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Hydro Tasmania

Renewable generator upgrades and automates its power system study approach

Power system simulation is an essential function of any electricity generation business. Timely and accurate models produced from sophisticated software tools are needed to analyze, plan, and respond to dynamic energy market conditions. The need is heightened for renewables, now the second largest source of global electricity production and still rapidly expanding.

Hydro Tasmania (*www.hydro.com.au*), Australia's largest producer of renew-able energy, turned 100 years old in 2014. Owned by the Government of Tasmania, it is the major electricity generator in the island state of Tasmania. Addressing the condition, risk, reliability, and sustainability of its generating assets is a high priority.

Hydro Tasmania is a generator business with 30 hydroelectric power stations and one thermal gas-fired station (combined cycle gas turbine and five gas turbines). It also has off-takes for 308 megawatts (MW) of wind generation in Tasmania, and arbitrage rights for flows across Basslink, the high-voltage, direct current (HVDC) interconnector between Tasmania and the Australian mainland.

To better support long-term energy security for Tasmania and facilitate new renewable energy development, Hydro Tasmania sought to upgrade its methods for optimizing its existing power systems and planning future expansions. This was accomplished by deploying an innovative, hybrid simulation interface between transient stability programs using Siemens PTI's PSS®E-PSCAD Co-Simulation Add-On Module and E-Tran Plus for PSS®E from Electranix.

Steady Progress but Aiming Higher

Hydro Tasmania has long been a leader in its power system strategies. It purchased a PSCAD site license in the late 1980s to replace its existing electromagnetic transients program (EMTP) solution. At the same time, a switch was made from software developed in-house to Siemens PTI's PSS®E for power transmission system analysis and planning.

Still, Hydro Tasmania faced challenges, particularly with modeling large system sizes and the associated long run times. "We were using PSCAD with prepared E-Tran equivalents, and before this we were using manually prepared system equivalents," says Marian Piekutowski, Chief Engineer, System Integration at Hydro Tasmania. "We were one of the first utilities modeling all of the state's alternating current (AC) network and line-commutated converter (LCC) HVDC with the other end of the HVDC modeled as an equivalent."

Hydro Tasmania was also the first to embrace large-scale "substitution library" development to make future studies easier. Using E-Tran (data conversion module) from Electranix, it created a full model of Tasmania, including all the generators, excitation systems, governors, DC links, etc. This model was extremely detailed and built as a reusable library suitable for quick generation of future system models.

Other issues were harder to overcome. Tasmania's system is relatively small and at times weak, and it requires very thorough integration studies to reflect all of the interactions. With critical condition being low load (900MW), its high HVDC (470MW) import and high wind generation (300MW) result in a very low fault level and low system inertia. Simulating and managing these interconnections, as well as wind farm connections and the interaction between the HVDC and wind farms, was an ongoing requirement.

Tarraleah power station

A further challenge was that it had been impossible to fully integrate the Australian mainland into the studies because the PSS®E models of each system were implemented using incompatible PSS®E versions with many user-defined models, which caused conversion issues. As a result, small system equivalents were required. Hydro Tasmania realized it could do better.

Proposed Solution Matches Strategic Vision

By 2013, Hydro Tasmania was ready for a more efficient power simulation interface between its PSCAD and PSS®E transient stability programs. As part of the Tasmanian Government's Energy Strategy, in 2016 a joint Federal-State feasibility study was required to assess development of a second Bass Strait interconnector. The study would look into the preconditions necessary to make the second interconnector viable.

The need to run pre-feasibility studies of the second HVDC interconnector, which required running the entire Tasmanian system plus wind farms and two HVDC interconnectors, incentivized the power generator to consider upgrading its simulation approach. Hydro Tasmania had been following the general direction of E-Tran development for some time, and when Electranix introduced Hydro Tasmania to Siemens PTI's PSS®E-PSCAD Co-Simulation Add-On Module, interest in the concept was immediate.

Leveraging the strengths of the PSS®E and PSCAD platforms, the PSS®E-PSCAD Co-Simulation Add-On Module helps to manage complex interfaces between sub-systems and produces accurate and detailed EMT models. It automatically creates network equivalents in PSCAD that will communicate with a PSS®E transient stability simulation during runtime. Then, they run in parallel, communicating with and updating each other.

Electranix offered an experimental platform allowing hybrid use of PSS®E modeling the AC system and two HVDC links. The application included the use of parallel processing. This approach offered much faster execution times compared to the PSCAD-only approach, and Hydro Tasmania would also be able to retain electro-mechanical modes.

Other advantages included the possibility of using two different PSS®E versions to model the Tasmanian system and Australia's mainland National Electric Market (NEM) system, eliminating the prior model conversion issue. In addition, it offered the possibility of using a detailed model of the Basslink HVDC.

"Our dynamic models had been developed for PSS®E and PSCAD, so this solution provided efficiency and seamless integration," explains Piekutowski.

Another reason the solution was chosen was because Hydro Tasmania valued its long-standing support and cooperation with the PSCAD developer, Manitoba HVDC Research Centre, and Electranix. Electranix was involved in a number of studies carried out by Hydro Tasmania, including Basslink integration and commissioning, the second HVDC interconnector, wind farm connections, complex studies of an experimental remote area power supply (RAPS) system running exclusively on power electronics (non-synchronous sources), plus occasional switching and lightning transient studies.

Premiere Solution Implementation

This was a groundbreaking implementation. "Hydro Tasmania was the first test system in the world where the PSS®E-PSCAD Co-Simulation Add-On Module was applied in a real study. Lessons learned from that study were integrated into the commercial product available today, and we're grateful to Hydro Tasmania for their patience," says Andrew Isaacs, vice president at Electranix (*www.electranix.com*).

The initial implementation timeline for the Siemens PTI PSS®E-PSCAD Co-Simulation Add-On Module was one year, however it was significantly extended. The project ran in parallel with the pre-feasibility study of the second HVDC interconnector, and the progress of this study was fully dependent on continuous development and testing of early versions of E-Tran. Piekutowski believes new users should be able to use the Co-Simulation tool within two to four weeks.

Piekutowski rates support of both Electranix and Siemens PTI during the deployment very highly. Most of their contacts were with Electranix and related to E-Tran development, while Siemens PTI support was required to understand the hybrid interface and master the Python scripting language used to automate and control PSCAD and PSS®E simulations.

Upgraded Approach Provides Needed Efficiencies

To Hydro Tasmania, the ability to use a detailed PSCAD model in an area of interest, and the ability to model external environments on PSS®E, are key benefits of the new PSS®E-PSCAD Co-Simulation Add-On Module. Today, development of a new hybrid case takes Hydro Tasmania around three to five days, and most of this time is consumed by manipulation of PSS®E models with multiple interfaces. This time frame will further improve with time and experience.

Additionally, newer versions of the module have automated the Python scripting to a large degree, automating the dynamic setup of the interfaces on the PSS®E side, though some setup time is still required to customize the scripts for any specific study.

"We have achieved all of our goals, despite some significant delays. I must acknowledge that E-Tran has changed significantly for the better, and our struggles with the hybrid interface and correct exchange of signals have been resolved," says Piekutowski.

Hydro Tasmania remains an occasional user of PSCAD and more frequent user of PSS®E. However, when there is a project identified suitable for hybrid application, Hydro Tasmania's use of the PSS®E-PSCAD Co-Simulation Add-On Module becomes very intensive.

For example, Hydro Tasmania currently uses the hybrid interface to simulate the impact of Siemens PTI's frequency stabilizer modeled in-house, based on the PSCAD static synchronous compensator (STATCOM) model with a larger energy source, which interfaces with the PSS®E model of the AC system. This allows Hydro Tasmania to assess the frequency stabilizer capability to provide ancillary services, while also providing other services such as V-Q support, phase balancing, and more. Hydro Tasmania plans to augment the simulation model to include an HVDC model with the frequency controller.

Musselroe wind farm

Example Application

Hydro Tasmania required hybrid PSS®E / PSCAD simulation to combine a detailed representation of an HVDC link (equipped with a frequency controller) and a special frequency stabilizer device (STATCOM and energy storage technology) in PSCAD, as well as all other frequency control sources and loads modelled in PSS®E dynamics.

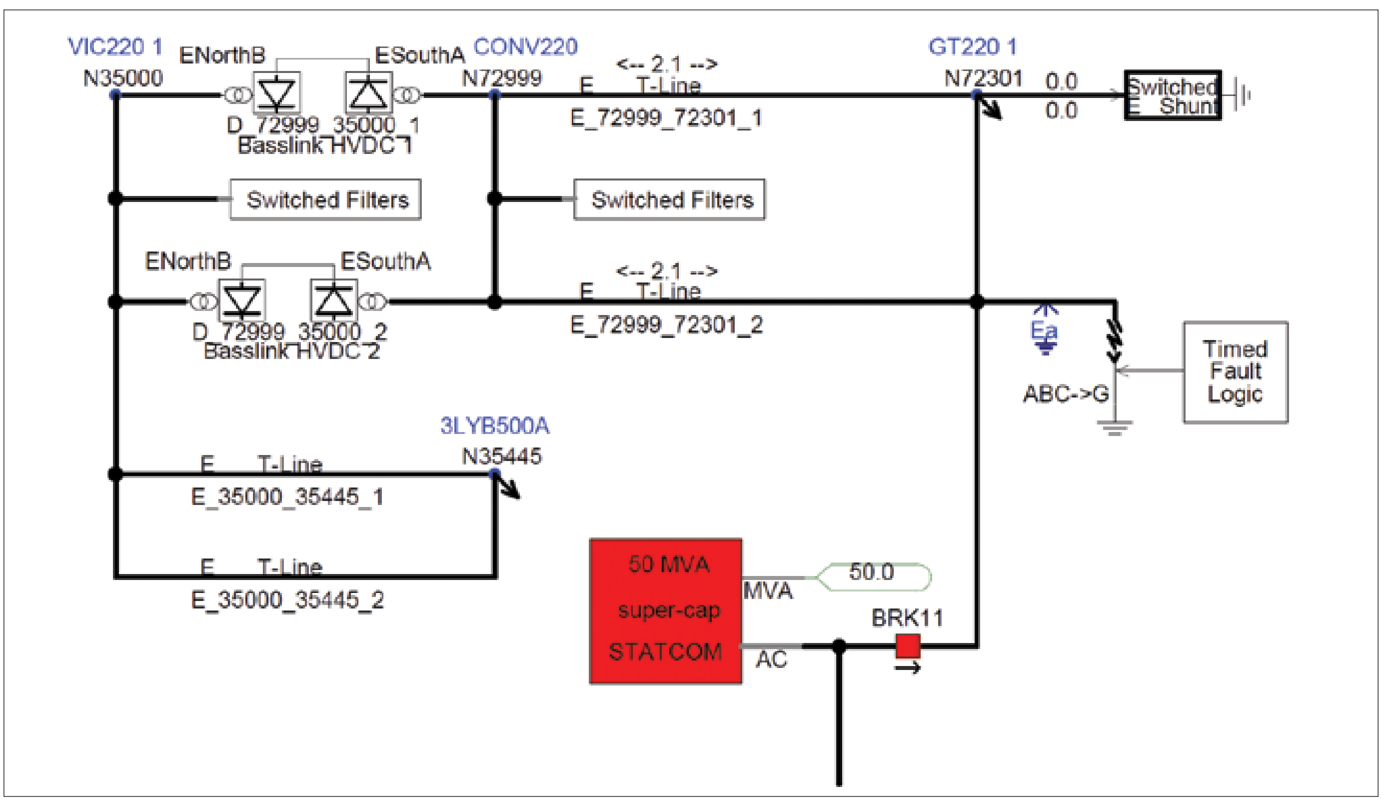

Figure 1. PSCAD representation of the study case. The HVDC and the Frequency Stabiliser (STATCOM/storage) are represented in PSCAD. Interfaces with PSS®E are located at busses N72301 (Tasmanian system) and N35445 (Australian mainland).

Hydro Tasmania concluded with confidence that that the Frequency Stabilizer action would significantly improve Tasmanian frequency during severe contingencies (such as an HVDC trip) despite the fact it is active for a very short period of time. Comparisons of flows in each program (Figure 2) across the program interface were excellent, particularly accounting for the widely different simulation timesteps (1 us vs. 1 ms).

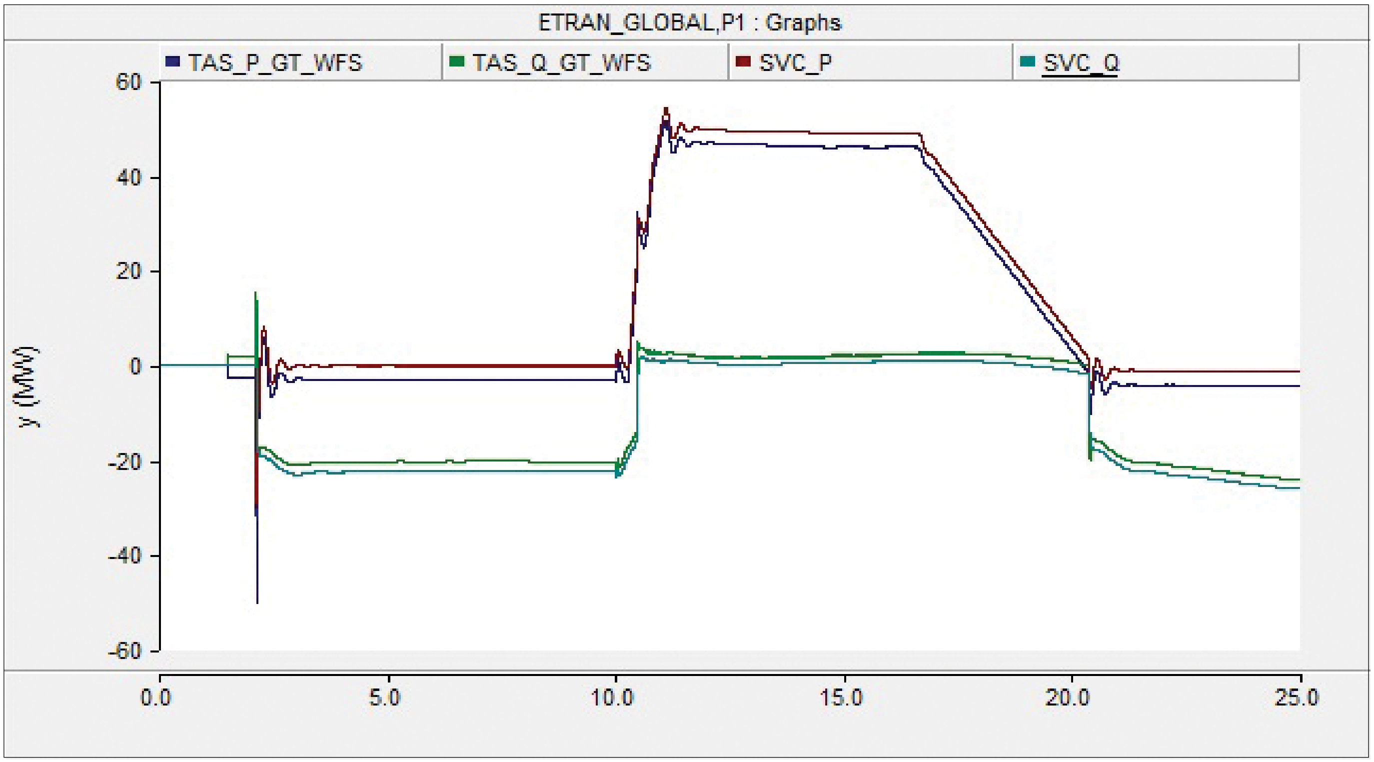

Figure 2. Comparison of active and reactive power flow across the PSS®E / PSCAD hybrid interface following HVDC trip. SVC_P and SVC_Q refer to PSCAD side measurements while TAS_P_GT_WFS and TAS_Q_GT_WFS refer to the PSS®E side measurements. Simulation time-step of the PSCAD traces is 1000 times faster than that in PSS®E.

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Energy Management Division
Freyeslebenstrasse 1
91058 Erlangen, Germany

For more information, please contact:
pti-software-sales.ptd@siemens.com