Power Systems Engineering Research Center

PSERC Background Paper

Distributed Generation

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The electrical power system consists of three major components: generation, a high voltage transmission grid, and a distribution system. The high voltage transmission system links the generators to substations, which supply power to the user through the distribution system. Interruptions in these connecting links can disrupt the flow of power from generators to the users.

Over the last ten years the reserve capacity in transmission has been falling due to increases in both electricity demand and generation capacity. This has resulted in an over utilized transmission system with an increasing likelihood of loss of power during a disturbance.

One obvious solution is to build more transmission lines and improve reliability protocols. A not so obvious alternative is to integrate generation within the distribution system reducing the dependence of local loads on the transmission grid. This latter approach is referred to as distributed generation.

It is generally agreed that any power production that is integrated within the distribution system is called distributed generation. Distributed generation encompasses a wide range of generator technologies, such as internal combustion engines, gas turbines, microturbines, fuel cells, photovoltaics and wind power. The larger units are normally gas turbines, large internal combustion engines, wind turbines and some fuel cells. Their ratings are in millions of watts of power at thousands of volts. The applications include direct power support at substations and deferral of the need to build more transmission.

While placing distributed generation at substations will reduce the reliance on the high voltage transmission grid, it does introduce problems of control and dispatch of each unit. At a minimum, additional central real time monitoring and control systems need to be designed and implemented. The net result is an increase in the power system's complexity. An example that neglects this complexity is IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems. This standard requires that distributed generators disconnect from the grid when there is a disturbance. In the case of a grid disturbance due to overload, disconnecting is exactly the wrong action since the system needs loads not generation to disconnect.

It is obvious that indiscriminant application of distributed generation with central control can cause as many problems as it may solve. A better way to realize the emerging potential of distributed generation is to take a system approach which views generation and associated loads as a subsystem or a "microgrid". This approach allows for control of distributed generation through load following techniques, reducing or eliminating the need for central dispatch. During disturbances, the generation and corresponding loads can separate from the distribution system to isolate the microgrid's load from the disturbance (and thereby maintaining service) without harming the transmission grid's integrity. This ability to island generation and loads together has a potential to provide a higher local reliability than that provided by the power system as a whole.

Smaller units, having power ratings in thousands rather than millions of watts, can provide even higher reliability and fuel efficiency. These units are also clustered with loads creating microgrid services to customer sites such as office buildings, industrial parks and homes. Since the smaller units are modular, site management could decide to have more units than required by the customer load, providing local, online backup if one of the operating units failed.

Most existing power plants, central or distributed, deliver electricity to user sites at an overall fuel-to-electricity efficiency in the range of 20-40%. This represents a loss of around 70% of the primary energy provided to the generator. To reduce this energy loss, it is necessary to either increase the fuel-to-electricity efficiency of the generation plant and/or use the waste heat. For site-based microgrids, it is much easier to place generators near the heat loads therebyallowing more effective use of waste heat than substation-based systems. Of course, there are special situations where the waste heat from large generators can also be utilized. These applications produce both electricity and the byproduct ofonsite thermal energy, converting 80 percent or more of the input fuel into useable energy. It also has the potential to dramatically reduce industrial sector carbon and air pollutant emissions.

Economic, technology and environmental incentives, along with end user demands, are changing the face of electricity generation and transmission. Centralized generating facilities are giving way to smaller, more distributed units. Either type of microgrid could help shoulder the nation's demand for more power, less complexity and higher local reliability without further overburdening the transmission grid.

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