THE IOWA STORED ENERGY PARK

Iowa Stored Energy Park (ISEP) Project
Economics Study Summary
January 11, 2011

I. Introduction

The Iowa Stored Energy Park (ISEP) is a proposed $400 million, 270 Megawatt (MW) compressed air energy storage (CAES) project to be located near Dallas Center, Iowa, near Des Moines. Commercial in-service is planned in 2015.

The ISEP Project owners, the Iowa Stored Energy Plant Agency (ISEPA), represent 95 municipal utilities in four states. ISEPA retained RW Beck, a nationally-recognized energy consulting firm, to perform an economic study of the Project. Study funding was provided by the U.S. Department of Energy (DOE). The study, completed in January 2011, addresses the project's potential cost effectiveness to the project owners and new participants. It also developed supplemental information for use by potential new participants to evaluate the project for themselves.

This report summarizes the study results. Detailed project reports are available to entities interested in Project participation, as described at the end of this report.

II. Results Summary

The study examined the costs and benefits of ISEP and the alternatives when dispatched according to MISO market prices at the MidAmerican Energy Grimes substation node near Des Moines. The study addressed a twenty-year planning period (2015 to 2034). It included assumptions for regional generation development, including aggressive wind capacity build-out. Assumed future regulatory costs for carbon dioxide (CO_2) costs were included.

The conclusions of the study for public power entities included:

- In normal operation against future MISO market prices, ISEP will look like an intermediate generation resource (i.e., generating output during weekday hours). It would accomplish compression during weeknight and weekend hours.
- Dispatch of the 220 MW compression/270 MW generation ISEP facility in the MISO market over the study period did not challenge the assumed useful size of the storage reservoir (i.e., 100 million pounds of air).
- In the Base Case, ISEP can pay for itself over its lifetime in future operations in the MISO market.

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- In the various sensitivity cases (High Fuel Prices and Lower Wind Build-Out), ISEP economics improved further compared to the Base Case:

    - Higher fuel prices increased the off-peak to on-peak price spread compared to the Base Case, thereby further improving ISEP economics.

    - The fact that Lower Wind Build-Out sensitivity case showed *increased* value for ISEP compared to the Base Case was initially counter-intuitive. However, further examination showed that capacity values assigned to aggressive wind build-outs in the Base Case, when reduced in the sensitivity case, time-advanced the capacity value of ISEP. And, the study included cost benefits for ISEP only; not potential benefits to regional generation resources including the wind industry of having storage like ISEP available. As a result, such additional benefits were external to the ISEP study.

- Although an aggressive program of future carbon dioxide (CO_2) costs were assumed in the study, they were not material to the overall economics conclusion for the CAES facility.
    - This was true even though the CAES facility was assumed to use available MISO market resources for compression energy (and thus was charged with the cost of their CO_2 emissions); not renewables alone.
    - Increasing the amount of compression energy provided by renewables would further increase the cost-effectiveness of ISEP by reducing the CO_2 penalty associated with compression power assumed in the study.

- The analysis included both intrinsic and extrinsic values for the ISEP CAES project and its alternatives.
    - Intrinsic value relates to dispatch of the facilities in accordance with expected average hourly off-peak and on-peak prices.
    - Extrinsic value, which is common to the natural gas storage industry, relates to the option value of addressing price volatility around the average expected prices.

- Because of its greater flexibility in start-up speed, cycling and ramping, and particularly storage capabilities:
    - In addition to intrinsic value (which is typically examined in electric utility resource planning analyses), extrinsic value is also potentially a material benefit to the ISEPA CAES project.
    - The CAES project shows higher extrinsic values than the alternatives.
    - Although a robust market for such price option products does not currently exist, ISEP owners themselves as Load Serving Entities (LSEs) or wind owners could take advantage of the extrinsic value.
        - Although they would need to adjust their system operations and resource planning procedures to tap the extrinsic value available from the unique ISEP storage resource.

- The study results did not examine the potential for additional benefits resulting from a project participant using ISEP to store their off-peak wind energy and time-shift it to on-peak.

- The study results did not include the potential for additional benefits resulting from the ISEP storage being eligible for credit toward Renewable Energy Standard (RES) or Renewable Performance Standard (RPS) requirements.
  - Such storage legislation is under consideration in the states of California, Ohio and Utah.
  - A national RES is under consideration in Congress.

In addition to the results summarized above for public power entities, the study also examined the corresponding costs and benefits for ISEP when owned and operated by an investor-owned utility (IOU). For this analysis, the capital, operating costs, MISO price spreads and other factors used in the public power analysis were the same. However, IOUs have different financial structures including higher capital return requirements. This causes a higher discount rate to be used in the present value calculations.

The analysis for IOUs also included consideration of the 20% Investment Tax Credit (ITC) for storage included in the "Storage Energy Act 2010" bill introduced in Congress by Senators Bingaman, Wyden and Shaheen.

The results for IOUs included:

- ISEP can pay for itself over its lifetime in operation in future operations in the MISO market, although passage of the ITC bill would have a material positive effect on this result.
  - Such an ITC could offset some or all of the capital cost difference between ISEP and a combined-cycle alternative.

- Other conclusions for IOUs were similar to those for public power entities summarized above.

III. Discussion

In development of the study, RW Beck produced construction and operating costs for ISEP conventional natural gas-fired combined-cycle and simple cycle combustion turbine alternatives. They also evaluated ancillary services and intrinsic/extrinsic values. Supplemental information for use by utility resource planners in evaluating ISEP for their own system was also prepared. These results are summarized below.

Construction Costs

The Iowa Stored Energy Plant Agency (ISEPA) Project Team and Brulin Associates, Subject Matter Expert (SME) subcontractor on the study for CAES facility design, developed an initial construction cost estimate for the ISEP CAES facility. The estimate was developed using information developed for previous studies by Burns & McDonnell, updated assumptions, and the experience of the SME in similar projects. The ISEPA Project Team and Brulin also worked with Dresser-Rand, a supplier of CAES equipment in other projects, and other vendors to secure current cost estimates for major plant components.

Although the project has not yet selected a final plant technology or configuration, for purposes of the CAES estimate and economics study the Project Team selected dual, 135 MW generation trains (for a total plant generation output of 270 MW), in a split-train configuration with compression and generation components on separate shafts. This configuration would provide additional flexibility in plant operation compared to compression and generation on a single shaft.

Although ISEP is planned as a regional resource, for purposes of comparison ISEP's 270 MW generation output would be more than double the size of the electric load of downtown Des Moines on a hot summer peak day. ISEP's fully-dispatchable compression power would be about 220 MW as a base assumption. The study also examined the potential value of "supersizing" the compression side of the facility, to enable the facility to absorb more wind energy faster during off-peak periods while staying within the total storage capacity of the reservoir.

The estimate included:

- Procurement costs
  - Civil/structural
  - Mechanical
  - Electrical
  - Instrument and Control
  - Chemical/Water Treatment

- Direct construction costs
  - Civil/Structural Construction
  - Engineer/Procure/Construct (EPC) Contracts
  - Mechanical Construction
  - Electrical Construction

- Indirect construction costs (Some examples):
  - Heavy hauling
  - Construction Power/Meter
  - Preoperational testing
  - Site Surveys/Studies/Permitting
  - Builder's Risk insurance
  - Construction Bonds

- An allowance for owners costs
    - Operator training
    - Owner's development costs
    - Owner's cost contingency

- Interest during construction

- Escalation

- Other construction costs necessary to achieve an all-in capital cost estimate for facility in-service. (Some examples):
    - Spare parts inventory
    - Startup consumables (fuel, water, test power sales)
    - Plant and equipment performance testing

The Project Team provided this initial estimate to RW Beck, lead study consultant, on July 29. RW Beck then reviewed the initial estimate and further improved/refined it based on their expertise and experience with similar facilities.

RW Beck also developed corresponding construction cost estimates for alternative facilities including natural gas-fired simple-cycle combustion turbines and combined-cycle facilities. A key consideration for the study was ensuring that the construction costs for the CAES facility and alternatives were directly comparable.

Development of estimated construction costs for the CAES facility and its alternatives were completed during August 2010 and included in the final RW Beck report.

Operating Costs

The ISEP Project Team, Brulin Associates and RW Beck worked together to develop operating parameters for the CAES facility. These parameters include:

- Start-up times (both for compression and generation modes)

- Ramp rates (in Megawatts (MW) per minute, in both compression and generation modes)

- Minimum turn-down levels (in MW, for both compression and generation modes)

These parameters for the CAES facility are particularly important, in that they relate to possible value of the facility in providing ancillary services in the Midwest Independent System Operator (MISO) regional marketplace. Providing such services would represent additional monetary value for the facility, in addition to off-peak/on-peak price benefits.

The ISEP Project Team, Brulin Associates and RW Beck also worked together to develop corresponding operating costs for the CAES facility. These costs include:

- Fixed and variable operating costs
- Start -up costs
- All other operating costs attributable to the facility

RW Beck also developed corresponding operating parameters and costs for the alternative facilities for the study. This information was completed during August 2010 for use in the economic analyses.

Evaluation of Price Arbitrage

RW Beck was the lead consultant for the cost and economics studies. They developed a lifetime economic analysis of the ISEP CAES facility compared to alternatives as they would be applied in the Midwest Independent System Operator (MISO) marketplace. The ISEP unit was assumed to be located at the Dallas Center, Iowa site; with transmission interconnection at the Grimes Substation located about nine miles east of the plant site. Grimes is located in the Northwest suburbs of Des Moines.

The Project Team and RW Beck also discussed needed future scenarios to be used as sensitivities in the economic analysis. The analysis included future scenarios for various levels of regional wind energy development, and fuel prices. Economic performance of the ISEP facility as a price taker in the MISO market was then examined under each of these scenarios. In addition, the overall economics of the facility was compared to natural gas-fired combined-cycle and simple cycle generation alternatives; also operating in the MISO market. RW Beck built computer models for each of the scenarios to accomplish the economic calculations

As a supplement to the RW Beck study, the ISEP Project Team during August 2010 also reviewed draft economic study information developed by the MISO planning staff regarding cost comparisons of CAES to other natural gas, coal and wind generation options. The Team provided review comments to MISO. Overall, the MISO analysis shows CAES to be very cost-effective compared to conventional generation options; particularly for future scenarios with higher off-peak to on-peak price spreads, and higher natural gas prices. The MISO analysis of CAES was included in their Midwest Transmission Expansion Plan (MTEP 2010) released in December 2010.

Evaluation of Ancillary Services

The ISEP Project Team also provided estimated operating parameters of the ISEP CAES facility to RW Beck during August. These parameters were reviewed and further improved by RW Beck. The parameters include facility start-up times, ramp rates and turn-down levels, including performance graphs for these parameters as a function of time.

These parameters were then used for the ancillary services economic analysis. RW Beck examined the potential value of the ISEP Project in providing ancillary services in the MISO market, in addition to price arbitrage. Subject Matter Expert (SME) Customized Energy Solutions (CES), a subcontractor for the study, provided input to the design of the ancillary services analysis. CES also developed and provided a report on their work as SME on ancillary services and MISO rules and tariffs potentially affecting the ISEP Project.

Supplemental Information for Utility Resource Planners

The Iowa Stored Energy Park (ISEP) Project Team plans to formally solicit new participants to the Project in 2011. The purpose of this Deliverable was to prepare supplemental information about CAES that will enable prospective project participants to perform their own, system-specific analyses. This included development of supplemental, "cook book" primer information that would allow a utility resource planner who is unfamiliar with CAES to adequately perform a study of the facility on their own system.

The supplemental information includes:

For hourly price arbitrage analysis:
- A description of how a CAES facility is operationally different from conventional generating facilities.
- How the operational differences of CAES requires any particular modeling differences or techniques to adequately evaluate such facilities. Initial assessments indicate that current utility resource planning models such as PROMOD or STRATEGIST are not capable of adequately modeling a CAES storage unit in its hourly operation.
- An example daily and weekly dispatch pattern for the ISEP CAES, and how that may vary seasonally.
- Other unique factors or considerations that a resource planner should take into consideration in an analysis of their own system.

For ancillary services analyses:
- A primer description of ancillary services.
- A description of how a CAES facility is operationally different from conventional generating facilities in its ability to provide ancillary services.
- A description of how to estimate the revenues for a CAES facility in providing ancillary services.
- An estimated range of values for ancillary service revenues that should apply to CAES operations in the MISO market.
- Other information that would allow a utility resource planner to adequately assess ancillary services benefits for their own system.

IV. Project Reports

RW Beck provided a final report in January 2011. The report includes:

1. An overall Project Report. This includes the results of all deliverables assigned to them.

2. A Resource Planner Toolkit. This further extends the content of the project report to include supplemental details and data for utility resource planners.

3. A Resource Planner Toolkit Supplement. This includes spreadsheet data for:
   a. Typical hourly dispatch sequences used for ISEP in the analysis.
   b. Monthly performance data for ISEP and its storage reservoir.
   c. Facility modeling assumptions for ISEP and the combined-cycle and simple-cycle combustion turbine alternatives.
   d. Historical and projected off-peak and on-peak MISO prices.
   e. Prices forecasts for the various ancillary services by year throughout the study period.
   f. Average typical week price shapes by month for the study period.

In addition, Customized Energy Solutions (CES) provided a report on their findings for ancillary services and MISO tariffs as they would apply to the ISEP project.

Copies of the project reports are available to entities interested in participating in the ISEP Project. Completion of a Non-Disclosure Agreement (NDA) will be required. Contact ISEP at www.isepa.com for more information.

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