U.S. Analyses on the Integration of DSM, DG, Renewables, Energy Storage and the Smart Grid

IEA Task XVII

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Introduction

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Conceptual Framework

Four aspects of grid integration

- Resources to be integrated -- technologies and availability
- Physical interconnection/integration
- Operational interconnection/integration
- Institutional/policy integration

Assumption -- IEA Task XVII primarily addresses how to advance physical and operational integration, rather than additional resource R&D or policy rules -- is this correct?

Demand Side Management

National Action Plan for Energy Efficiency

- Technology: energy efficiency
- Prepared for U.S. Department of Energy and Environmental Protection Agency, July 2006 and on-going
- Objective: This is a collaboration between federal and state regulators and industry (gas and electric utilities, major energy consumers, energy efficiency advocates) to reinvigorate America's commitment to energy efficiency.
- Results: To date over 100 utilities, state regulators, and other organizations have made and begun executing substantive commitments to initiate or increase energy efficiency for their businesses and customers.
- http://www.epa.gov/cleanrgy/actionplan/eeactionplan.htm

Bonneville Power Administration Non-Wires Alternatives

- Technologies: DSM, generation, DG, transmission pricing and transmission
- Initial report prepared by E3 for Bonneville Power Administration, 2001; work continues
- Objective: to outline a process for screening new transmission investments to identify non-wires solutions that can delay or avoid new transmission capital projects
- Results: BPA changed its planning process to include stakeholders and consideration of non-wires alternatives earlier, and has implemented several non-wires projects to date.
- http://www.transmission.bpa.gov/PlanProj/nonwires.cfm

Distributed Generation

Exploring Distributed Energy Alternatives to Electrical Distribution Grid Expansion

- Technology: distributed energy, energy efficiency, renewables, demand response
- Prepared for Oak Ridge National Laboratory by the Gas Technology Institute, December 2005
- Objective: This study assesses the costs and benefits of distributed energy to both consumers and distribution utilities by evaluating the combined impact of distributed energy, energy-efficiency, photovoltaics, and demand response that will shape the grid of the future
- Results: This study showed that advanced energy technologies are economical for many customers on the two Southern California Edison circuits analyzed, providing certain customers with considerable energy cost savings
- www.eere.energy.gov/de/pdfs/exploring_de_0512ornl.pdf

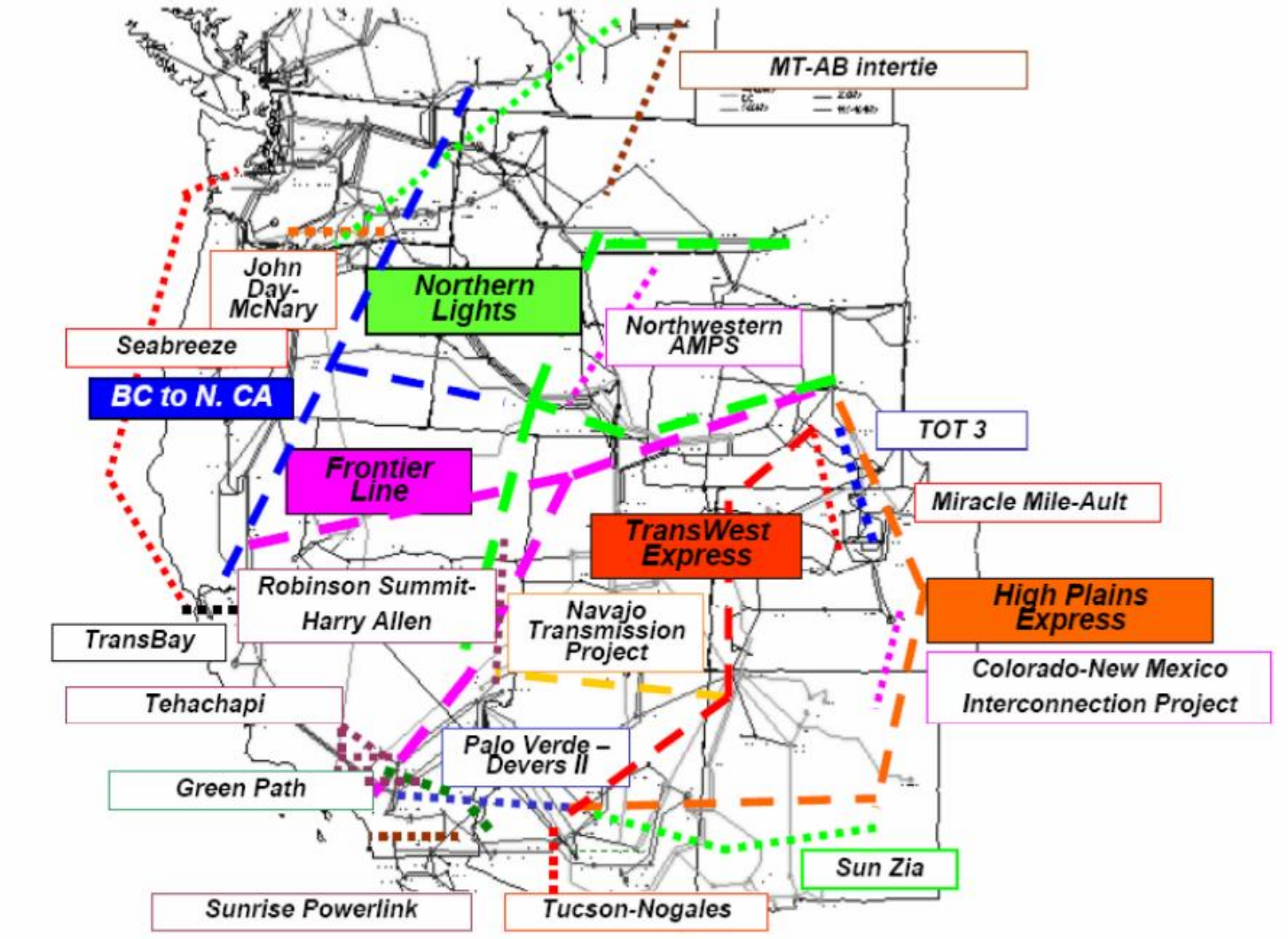
Distributed Utility Integration Test (DUIT)

- Technology: Combustion Turbines, Inverters, Controls, Microturbines, Engines, Photovoltaics, Fuel Cells, Electricity Storage
- Conducted by Distributed Utility Associates for the Department of Energy (ongoing)
- Objective: To addresses key technical issues such as electrical implications of operating multiple, diverse distributed energy resources at high penetration levels within a utility distribution system
- Results: Gathered data on the problems and benefits of the extensive use of distributed energy resources and the electricity distribution system
- www.dua1.com/DUIT

Renewable Energy Sources

Western U.S. Under Discussion
Possible New Transmission Projects

Many, if not most, are for integrating new renewable resources into the grid



Some projects have alternative routes not shown on the map

Grid Impacts of Wind Power Variability: Recent Assessments from a Variety of Utilities in the United States

- Technology: Wind
- Prepared by a multi-department team for the Department of Energy, July 2006
- Objective: To discuss recent studies that have occurred in the United States that quantify the physical impacts and costs of wind generation on grid operations and the associated costs
- Results: Although wind imposes additional operating costs on the system, these costs are moderate at wind penetrations expected over the next 5−10 years
- www.nrel.gov/docs/fy06osti/39955.pdf

DOE General Electric Western U.S. Wind/Solar Integration Study

- Technology: Wind/Solar
- Prepared for U.S. DOE by General Electric Energy Consulting, May 2007
- Objective: To support multi-state interests in understanding the operating and cost impacts due to the variability and uncertainty of wind and solar power on the grid
- Results: winter 2008
- Not posted yet

Ontario Wind Integration Study

- Technology: Wind Power
- Prepared for: The Ontario Power Authority, Independent Electricity System Operator and Canadian Wind Energy Association, 2006
- Objective: To aid in the development of the 20-year strategic Integrated Power System Plan for the province of Ontario. The strategic plan is intended to set the direction Ontario will take with regard to the mix of generation resources, demand response resources, and future transmission infrastructure needs.
- Results:
  - The average capacity value of wind resources in Ontario during the summer (peak load) months is approximately 17% and from 38% to 42% during the winter months.
  - The results of the regulation analysis show that, in all scenarios, the incremental regulation needed to maintain current operational performance is small.
- www.uwig.org/OPA-Report-200610-1.pdf

The Effects of Integrating Wind Power on Transmission System Planning, Reliability, and Operations

- Technology: Wind
- Prepared for The New York State Energy Research And Development Authority by General Electric Energy Consulting, March 2005
- Objective: In response to emerging market conditions, and in recognition of the unique operating characteristics of wind generation, this study was commissioned to produce empirical information that will assist in evaluating the reliability implications of increased wind generation.
- Results: Operation of the New York State Bulk Power System with 3,300 MW of wind was evaluated in numerous ways, considering impacts on reliability and generation capacity, forecast accuracy, operation of day-ahead and hour-ahead markets, economic dispatch and load following, regulation, stability performance following major disturbances to the grid.
- www.nyserda.org/publications/wind_integration_report.pdf

Assessment of Reliability and Operational Issues for Integration of Renewable Generation

- Technology: Renewables
- Prepared for the California Energy Commission by Electric Power Group and Consortium for Electric Reliability Technology Solutions, July 2005
- Objective: To review experiences and best practices of other regions that have integrated large amounts of renewables, compile input from grid operators and stakeholders in California, and analyze of the impact of renewables integration on key operating metrics.
- Results: expanding the contribution of renewable resources to meet the 2010 Renewable Portfolio Standard will change operating characteristics relative to 2004:
  - Average daily load swing will increase by 1 GW
  - Average residual minimum load in 2010 will be 1.1 GW lower than in 2004
  - Load ramping requirements for 2010 generally greater than 2004
  - Variability of renewable energy production higher in 2010 than in 2004
- www.energy.ca.gov/2005publications/CEC-700-2005-009/CEC-700-2005-009-F.PDF

Energy Storage

Energy Storage Enabled Renewable MicroGrid Power Network

- Technology: Integrating wind, hydro & distributed generation into microgrid using ultracapacitors
- Conducted for the California Energy Commission and U.S. Department of Energy
- Objective: To integrate a 950kW wind turbine, 250 kW hydro and 250kW natural gas generator into a MicroGrid using a 450kW ultra-capacitor energy bridge. The ultracapacitor energy storage technology is used as an energy bridge to enable the smooth transfer of renewables and distributed generation technologies.
- Results: December 2007
- www.sandia.gov/ess/About/docs/mckay.pdf

Impacts Assessment of Plug-In Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids Part 1: Technical Analysis

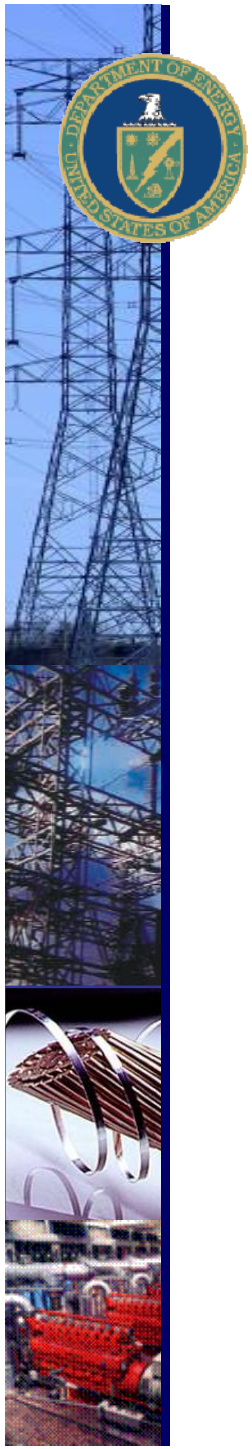
- Technology: Plug-in Hybrid Electric Vehicles
- Prepared by Pacific Northwest National Laboratory for the U.S. Department of Energy, January 2007
- Objective: To assess the impact of large scale numbers of plug-in hybrid electric vehicles on the electric grid
- Results: Off-peak electricity production and transmission capacity could fuel 84 percent of the 198 million cars, pickup trucks, and sport utility vehicles in the nation if they were plug-in hybrid electrics
- www.pnl.gov/energy/eed/etd/pdfs/phev_feasibility_analysis_combined.pdf

Impact of Plug-in Hybrid Vehicles on the Electric Grid

- Technology: Plug-in Hybrid Electric Vehicles (PHEVs)
- Prepared by the Oak Ridge National Laboratory for the U.S. DOE, October 2006
- Objective: To conduct an analysis of what the grid impacts may be in 2018 with one million PHEVs added to South Carolina, North Carolina, and much of Virginia.
- Results: Even if the overall region may have sufficient generating power, the region's transmission system or distribution lines to different areas may not be large enough to handle this new type of load.
- http://apps.ornl.gov/~pts/prod/pubs/ldoc3198_plug_in_paper_final.pdf

Costs and Emissions Associated with Plug-In Hybrid Electric Vehicle Charging in the Xcel Energy Colorado Service Territory

- Technology: PHEVs
- Prepared by National Renewable Energy Laboratory for U.S. DOE, May 2007
- Objective: To determine possible grid impacts of a high number of PHEVs on Xcel's Colorado electricity system (replace 30% of gas-fueled vehicles with PHEVs)
- Results: Impacts of PHEVs on bulk electric system will be modest if PHEV charging is controlled and optimized (limited to off-peak hours). No analysis of transmission and distribution level impacts.
- NREL/TP-640-41410



Smart Grid

Smart Grid

Advanced grid technologies needed for operational integration of DSM, DG, and renewables include:

- Communications
- SCADA, T&D automation and monitoring
- Advanced metering and meter information analysis
- Coordination and controls
- Modeling and analytics for current condition analysis, forecasting, and simulation of individual elements and interactions on the grid
- Interoperability protocols and standards

U.S. groups working on Smart Grid

Most studies to date are theoretical, developing concepts and applying technologies on a small scale…

- U.S. DOE, including GridWorks and GridWise R&D programs and many utility and private research projects funded by these budgets, such as Modern Grid Initiative
- GridWise Architecture Council
- EPRI Intelligrid
- Galvin Initiative
- GridWise Alliance (vendors and users)
- Advanced Grid Consortium
- California Energy Commission
- NYSERDA