



ABB EXPERIENCE IN THE ANALYSIS OF WIND FARMS AND THEIR INTERCONNECTION TO UTILITY GRIDS

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1. INTRODUCTION

ABB provides advanced technical consulting services to a large number of transmission and distribution companies around the world. Consulting is a key element in ABB's services and solution offerings to electric utilities, regulatory agencies, industrials, independent power producers, power marketers and energy companies operating in today's highly technical, deregulated power markets. The Consulting division is head quartered in Raleigh, North Carolina, with offices in Latham, New York, in Germany and in Spain. ABB has been a worldwide supplier of consulting services to the electric utility industry for more than fifty-years. ABB's expertise covers all areas of power transmission and distribution and includes extensive experience in power system planning, design and operation, development and application of innovative methods for operation and control of power systems, analyses of power system reliability and security, and modeling of advanced power system components for steady-state and stability analyses.

ABB's consulting engineers bring together capabilities that facilitate a unique set of skills for the analysis of the integration of wind farms into utility grids. These include:

- Extensive systems expertise, having performed numerous studies through the USA and many countries abroad, such as Singapore, New Zealand, Spain, Canada and others.
- Unique knowledge and expertise in modeling and analysis of generation equipment. In particular, ABB has developed extensive expertise in modeling and analysis of wind turbine generators (both conventional and doubly-fed induction generators). ABB engineers have worked closely on a number of studies with wind turbine manufacturers, where detailed controls and machine data were required for the purposes of the study. ABB consulting engineers have developed models for wind turbine generators both at the transient stability level (PTI PSS/E) and at the detailed 3-phase level appropriate for EMTP-type analyses.
- Unique knowledge and expertise in modeling of transmission equipment such as SVC, STATCOM, HVDC and other FACTS devices. ABB's consulting department has unique equipment knowledge and expertise to allow a full assessment of the most effective solution for each application.

Additional information on ABB's capabilities and recent work in the analysis of wind farms is contained here in the following pages.

1. BRIEF SUMMARIES OF A SELECTION OF RECENT STUDIES PERFORMED BY ABB

ABB engineers are expert users of the PTI PSS/E™ suite of programs, the GE PLSF™ suite of programs, PSCAD/EMTDC™, EMTP and MATLAB™, all of which, together with some specialized code developed by ABB engineers, are used for system studies. The choice of the software tool is based on customer needs and requirements, and the best tool for the specific job. All of the studies below were performed using the appropriate combination of the above listed software tools.

Project 1:

Client: Midwest Renewable Energy Corporation (MREC)

Project Scope: ABB has performed a number of studies for MREC in relation to the interconnection of wind farms for power generation into the transmission system in Iowa. The first of these studies was performed in 2001. The second was completed in February 2002. The third will be completed by early May 2003. This work involved developing models for wind turbine generators, based on close collaboration with the wind turbine generator manufacturer, and performing power flow and stability simulations and assessment. Some limited flow-gate analysis was also performed. The work was performed in close collaboration with the local utility and reviewed by both utility and regional independent system operator (ISO).

Project 2:

Client: Clipper Wind/Midwest ISO

Project Scope: In 2003, ABB performed studies related to the interconnection of a wind farm to the subtransmission system of the Northern Iowa system. The work involved extensive power flow, transient stability and flowgate analysis. The transient stability analysis phase of the work was performed for both conventional and doubly-fed induction generators. The doubly-fed induction generators were modeled using the user written models developed by ABB for the analysis of these types of units. This work was reviewed by the regional independent system operator (ISO).

Project 3:

Client: FPL Energy and Public Service Company of New Mexico (PNM)

Project Scope: In 2002 and 2003, ABB performed extensive study work for the purpose of interconnecting a large wind farm to the transmission system of a major US electric utility company, in the immediate vicinity of a High Voltage DC link. This work spanned over several months and involved a number of studies, including:

- 1) Development of a detailed 3-phase model of the doubly-fed induction generator and associated converter and turbine controls, through collaboration with the wind turbine generator manufacturer.
- 2) 3-phase, time domain simulation of system disturbances to investigate the low voltage ride-through capability of the wind turbine generator (WTG). This work was performed to facilitate control improvements, to be made by the wind turbine manufacturer, for the purpose of low voltage ride-through.
- 3) Subsynchronous torsional interaction (SSTI) analysis for the purpose of identifying the potential for detrimental interactions between the WTG and the HVDC system (The detailed model of the HVDC system was developed previously under a separate study scope.).
- 4) 3-phase, time domain simulations to investigate the potential for control interactions between the WTGs at the wind farm and the unique controls of the HVDC system. This task also required some further development of control loops such as the converter transformer tap changer etc. for the HVDC system model.

Project 4:

Client: WAPA

Project Scope: In 2002, ABB performed extensive studies to investigate transmission upgrades and enhancements for five potential wind, coal, and gas generation sites on the eastern (MAPP) part of WAPA's Upper Great Plains Regional transmission system. This study included steady-state and transient stability analyses. The study reports may be reviewed at <http://www.wapa.gov/ugp/study/East/Phase1/Phase1.htm>.

Project 5:

Client: MAPP (North Central U.S.) System

Project Scope: In 2001, ABB performed studies related to the interconnection of a large wind farm in the Dakotas. Load flow and stability analysis was performed.

Project 6:

Client: Western Farmers Electric Cooperative system (Oklahoma)

Project Scope: A number of facility and system impact studies have been performed since 2001 in relation to the interconnection of wind farms to the SPP electric utility system in USA. These studies involved extensive power flow and stability analyses.