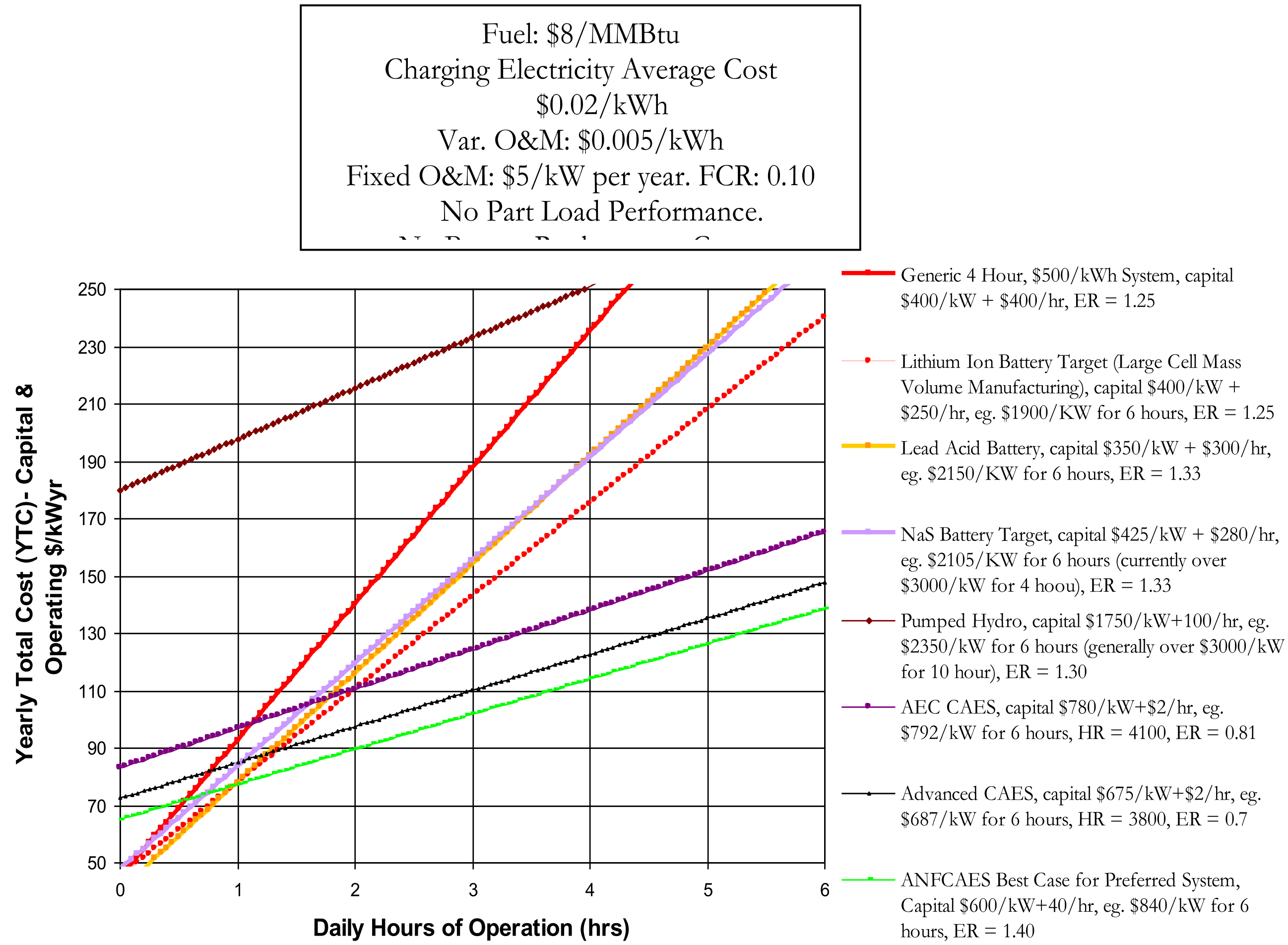

Figure 1. Total Cost of Energy Storage Ownership per kW Capacity

Ultimate Technological and Economic Impacts (Continued):

Specific Technical and Economic advantages of CAES include:

- Moving off-peak energy to high demand periods. Avoid renewable spillage and avoid thermal generator (TG) turndown o low load.
- Providing fast ramping services during on-peak, with excellent part load performance and low costs (capital and operating). Avoids the need for TGs following wind with poor performance and high emissions.
- Providing superior peaking than combustion turbines (CTs): low heat rate due to off-peak electric compression, recuperation, re-heat and inter-cooling.
- Providing grid damping, in contrast to TGs, by acting as both a load and a generation resource (fast ramping up or down).
- Reducing transmission adaptation costs for wind integration and required nameplate capacity of wind generators; over-sizing wind and transmission does not solve the problem.
- Minimizing CO_2 emissions by minimizing renewable spillage off-peak, minimizing TG low load operation during off-peak and minimizing TG ramping (transient) operation during on-peak.
- Minimizing renewable integration system reliability challenges, as well as cyclic maintenance/damage to thermal generators (TGs).
- Providing frequency Regulation, Spinning Reserve, Black Start, and Synchronous Condensing.

CAES systems store energy through air compression. During power production the expanding air is heated to increase power production, to more efficiently use the stored high pressure air, and to avoid cryogenic expander requirements. Diabetic CAES systems rely on premium fuel combustion to achieve the required heating, either through individual combustors or CTs. Adiabatic or no-fuel CAES systems are becoming more attractive due to the high price of premium fuels (such as natural gas) and the need to reduce greenhouse gas emissions.

The need for an energy storage mechanism that has a low carbon footprint is particularly important for wind integration applications. Advanced fuel-based (diabatic) CAES cycles generally include a CT and, as a result, cannot obtain or approach adiabatic or no-carbon operation.

Why the Project is needed:

Wind and renewable energy penetration levels are increasing. The inherent variability of these generators poses challenges for the electrical grid, including system stability challenges, reliability issues, difficulty in system operation, increased operational and capital costs, and minimal reductions or even increases in CO_2 emissions. Bulk energy storage (BES) is essential for large scale wind integration in maintaining grid stability and avoiding higher operating costs.

North Dakota Wind and Renewable Energy penetration into the existing grid cannot occur without infrastructure development, with the most important aspect being BES. Without an effective means of storing wind energy, wind investments will likely falter as more and more renewables' enter the grid. Further, as renewable energy enters the grid, greater strain is put on traditional power plants as they are turned down to allow renewable energy into the grid. CAES not only stabilizes the uncertainty of wind, but enables effective wind energy storage, and removes operating strain placed on traditional base load power generation associated by renewable energy entering the grid.

Over-sizing wind/solar capacity and transmission capacity may alleviate some wind integration issues but is very expensive and would not solve problems due to the hourly, daily and seasonal power output variations of wind and solar. Otherwise, extensive backup thermal generation would be required at high costs, poor thermal performance and high emissions, and subsequent increased 'spillage' of wind energy during off-peak and low load periods.

The first step to harvesting and capturing North Dakota's wind resource is to establish the following feasibility study for the purpose of continued Renewable Energy Investment in North Dakota.

STANDARDS OF SUCCESS

Standards of Success should include: *The measurable deliverables of the project that will determine whether it is a success; The value to North Dakota; An explanation of what parts of the public and private sector will likely make use of the project's results, and when and in what way; The potential that commercial use will be made of the project's results; How the project will enhance the education, research, development and marketing of North Dakota's renewable energy resources; How it will preserve existing jobs and create new ones; How it will otherwise satisfy the purposes established in the mission of the Program.*

One of the advantageous of Dakota Salts current endeavor is its immediate real, applicable, market impact. Dakota Salts has already established partner interest amongst multiple industry interests, mineral interest owners, and surface interest owners, all collaboratively working together to capture the value of North Dakota's salt in strategically CAES advantageous areas.

Current wind farm endeavors in North Dakota would be only a partial success without the necessary balancing and energy load ability offered by CAES, which significantly reduces or ideally removes altogether, fuel consumption. Further, the technical challenges overcome by addressing deep salt cavern generation for the purpose of CAES creates an immediate novel impact to existing technology and as Dakota Salts' technical challenges are overcome.

Dakota Salts fully intends to utilize its salt holdings in North Dakota to facilitate effective integration of energy into the North Dakota grid, allowing continued and aggressive wind development in the State. Since this project is a feasibility study, its measure of success will be the concrete deliverable of all those technical and economic considerations addressed in this proposal, which is the first step in advancing bulk energy storage to enable advanced and aggressive wind renewable investment in North Dakota. Portions outside Appendix 1, Confidential data, will be made available to those electric purchasing and distributing interests, both renewable and conventional, in North Dakota.

BACKGROUND/QUALIFICATIONS

Please provide a summary of prior work related to the project conducted by the applicant and other participants as well as by other organizations. This should also include summary of the experience and qualifications pertinent to the project of the applicant, principal investigator, and other participants in the project.

Dakota Salts is a wholly owned subsidiary of Sirius Exploration, a publicly traded company with a principle focus on sub-surface salt for the purpose of mining extraction, CAES, and CO2 sequestration. Dakota Salts has extensive natural resource exploration and experience including drilling, work over, subsurface wellbore and mining technology experience, including salt and deep salt.

<u>Dakota Salts Program Director</u>

Theodore A. Pagano, P.G., P.E.

Theodore A. Pagano is a registered professional geologist and registered professional engineer with a principle background in fossil fuel exploration, exploitation, and development. He has worked for Texaco, Chevron, Kerr-McGee, and Anadarko. He is president of an independent natural gas producer and consulting firm which focuses on the identification, capitalization, and exploitation of natural resource investment opportunities. As a geologist and petroleum engineer, Theodore Pagano has worked in Alaska, Wyoming, Texas, Oklahoma, New Mexico, Utah, Colorado, and North Dakota.

<u>Electric Power Research Institute (EPRI)</u>

The EPRI CAES RD&D team has extensive experience with economic optimal dispatch modeling and strategic planning for all types of energy storage technologies. EPRI has developed and refined in-house software for optimal dispatch/charging of storage plants. EPRI initiated and lead the development effort for the original US CAES plant in McIntosh Alabama (110M - 26 hours).

The EPRI team has 20+ years development experience with advanced compression based cycles with a number of patents awarded. The current EPRI demonstration projects and economic analysis for advanced compression based plants is currently under way and involves 15+ utilities.

<u>Schlumberger</u>

Schlumberger Limited (NYSE:SLB) is the world's leading oilfield services company supplying technology, information solutions and integrated project management that optimize reservoir performance for customers working in the oil and gas industry.

The company comprises two business segments: Schlumberger Oilfield Services supplies a wide range of products and services from formation evaluation through directional drilling, well cementing and stimulation, well completions and productivity to consulting, software, information management and IT infrastructure services that support core industry operational processes. And WesternGeco, the world's largest seismic company provides advanced acquisition and data processing services.

Schlumberger offers its clients four key advantages:

1. Deep domain knowledge of exploration and production operations gained through 75 years of experience
2. The service industry's longest commitment to technology and innovation through a network of 23 research, development and technology centers
3. A global reach in more than 80 countries coupled to strong local experience and the diversity in thought, background and knowledge that more than 140 nationalities bring
4. A commitment to excellence in service delivery anytime, anywhere.

Tetra-Tech

Tetra Tech provided environmental construction compliance, value and design engineering, and civil construction services for the Maple Ridge Wind Farm Project in Lewis County, New York. This “green” project is part of a statewide effort to ensure 25 percent of New York’s energy is produced by clean, renewable technologies by 2013.

The completed project consists of 195 turbines with a 12-mile 245 kV Article VII transmission line. In less than four weeks, Tetra Tech reviewed 38 environmental permits and evaluated them for any construction-related environmental compliance measures. Working side by side with our client, we developed a program to meet all environmental construction requirements in the most efficient manner possible. We presented the compliance program—the first ever done in New York for a wind farm—to the enthusiastic approval of the New York State Department of Public Service, the New York State Department of Environmental Conservation, and the New York State Department of Agriculture and Markets.

With projects around the country, Tetra Tech is now at the forefront of the energy industry, providing a full range of environmental, engineering, and construction services for wind energy development projects.

MANAGEMENT

A description of how the applicant will manage and oversee the project to ensure it is being carried out on schedule and in a manner that best ensures its objectives will be met, and a description of the evaluation points to be used during the course of the project.

The major participants in this project have been collaborated by Dakota Salts, and are herein identified as the (1) Electric Power and Research Institute (EPRI), the preeminent developer and expertise surrounding CAES in the United States, (2) Schlumberger, one of the world's leading subsurface characterization and engineering firms, (3) Tetra Tech, one of the Nation's largest environmental and project management firms with capabilities in facility planning, development support (assessment, permitting, design, build, and operation/maintenance), regulatory compliance, health and safety, engineering (civil, mechanical, electrical), and construction management.

Dakota Salts, LLC, EPRI, Schlumberger, and Tetra Tech are working collaboratively to expedite the subject proposal and project in North Dakota. Under contractual expectations through Dakota Salts, project timelines have been set for the described project objectives; (1) Feasibility Study Characterizing North Dakota Salts for its Utilization in Bulk Energy Storage and (2) Cost Benefit Analysis of Bulk Energy Storage for Wind Integration in North Dakota.

The following is a work structure breakdown of the assembled project team, along with defined areas of expertise and project responsibility:

Dakota Salts, LLC: Dakota Salts LLC is a wholly owned subsidiary of Sirius Exploration Plc and is incorporated in Colorado, USA. Based in Denver, Dakota Salts holds mineral leases in excess of 5,000 acres in North Dakota, USA, allowing for the exploration and extraction of salt and potash and the creation of caverns for the storage of compressed air for electricity generation.

Dakota Salts will assign a Program Manager to oversee the entire engagement. Duties will include: Study Project Management, Status Reporting to the NDIC Board, overall program budget management, and ownership of final deliverables. Status reports will be provided to the NDIC Board and to other parties on a monthly basis and this process will remain in effect until the completion of the project or may be amended as needed.

The following list describes artifacts, and documentation that will be developed and implemented during the project. Dakota Salts and its Program Manager will be responsible for the following throughout the lifecycle of this engagement:

- Overall Wind Energy Integration Project Plan
    - This will include all sub-tasks for each phase of the project
- Project Milestones (to ensure critical path is met during each phase)
- Budget Reporting
- Status Report
    - To be submitted monthly to the NDIC
    - Minutes of each team meeting/conference call will be included in project status updates

EPRI: The Electric Power Research Institute, Inc. (EPRI) conducts research and development relating to the generation, delivery and use of electricity.

EPRI will be responsible for the following deliverables as part of this engagement:

1) Generic performance, sizing and operating specifications for BES plant including ranges for heat rate, ranges for energy ratio, variable and fixed O&M, up and down ramp generation rates, maximum discharge capacity, and switchover time.
2) Capital cost estimates based on known compression based BES plants. These total costs will include construction costs with indirects, contingencies, turbomachinery, heat exchangers, piping, electrical, civil, motor generators, transformers, engineering and management, commissioning, and capital cost reductions estimates from state and federal incentives.
3) Optimal Dispatch and Cost/Benefit analysis based on historical hourly MISO data including ownership costs, optimal dispatch and revenue streams.
4) Optimal Dispatch and Cost/Benefit analysis based on projected hourly MISO data for increased wind penetration including ownership costs, optimal dispatch and revenue streams. Projections for future hourly electricity prices in MISO based on increased wind penetration levels, historical data and fuel costs. Projections will be provided by Basin Electric or they will be based on an EPRI staff on/off peak escalation approach.

Schlumberger: Schlumberger has developed a series of down-hole wire line logging tools that are directly applicable to CAES evaluation. Innovative down-hole logging tools such as: magnetic resonance, natural gamma ray spectroscopy, multi-component sheer sonic, resistivity borehole imaging and modular testing tool have the potential to significantly reduce the effort needed to characterize a potential CAES resource. During drilling of the exploratory hole, Schlumberger will selectively utilize these tools to aid in the evaluation of the suitability salt deposit for CAES storage. The collected data will be utilized by EPRI to assist in understanding the cavern size development potential and CAES injection and withdrawal rates.

Schlumberger will be responsible for identifying the following:

- Depth of salt and overlying structure;
- Presence of overlying or underlying permeable formations to receive brine injectate water;
- Degree of low permeability material interbeded in the salt deposit;
- Mechanical integrity of the salt deposit;
- Potential brine water impurities; and
- Temperature gradients.

While there is a prolific database on natural gas storage in salt deposits, the only two production scale CAES facilities in world are in Alabama and Huntorf, Germany. The analog of CAES to natural gas storage is very strong, but the primary differentiating factors of CAES to natural gas storage are the extremely high gas withdrawal rates and low pressure losses need to make CAES effective.

Due to the depths of the salt deposits (depths of 5,000 to 8,000 feet) exploratory work to assess the suitability for CAES is an integral component to the feasibility of a CAES project. Traditional surface investigation methods can typically only identify the presence of a salt body, and provide little information as the suitability of the salt deposit for CAES. Exploratory borings, salt core sampling and well testing are currently used to assess the formation prior to CAES implementation.

Tetra-Tech:

Because there is little permitting precedent for CAES facilities, Tetra-Tech will develop a comprehensive permitting strategy. The different development scenarios will likely have different permitting strategies based on their project components. For example, a project with a gas storage component will likely involve the Federal Energy Regulatory Commission (FERC) and a project with a linear facility (transmission or pipeline) is likely to trigger National Environmental Policy Act (NEPA) considerations. Tetra Tech will develop a preliminary permitting strategy for each of the proposed facility concepts.

Key components of each permitting strategy will include:

- Determining the lead agency
- Identifying potential federal NEPA drivers
- Recommended underground injection control (UIC) permitting approach for CAES and/or gas storage

For each strategy, the primary required permits and issuing agencies will be described along with the sequence in which the permit applications would be submitted in order to maximize permitting efficiency. Based on the current project concept, it is anticipated that the following permits and approvals will be required:

- Storage caverns may be permitted as Class III Underground Injection Control (UIC) Wells through the North Dakota Department of Health, Groundwater Protection Program
- Brine disposal wells may be permitted as Class I UIC Wells through the same agency
- Gas storage and associated wells may be permitted through the North Dakota Industrial Commission, Oil and Gas Division
- Surface facilities and transmission lines may be sited under the Public Service Commission (PSC)
- Gas storage operations may be certificated through FERC
- Air permit would be obtained from the North Dakota Department of Health

TIMETABLE

Please provide a project schedule setting forth the starting and completion dates, dates for completing major project activities, and proposed dates upon which the interim reports will be submitted.

The period of performance for the Salt Cavern Geo-Mechanical Study for CAES will be 8 months with interim report after 4 months.

The period of performance for the CAES Cost-Benefit Analysis and Impact on Wind Integration will be 8 months with interim report after 4 months.

	1Q '10	2Q '10	3Q '10	4Q '10	1Q '11	2Q '11
Salt Cavern Geo-Mechanical Study for CAES INTERIM REPORT (4 Months)						
Salt Cavern Geo-Mechanical Study for CAES FINAL REPORT (4 Months)						
CAES Cost-Benefit Analysis and Impact on Wind Integration INTERIM REPORT (4 Months)						
CAES Cost-Benefit Analysis and Impact on Wind Integration FINAL REPORT (4 Months)						

BUDGET

Please use the table below to provide an itemized list of the project's capital costs; direct operating costs, including salaries; and indirect costs; and an explanation of which of these costs will be supported by the grant and in what amount. The budget should identify all other committed and prospective funding sources and the amount of funding from each source. Please feel free to add columns and rows as needed. Higher priority will be given to those projects have matching private industry investment equal to at least 50% or more of total cost.

Project Associated Expense	*NDIC's Share*	*Applicant's Share (Cash)*	*Applicants Share (In-Kind)*
Salt Geo-Mechanical Model	150,000	150,000	
Cost/Benefit Analysis of BES	75,000	75,000	
Dakota Salts Project Management			120,000
TOTAL:	225,000	225,000	120,000

Project Cost Detail

Budget Item	Associated Tasks	Cost
Salt Geo-mechanical Model & Permitting	• Study of a solution mining cavern and cavern field in order to optimize cavern geometry and layout to maximize size while maintaining cavern stability. • Provide initial CAES cavern assessment of performance and stability of the caverns for CAES. • Determination of an allowable operating pressure range in a cavern that will ensure cavern stability and provide acceptable performance for a CAES facility. • Assessment of any technical issues associated with CAES in ND that will need to be addressed and overcome. • Identify depth of salt and overlying structure; presence of overlying or underlying permeable formations to receive brine water; potential	$300,000

	brine water impurities; potential mechanical integrity of the salt deposit. • Develop initial permitting strategy for the proposed facility concepts.	
Cost/Benefit Analysis of Bulk Energy Storage (BES)	• Generic Performance and Operating Cost Specifications for a BES Installation in the Midwest Independent System Operator (MISO) territory.	$150,000
	• Target Capital Costs Estimations for the BES Plant.	
	• Optimal Dispatch and Cost/Benefit Analysis based on Historical MISO Data.	
	• Optimal Dispatch and Cost/Benefit Analysis based on Projections for future MISO prices based on increased wind penetration.	
Dakota Salts Program Management	• Governance Model • Project Schedule • Responsibility Assignment Matrix • Controlling project execution • Tracking and reporting progress • Issues management • Issue solving • Project closure (and project debrief) • Communicating to NDIC	$120,000 (600 Hours x $200/hr. hourly rate)

1. CONFIDENTIAL INFORMATION

Any information in the application that is entitled to confidentiality and which the applicant wants to be kept confidential should, if possible, be placed in an appendix to allow for administrative ease in protecting the information from public disclosure while allowing public access to the rest of the application. Such information must be clearly labeled as confidential and the applicant must provide all required information set forth in NDCC 54-63-02. If there is no confidential information please note that below.

Dakota Salts currently has confidential agreements with both, EPRI and Schlumberger.

PATENTS/RIGHTS TO TECHNICAL DATA

Any patents or rights that the applicant wishes to reserve must be identified in the application. If this does not apply to your proposal, please note that below.

While most of the data uncovered in the following project is to be released to North Dakota for the purpose of fostering continued renewable energy investments via wind-CAES solutions, there may be portions of the project directly attributable to the applicants' contractual engagements for the purpose of competitive advantage. In any such instance, the applicants reserve the right to disperse said data at the applicants' discretion, after written request by inquiring parties.