T-48 Status Report for the December 2013 IAB Meeting

Work progress since May 2013

At ASU (Heydt): The research has been on the use of various software tools to examine the operating cost of a transmission system – including energy storage in the system. John Ruggiero, a graduate research assistant, is using a quadratic programming algorithm and a large scale application (the Arizona section of the WECC). He has completed a literature summary of bulk energy storage technologies including their ramp rates and storage capabilities. The researchers have implemented a portion of the WECC system including a ‘dc load flow model’, energy storage constraints, line loading constraints, security limits (i.e., bus voltage ophase angles), and energy storage ramp rate constraints. A number of scenarios have been evaluated and it appears that about 8 to 13% reduction in operating costs can be attained, accounting for (i.e., including) the cost of the development of large scale pumped hydro storage. A very large scale case was evaluated utilizing the Salton Sea in California as well as Lake Mead and Lake Powell as pumped hydro storage. A technical paper summarizing results was presented at the 2013 North American Power Symposium, in Manhattan KS.

At ASU (Hedman): A day-ahead generation scheduling model with energy storage (pumped storage and compressed air energy storage) has been developed. The day-ahead generation scheduling problem is modeled as a multi-period stochastic unit commitment model with multiple scenarios of wind generation. The model will be applied to the RTS 96 test system to demonstrate the benefit of energy storage units under high penetration level of renewable resources. This model also accounts for the ramping requirements (and ramping costs) imposed on conventional generators for systems with high levels of non-dispatchable renewable resources in comparison to the benefits of utilizing energy storage. We will be presenting new results at the December IAB meeting that show that the average costs for conventional units increase with the penetration level of renewables. This is a result of generators having to operate at lower production levels since they are being displaced. The conventional units are also operating in a region where their marginal costs are lower; with the integration of renewables and the reduction of marginal costs due to the operating levels of these units, it is anticipated that the market prices will be reduced. Thus, not only are the fossil fuel generators going to see an increase in their average cost but they will also see a reduction in revenue. On the other hand, the benefits of storage are more pronounced at these higher renewable penetration levels due to the ability to store energy when it is cheap, provide energy when it is expensive, as well as provide fast ramping support. This work is going towards a paper that demonstrates the economic benefits of storage with high levels of renewables.

Wichita State:

Ms. Aburub has completed a study of the use of a wholesale grid state indicator [references are available on the project website]) to dispatch energy storage. She has written two papers documenting her results, which are posted on the project website.

Dr. Hu has published one paper on his dissertation, Optimal Generation Expansion Planning with Integration of Variable Renewables and Bulk Energy Storage Systems (both the paper and dissertation are posted on the project website) and is preparing a transactions article on the work. In his work Dr. Hu developed an optimal generation planning model using a multi-period optimization formulation. The model incorporates energy regulatory policies, hourly renewable profiles, and optimal operation-based investment of energy storage. The technique is implemented in MATPOWER’s extensible optimal power flow structure. He then used the technique with the reduced 240-bus Western Electric Coordinating Council (WECC) system (developed in PSERC Project M24 and available on the PSERC website with the M24 final report) to investigate the use of
storage in the WECC system. Results of the dissertation include optimal generation and storage plans for the WECC system under varying fuel price and regulatory scenarios.

Mr. Hardy is proceeding with the work that is outlined in his proposal, also posted on the website, for his dissertation, *Economic Applications for Energy Storage*. His proposal includes a detailed literature review on applications, economics, and technologies for energy storage. His work will also use the M24 WECC model along with a detailed model he is developing of sodium sulfur batteries to address:

- What is the revenue potential for energy storage in an energy time-shift application?
- What effect does energy conversion efficiency have in this scenario?
- What effect does the price of energy at the energy storage location (LMP) have in this scenario?
- How significant an improvement in the economics is a multi-year, multi-node use of energy storage for these applications?
- What effect does control strategy of the energy storage have in this scenario?
- What effect does the energy storage have on energy prices, both at the node(s) at which it is installed and the network as a whole?
- How does storage effect the general dispatch of generation?
- What generation is used to charge it and what generation is not used when the energy storage is discharging?

*Description of work activities and anticipated project outcomes/deliverables by each project team member during next reporting period.*

ASU: It is expected that the large scale WECC test bed shall be ‘debugged’ and tested with various types and levels of energy storage. From that work, some conclusions of feasibility shall be drawn.

By the end of the next period, we will have submitted a transactions paper on the benefits of energy storage.

Wichita State:

Ms. Aburob and Mr. Hardy will continue with the research discussed above.

*Description of and reasons for any revisions to the current work plan*

No changes needed in the current work plan.

*Conference calls with industry advisors between May and November 2013*

November 14, 2013

*Describe other interactions with industry advisors since the project began*

Dr. Jewell presented results of the project at SPP in October, and will present results at Duke in November and at NRECA in December.

*Students working on the project*

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New project-related documents or presentations (such peer-reviewed papers, conference papers, conference presentations, etc.) since May 2013


Project Website

Project website can be found at www.wichita.edu/t48.