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Grid impact investigation

System interconnection studies for grid operators and developers

At a glance
As electric power system loads continue to increase and older power plants are retired, a significant number of new power generation units, including conventional fossil-fired and renewable energy units, will be connecting to the grid.

Siemens Power Technologies International (Siemens PTI) can help customers gain a better understanding of the ability of their grid to accommodate new generator interconnections.

The challenge
New power plants may be located far away from load centers. This may create a technical challenge for the existing power grids, which may not have been designed to handle large amounts of power transfer from remote locations. Furthermore, the variable nature of renewable generator output may introduce frequency and voltage control issues that are not often encountered with conventional thermal or hydro power plants.

In consequence, many grid operators have developed interconnection criteria or grid codes to ensure that the interconnection of a proposed generation project will not negatively impact the reliability performance of the power system.

Our solution
Siemens PTI has extensive experience in performing generation interconnection studies for clients in many countries. We have conducted studies involving power flow, short circuit, transfer limit, transient, and dynamic stability analyses for generator interconnections of conventional steam/gas turbine plants, hydro plants, nuclear plants, as well as wind farms and solar plants.

In addition to providing consulting services, Siemens PTI is also the developer of the PSS® Suite: software tools in that are used by system operators and electric utilities around the globe for power systems analyses. Our powerful and comprehensive software contains a vast library of simulation models for power system equipment and controllers, including conventional generators, wind generators, photovoltaic (PV) units and FACTS devices.

An initial high-level review of the transmission capacity in the immediate neighborhood of one or more proposed plant sites can be conducted to determine if the plant's output can be exported to the network with no or limited restrictions.

Furthermore, Siemens PTI can provide a feasibility study, which may include steady-state power flow and short-circuit analyses of the grid with the proposed plant interconnected. This will provide the power plant developer or owner with preliminary information on whether major investments will be required to reinforce the grid for interconnecting the project.

A more detailed analysis is the system impact study. This study consists of thorough steady-state analyses that consider a range of operating scenarios, as well as dynamic simulations that evaluate the transient and dynamic performance of the network to ensure compliance with the transmission network criteria or grid code.

Before a power plant can be interconnected, a facility study may be required. The equipment requirements for interconnecting the project and, if necessary, for upgrading the network to maintain reliability, are better defined in this stage. This step typically involves the interconnecting grid owner to provide input on their equipment preferences and practices.

Technical issues
An interconnection study looks at the potential impact of a proposed generation project on the performance of the power grid.

Steady-state performance
Transmission facilities are expected to be within their respective thermal-normal and emergency ratings, and system voltages should be maintained within normal and emergency ranges. The analysis typically requires hundreds or even thousands of power flows that look at a variety of conditions, including the outages of major components in the grid.

Our power system analysis tools are designed for such type of contingency analyses and produce graphs and reports that can be reviewed by our experienced consultants. Very often, tests are performed with and without the proposed power plant, so that the relative impact of the project can be easily identified. Situations that do not meet the criteria will require corrective action, which may involve the addition of new equipment or replacement of old equipment.

Transient and dynamic stability
The introduction of a power plant to the grid may cause dynamic stability issues after disturbances, which should be analyzed by means of dynamic simulations. Problems with stability may require adjusting the parameters of power plant equipment or the protection settings. Dynamic stability problems can be resolved by applying power system stabilizers. Our consultants are experienced in calculating critical fault clearing times and tuning power system stabilizers to address such concerns.

Short-circuit level
The addition of generating equipment may increase the short-circuit currents in the network and, as a result, may cause the duties of existing power system protection equipment to be exceeded. Short-circuit calculations are performed to determine if circuit breakers in the existing system need to be replaced as a result of new power plant interconnections.

Voltage support
Conventional synchronous generators are typically able to provide adequate voltage support to the grid. Hence, their interconnections are generally not of concern in terms of system voltage performance unless the power transferred from the power plant to the load centers creates significant voltage drop in the grid. On the other hand, some renewable generating units have limited voltage control capabilities. Power flow and dynamic simulation studies are performed to identify such voltage issues so the appropriate voltage support equipment can be selected. Our power system analysis software tools include models for many types of wind turbines and solar voltaic units, as well as static var compensators (SVCs), static synchronous compensators (STATCOMs) and conventional synchronous condensers (SYNCONs).

An example of a reactive power capability study for a wind farm is shown in Figure 1. The green curves show the maximum reactive power capability in the inductive and capacitive regions. The brown curve indicates the grid code requirements. In this case, appropriate measures must be taken to achieve grid code compliance.

Voltage ride-through
Many grid owners and operators are now requiring renewable energy units to continue operating during severe voltage dips in the grid.

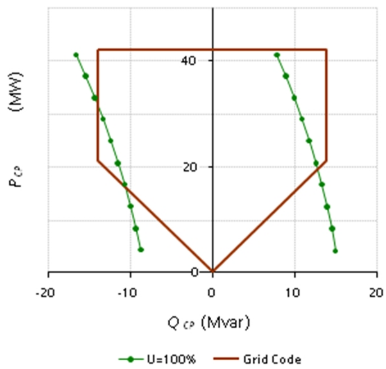

Figure 1: Example of reactive power capability curves

Often, the interconnection study of a power plant will include a voltage ride-through test to ensure performance within the criteria of the grid code. An example of such criteria is shown in Figure 2.

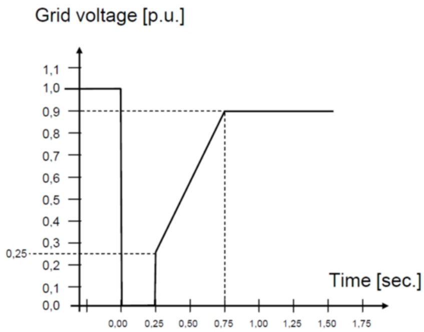

Figure 2: Example of a fault ride-through requirement curve

Frequency response
While most conventional generators can respond rapidly to system frequency changes, wind and solar-powered generators have limited ability to vary their output. Some grid codes are now requiring renewable generators to ramp their outputs up or down in response to system disturbances.

Published by
Siemens AG 2018

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AL=N, ECCN=EAR99

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