

Hydro-Québec Models Wind Power Plant Performance



Turbines on a wind farm.

Hydro-Québec is committed to using renewable energy sources, mainly hydroelectric and wind power. Before bringing new wind farms online, Hydro-Québec conducts extensive simulations to plan the integration of wind farms into the grid, forecast power output, and ensure safe, reliable operation of the overall power system.

Hydro-Québec engineers use Simulink® and SimPowerSystems™ to model and simulate individual wind turbines and entire wind farms. They use Simulink Coder™ to generate code, which they incorporate into Hypersim, Hydro-Québec’s multiprocessor simulation environment.

“We model control systems, machines, power electronics, and measurement systems,” says Richard Gagnon, researcher at Institute de recherche d’Hydro-Québec. “By generating C code from these models, we can use them with Hypersim to study the integration of new wind farms into power system networks.”

The Challenge

Hydro-Québec must determine how much equipment, such as static VAR compensators (SVCs), will be needed when new wind farms are connected to the power system. “Without accurate models, we risk installing millions of dollars’ worth of unnecessary equipment or not having the equipment we need to meet our reliability and production goals,” says Denis Laurin, manager of technological innovation at Hydro-Québec TransÉnergie.

To obtain accurate simulation results, Hydro-Québec needed to model not only

transient stability, which accounts for electromechanical phenomena, but also electromagnetic transients (EMTs). EMT models enable the engineers to understand the dynamic interaction between the electrical modes of the network and the wind power plants.

Hydro-Québec needed to model the control system and power output of a single turbine, simulate the 70–100 turbines of a single wind farm to validate an aggregation method for modeling wind farms, and then simulate the interaction of wind farms with the power system network.

The Solution

Hydro-Québec engineers modeled individual turbines and entire wind farms using MATLAB®, Simulink, and SimPowerSystems; generated code from the models with Simulink Coder; and used this code in their multiprocessor environment to evaluate wind farm performance in the context of the power system as a whole.

The engineers built wind turbine models in Simulink using generator, converter, capacitor, harmonic filter, and other power electronics blocks from SimPowerSystems. They also built Simulink models of generator control systems.

To study stability, Hydro-Québec simulated the mechanics of the turbine using a two-mass system model in Simulink that accounted for the pitch of the blade and torsional effects, among other details.

Hydro-Québec engineers assembled a Simulink model of an entire wind farm

The Challenge

Plan the integration of new wind farms into the power system, predict power output, and ensure safe, reliable operation

The Solution

Use MathWorks products to simulate individual wind turbines and wind farms and to generate C code for multiprocessor simulation of entire power systems

The Results

- Simulation speed increased to real time
- Equipment needs accurately predicted
- Dynamic simulations enabled

“Accurate modeling is essential not only for planning investments but also to detect situations that can cause an outage. With MathWorks tools, we can simulate power electronics, mechanics, and control systems in one environment, and our models respond like the turbines we have in the field.” —RICHARD GAGNON, HYDRO-QUÉBEC

comprising 73 individual turbine models and the collector network that links them.

Using Simulink Coder, the team generated C code from their Simulink and SimPowerSystems models, which they ran in Hydro-Québec’s Hypersim simulation environment on a 32-processor supercomputer.

In the resulting real-time environment, the team performed hundreds of simulations with varying operating conditions, wind speeds, and fault scenarios.

The simulation results confirmed that their aggregate wind farm model and the entire wind farm model produced the same voltage and current output at the point of common coupling between the wind farm and the power system.

The engineers then ran simulations in which wind farms were integrated with the power system to evaluate equipment needs and assess regulatory compliance. They used Siemens PSS®E software to verify transient stability compliance and MathWorks tools to build robust and accurate EMT models.

Hydro-Québec is using results from the simulations to guide the planning of new wind power plants that will add 4,000 megawatts of capacity to its power system.

The Results

Simulation speed increased to real time.

“Previously, completing a straightforward simulation of a few seconds for turbines connected to a large power system took hours,” says Laurin. “Now we can complete complex EMT simulations for entire wind farms in seconds, and we obtained real-time simulation speed for aggregate wind farms connected to the same large power system.”

Equipment needs accurately predicted.

“Using our stability simulation tools with models based on reference Simulink and SimPowerSystems models, we were able to simulate the integration of wind farms into the power system and determine more accurately the amount of dynamic shunt compensation needed,” says Laurin. “When our simulations show that we can reliably operate with just one less SVC, it saves Hydro-Québec millions.”

Dynamic simulations enabled. “With traditional tools, we could not study the interaction between series capacitance and the wind power plant,” notes Gagnon. “The EMT aggregate wind farm models enabled us to perform large-scale power systems studies such as the interaction between series compensation and wind farms.”

Industry

- Energy production

Application Areas

- Mathematical modeling
- System design and simulation
- Physical modeling
- Control systems

Products Used

- MATLAB®
- Simulink®
- MATLAB Coder™
- SimPowerSystems™
- Simulink Coder™

Learn More About Hydro-Québec

www.hydroquebec.com/en

Hydro-Québec is the author of SimPowerSystems.