POWER NETWORKS

Power System Studies

We help our clients plan and evaluate with confidence relying on our extensive experience in modelling, analysing and planning transmission and distribution networks.

Overview

PSC's team of transmission and distribution system study specialists combines engineering excellence, deep domain knowledge and a thorough understanding of the mathematical tools used to study electrical networks.

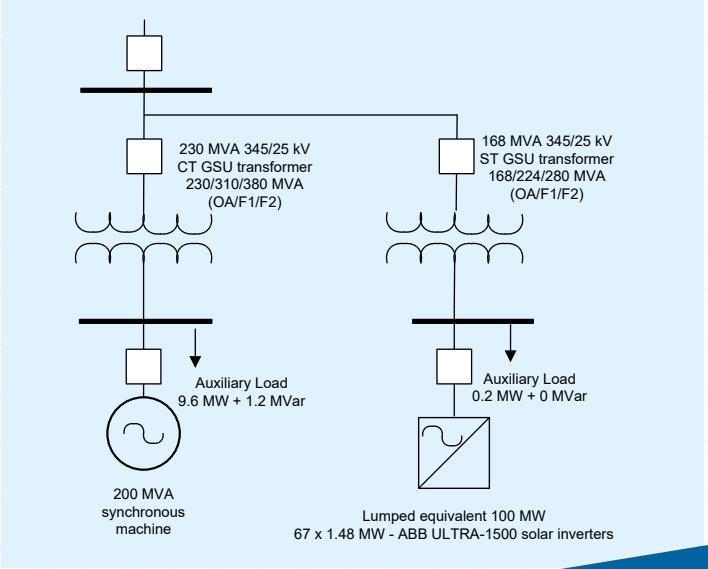
Our varied and extensive experience in the modelling, analysis and planning of transmission and distribution networks make PSC the partner of choice for electricity industry participants seeking experts they can trust.

System Impact Studies

PSC's study engineers have extensive ongoing expertise in generator, load and transmission interconnection studies in the US, Canada, Australia, New Zealand, the UK and Ireland. Our clients include North American ISOs and RTOs as well as transmission and distribution providers and private developers around the world.

PSC can help with:

- Feasibility and sensitivity studies of large and small networks
- Generator stability assessment using time domain simulations requiring detailed modelling of complex networks and generator controls
- Frequency domain assessment of harmonic distortions caused by non-linear loads such as HVDC facilities and PV inverters
- Testing of network contingencies to evaluate compliance with relevant reliability criteria, planning standards and grid codes



Generation interconnection process support

PSC's team of engineers has significant experience providing developers with comprehensive assistance throughout the generation interconnection process.

- Identification/evaluation of potential points of interconnection
- Generation interconnection applications
- Model development and testing
- Support with various studies required in the interconnection process

Network and Station Planning

PSC's planning engineers are familiar with the uniquely complex nature of transmission and distribution investment justification. PSC delivers the technical analysis required to support justifiable investment recommendations and can provide critical reviews of utility investments for internal and external stakeholders.

- Multi-year network development plans based on deterministic or probabilistic criteria
- Discounted cash flow analysis
- Planning level cost estimates of projects
- Development and assessment of non-transmission alternatives

Detailed Engineering Studies

Project developers and asset owners from transmission providers, generators and large industrial loads require detailed calculations and assessments to safely energise and operate their equipment. PSC engineers excel at detailed analysis and modelling of electric networks and their component parts.

- Insulation co-ordination
- Equipment and technical specifications. Independent technical review
- Modal analysis and generator control tuning
- Fast transient analysis, including switching surge and lightning surge analysis
- Power quality analysis and modelling of transmission and distribution networks and large industrial loads
- Research and development of power system optimisation models

Operations and Market Support

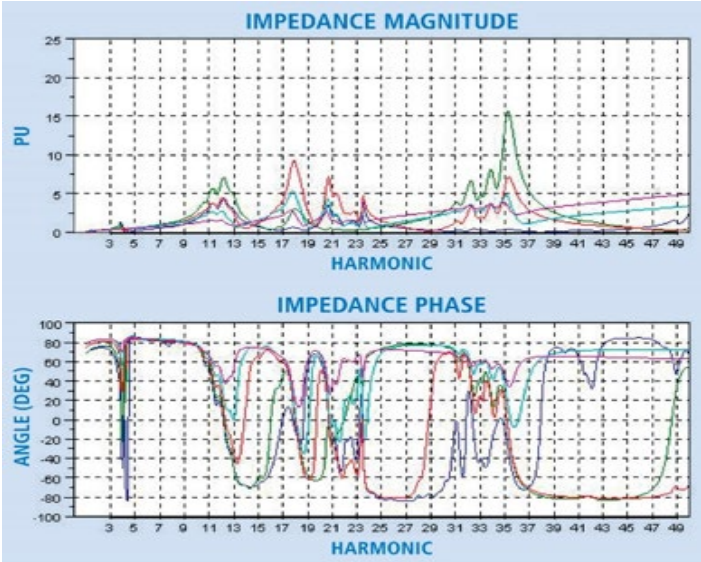
PSC engineers bridge the gap between the reliable operation of the electric power system and the electricity markets that determine the dispatch the network.

- Grid outage planning and operations studies
- Root cause analysis of network events
- Risk analysis and security studies for transmission and distribution networks
- Concept design and testing of automated protection schemes (e.g. RAS, SPS)
- Development of network constraint equations for use in market dispatch

Analytical Tools

Tools and software used by members of our power system studies team include:

- Siemens PTI PSS/E
- DIgSILENT PowerFactory
- PowerGEM TARA
- PSCAD/EMTDC
- GE PSLF
- PowerWorld
- DSATools
- EMTP-RV
- ASPEN
- PSCHarms, our in-house harmonics package
- Mathworks MATLAB/Simulink
- PowerWorld Simulator



PSC projects

A selection of projects which demonstrate our power system studies experience appears

System Impact Studies, USA
PSC has supported a North American ISO with several system impact studies for wind farms, solar farms, and battery energy storage projects. Depending on the MW capacity of a project either a partial or full system reliability study is performed. In addition to studies such as power flow, short circuit, and dynamic stability, some projects require specific studies such as harmonic analysis, or subsynchronous interaction screening assessment with nearby series capacitors or inverter-based controllers.

Stability Study for Renewable Integration, Canada
PSC performed a study for a Canadian utility to determine the level of renewable energy that can be accommodated by the existing system as well as by considering several system reinforcement measures. The approach involved examining the client's system model and comparing with other jurisdictions that are experiencing increased levels of renewable penetration in their systems. In addition to calculating the regulation reserves needed to compensate for renewable energy intermittency, and the short circuit levels at wind farm points of interconnection, PSC performed several dynamic simulations on the client system model to check the transient stability of the system in the face of severe events. PSC's global presence and specific knowledge of South Australian and Irish power systems were critical to making a sound comparison between the client system and these other systems. Based on the performed studies, recommendations were made to plan system reinforcements.

System Studies for Massachusetts Clean Energy Project, USA
PSC's knowledge of the ISO NE footprint came in handy for a transmission developer in need of system impact studies for a bid to provide an HVDC solution to transmit renewable energy in line with the Massachusetts Clean Energy RFP. PSC performed base case tuning, load flow studies, stability analysis and recommended network reinforcements to support the bid. The project crosses multiple jurisdictions, whose planning and operations criteria can differ. PSC's expertise in System studies and planning have streamlined the process.

Series Compensation Whitepaper for SPP, USA
The RTO's planners identified series compensation as a potentially viable alternative for resolving reliability needs. Significant concerns and uncertainties were expressed about the merits and implications of adding the first series compensated transmission line to the EHV network in the RTO's footprint. This document provides a better understanding of the implications of adding series compensation technology to the network. The current state of the technology is reviewed and recent advances in the techniques that deal with known issues that affect the network are explored.

Power Breaker Failure Investigation, USA
PSC performed a detailed electromagnetic transients study of transformer energisation conducted in PSCAD™/EMTDC™ to investigate whether system conditions during energisation could bring about large enough over-voltages to cause flashover. PSC provided the client with a recommendation on how to proceed with energising the transformer with a new breaker, based on the findings of the study. Following best practice for root cause analysis allowed the client to quickly replace the lost breaker while ensuring safe, reliable service for their customers.

System Normal Limit Equations, Australia
PSC completed a System Normal Limit Equation project for an Australian RTO, which included a review and update of the limit equations for export, development of procedures for the formulation of limit equations and testing the limit equations for robustness.

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Analysis for Microgrid Design, USA
PSC engineers are assessing opportunities to develop a microgrid and DER solution for a technology manufacturer in the northeast of the United States with a rapidly growing energy demand with high power quality requirements. Analysis includes defining network limitations, assessing proposed network augmentations, and developing the microgrid concept.

Connection Studies for Major North American RTO
PSC delivers numerous services for a major North American RTO's connection studies group including base case preparation, generator model and data validation, stability assessments, and reinforcement evaluations using PSS/E. PSC work flows are integrated into the RTO's processes and engineers from both companies interact daily. PSC engineers have been involved in over 300 connection assessments for technologies ranging from conventional thermal generation, wind turbines, solar/PV, and HVDC.

Technical Lead for North American ISO
PSC engineers are responsible for the development and execution of study scopes for generator interconnection projects. This entails the development of study methodologies, determining the system stresses to apply, and the preparation of the base cases and other files necessary for consultant engineers to perform the connection studies. PSC Tech Leads are also responsible for gaining buy-in and endorsement of the study scopes by consulting with internal stakeholders (eg control room) and presenting and defending the scope to inter-company working groups. Study results are presented and defended to stakeholders in the relevant working groups.

Generator Impact Studies for NA ISO
PSC engineers perform ongoing system impact studies for generator interconnection projects in North America. Studies include steady state contingency assessment for thermal and voltage violations, short circuit analysis to ensure equipment ratings are compliant, and time domain simulations to assess generator stability. Studies are delivered in a collaborative way with ongoing interim assessments of results that lead to responsive scope modifications.

Utility-Scale Solar Connection Project, Australia
PSC completed system studies and developed a proposed set of generator performance standards for a utility-scale solar farm in Australia. Working with the inverter manufacturer, the system operator and the transmission network asset owner to ensure alignment between models and reality, PSC carried out steady-state and dynamic system studies, including power quality calculations, to develop the proposed generator performance standards.

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Power System Performance Improvement, Malaysia
PSC completed a review and assessment to improve the performance and reliability of the distribution network for a utility in Malaysia. This work culminated in the development of a detailed reliability improvement roadmap for the utility, which was presented to their operation and management committee.

Load Retirement System Impact Study, Australia
PSC completed a system impact study to assess the impact of the removal of a retired plant on transmission network powerflow and stability for a client in Australia. Major aspects of the study included any significant network modifications required to maintain powerflow and stability, and any significant powerflow and stability impacts on a local wind farm and associated transmission network equipment (2015).

Generator Modelling, Australia
PSC develops complete mathematical model in PSS/E of the generator governor and automatic voltage regulator (AVR) controllers for clients in Australia and New Zealand. The models are used to simulate the effect of different tuning settings for the new controllers to test the performance and assess the compliance with the National Electricity Rules and other grid code requirements. The models are validated by overlaying the tested results from commissioning with the simulated results matching the test conditions and assessing the accuracy of the model (2014 – ongoing).

Remote Islanded Solar-Diesel Grids, Australia
PSC was engaged to provide electrical engineering services for the Solar Energy Transformation Program at remote locations with existing diesel generation. Services provided include analysis of system load flow, short circuit, feeder voltage profile and protection systems for before and after the addition of solar generation. PSC also provided advice in regards to HV and LV cable and transformer sizing, along with recommendations for earthing and lightning protection for 11kV assets.

Insulation Coordination Studies for Wind and Solar Farms, Australia
PSC routinely carries out insulation coordination studies for integration of wind and solar farms to the transmission and distribution grids. The work typically includes construction of a model of the plant and nearby network in the EMTP-RV electromagnetic transients package and then executing simulations to identify likely over-voltages and recommend or modify surge arrester selections. Insulation coordination is carried out applying the principles of IEC 60071.

Wind Farm Cable Sizing Study, Australia
PSC performed load flow, short circuit, voltage profile and power loss studies for a prospective wind farm to be connected to the 275 kV network in South Australia. The results of these studies were used by PSC to recommend cable sizes to be used in the wind farm 33 kV collector network.

Traction Power Quality Study, Australia
PSC was selected to complete a power quality study for a traction feeder station in Perth, Western Australia. Included in this study were steady state voltage, unbalance, harmonics, and flicker and rapid voltage fluctuations analysis (2014).

Power Station Governor Upgrade, New Zealand
PSC developed a mathematical model of the new governor controller in PowerFactory suitable for the System Operator to be able to use in dynamic simulation studies. A tuning study was also carried out to tune the governor for maximum response to frequency deviations while still meeting the stability requirements. For each unit the generator test plan was reviewed and changes identified to ensure that sufficient information could be obtained from the site testing and commissioning to both improve and validate the model, and then assess compliance against the Electricity Industry Participation Code.

Transformer Energisation Investigations
PSC performed a study of the energisation of four 400/230kV network transformers and seven generator step-up transformers, for the regulator of a heavily meshed transmission system in Asia. As well as completing the specialist technical work, executed by PSC staff using PSCAD/EMTDC, PSC was heavily involved in the interaction with the client, including several meetings with the client team and two workshops.

Generation Reserve Requirements, Australia
PSC carried out a review of the frequency control ancillary services (FCAS) tool used by the market operator to calculate reserve requirements. PSC also designed an over frequency generator shedding scheme and settings for two separate states, with each state requiring unique design considerations based on the available generation mix.

Embedded Support of Planning Engineering, Australia
PSC continues to support network planning and system analysis activities for transmission network owners throughout Australia, through long-term engagement of planning personnel that act within the TNSP's organisation as part of their internal teams.

Review of Design Processes, Australia
PSC performed a review of the design processes deployed by a major Australian transmission network owner, to identify areas of class-leading performance, areas where improvement can be delivered through process improvement or implementation of alternative technologies, and comparison of design costs against those for comparable TNSPs and external design providers.

Preparation of a Business Case for Network Control Services, Australia
PSC prepared a business case for the implementation of NCS by way of local generation in a remote portion of a transmission network operator's system, including review of existing long term plans, planning reports, business cases and related documentation, performance of planning studies to verify and/or update previous studies, option evaluation, assessment of compliance with applicable transmission system operation rules, and economic evaluation of options including alternatives such as transmission system augmentation.

Generation Connection Study, Australia
PSC performed a connection study for a 60 MW new power station in Western Australia. Work included analysis of the capability of the 330 kV and 132 kV transmission network to accept the new generation against the requirements of the Technical Code. The study included contingency analysis for thermal and voltage constraints, voltage step changes due to switching of transmission elements, and short circuit analysis. The study included analysis of potential mitigations where constraints were identified to determine feasibility of mitigation.

Review of Transmission Substation Fault Levels, Australia
PSC, on behalf of an Australian transmission network operator, investigated previously-identified high single-phase fault currents at a major transmission substation to identify whether these results represent valid constraints on the transmission system, and to propose any necessary short-term remedial action measures appropriate for the 2011/12 and 2012/13 summer peaks.

Load Connection Study, Australia
PSC performed a connection study for a large mining load in Western Australia. Work included analysis of the capability of the 330 kV and 132 kV transmission network to supply the new load against the requirements of the Technical Code. The study included contingency analysis for thermal and voltage constraints, voltage step changes due to switching of transmission elements, and short circuit analysis. The study included analysis of potential mitigations where constraints were identified to determine feasibility of mitigation.

Fault Level Study for Pilbara Transmission Network, Australia
PSC performed a fault level study on a mining company transmission network in the Pilbara region of Western Australia. The work involved calculating the fault levels at a new 220/33 kV substation under various development and operational scenarios, and was subsequently extended to include 33 kV feeder remote end fault levels. The calculated fault levels were used by the client to verify equipment ratings, determine a design fault level for the substation earthing grid, and calculate protection settings.

Development of Outage Management Tool, Australia
PSC developed a software-based tool to assist an Australian network operator with identification of system reconfiguration options and potential constraints during planned and unplanned outages on critical plant.

Load Increase Study, Australia
PSC performed a planning study for a customer load increase within the Perth metropolitan area. The scope of the study included adding the customer load forecast to the client's internal load forecast to determine whether a new zone substation was justified. Several options were analysed to determine the optimum network investment path to meet the customer load increase. The impact of the customer load increase, in combination with load transfers between various zone substations, on proposed major network reinforcement at the 330kV and 132kV level was also examined.

Transformer Energisation Analysis for Substation Upgrades, Australia
PSC performed a voltage dip study for new transformers at two sites in the South Australian transmission network. Work included a statistical analysis of system voltage dips on energisation of transformers rated above 100 MVA on a weak part of the system, with various mitigation measures considered. Transformer saturation was modelled. Variations in remnant flux and breaker closing times were included in order to provide a risk-based, rather than potentially unduly pessimistic worst case, assessment of system impact.

Transmission Line Shunt Reactor Study, Australia
PSC performed a single-phase auto-reclose study for an uprated shunt line reactor in the South Australian transmission network. Secondary arc currents induced in a fault from healthy phases and an adjacent circuit after single-phase tripping were simulated, to determine the neutral earthing requirements for the shunt reactor. The aim was to ensure successful single-phase auto-reclose operation. Impacts of switching the shunt line reactor were also studied, with focus on switching over-voltages from current chopping and circuit breaker arc re-ignition effects during de-energisation, as well as inrush current during energisation.

Victorian Transmission Network Constraint Analysis, Australia
PSC personnel performed the analysis of constraints on the Victorian transmission network and performed load flow studies, including the preparation of 10 year load flows in accordance with various new generation planning schedules.

Transmission Study for Supply to Proposed Mine Upgrade, Mauritania
PSC performed a high level transmission study for a proposed new single circuit 275 kV transmission line from the proposed new generating plant to the inland mine site, including the development of the model in PowerFactory, determination of optimum voltage and size of switchable reactive plant.

Tasmanian Transmission Network Model in PowerFactory, Australia
PSC developed a complete network model of the Tasmanian power system in PowerFactory from first principles. The scope covered load flow, short circuit, and harmonics data. Transformer data was validated against FAT reports, and transmission lines were represented by their geometric tower configuration, with mutual couplings to parallel transmission lines included. The model was also used to audit the existing PSS/E model of the Tasmanian network.

Harmonics Analysis for Substation Upgrade, Australia
PSC performed a harmonics study for a future power factor correction capacitor bank installation on the South Australian transmission network. Work included the construction of a harmonic model of the South Australian transmission system and key harmonic sources, calculation, analysis and interpretation of harmonic voltages and impedances within the transmission system and examination of zero-sequence harmonic conditions.

Transpower New Zealand HVDC Pole 3 Upgrade, NZ
PSC performed system studies associated with upgrading the existing 1000MW HVDC connection to 1200MW (to be commissioned around 2013). The studies included development of a PSS/E dynamics model for the HVDC link to investigate fault recovery, as well as development of performance criteria for the specification.

Feasibility Studies for Wind Farm Connections, NZ
PSC performed dynamics and load flow analysis using PSS/E and DIgSILENT to investigate the effects of adding wind farms to the New Zealand power systems. These studies identified congestion issues and stability constraints dependent on location and type of wind generator, and system short circuit strength.

Statement of Opportunities for the New Zealand Electricity Commission, New Zealand
PSC performed PSS/E load flow analysis of the NZ power system over a 30 year timeframe to identify likely issues with congestion and possible mitigations including transmission augmentations and generation. This analysis was a key contribution to the Electricity Commission's 'Statement of Opportunities'.

Basslink PSS/E User Model, Australia
PSC personnel updated the Basslink PSS/E user model, adding a number of enhancements and bug fixes to facilitate simulation of the Tasmanian and Victorian systems.

Connection of large scale remote generation to the NEM, Australia
PSC were engaged by the electricity market operator to develop a case study for connection of a large scale renewable generation to the National Electricity Market over a distance of 1200 km. The case study included a planning guide for new transmission lines, as well as the development of potential options including costing to provide the required transmission capacity. Several solutions were developed and verified with load flow, and included both AC and DC solutions.

George Town Automatic Voltage Control Scheme, Australia
PSC personnel were engaged to design a voltage control scheme for the George Town 220 kV bus in Tasmania. The scheme is currently in operation and includes generator voltage and reactive power dispatch, capacitor bank switching, and takes account of the Basslink HVDC operating range, power transfer and harmonic filter switching. Subsequently in 2011, PSC also carried out a due diligence of two modifications proposed by the TNSP to enhance its performance.

Under Frequency Load Shedding Scheme, Australia
PSC personnel carried out the design review of an existing under frequency load shedding scheme for Tasmania. This involved simulating a number of multiple contingency events with generator governor response and operation of the UF relays modelled, and included validating new settings required for the change in the Tasmanian frequency standard.

Lower South Island Stability, New Zealand
PSC personnel carried out dynamic stability studies using DIgSILENT PowerFactory for various potential transmission system upgrade options in the lower South Island including re-conductored lines, series compensation, and new transmission lines. Stability limits were determined for a range of operating conditions including HVDC transfer.

NEM Entry & Basslink System Studies, Australia
PSC provided system study support for the transmission system owner in Tasmania for a range of studies related to entry to the National Electricity Market and connection of the Basslink HVDC link between Tasmania and Victoria. This included development of an algorithm to calculate thermal limit equations, and development and testing of thermal, voltage and stability limit equations. Other studies included an audit of protection clearing times for 220 kV & 110 kV transmission lines for compliance with the National Electricity Rules and dynamics simulation of the backup Network Control System Protection Scheme to test timing and coordination of circuit tripping and test the operating logic for multiple contingency events.

Anglo Regional Strategy Hydrogen Analysis, Southern Africa
PSC performed analysis to determine excess energy available, and the build needed for the hydrogen requirements using the whole regional portfolio. Tasks included modelling and load and yield analysis.

PSCAD Electrolyser Modeling, UK
PSC is currently developing an electrolyser model for use in electromagnetic transient simulations.

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