Distributed electricity generation from wind and solar energy is enjoying rapid growth in the Western world. For all the advantages offered by clean power generation from renewable raw materials and distributed power generation, network operators and municipal utilities still face new challenges. Renewable forms of energy are extremely volatile and thus produce load variations at all voltage levels.

In addition to the discontinuity of power generation, the distribution of the energy generated by large power plants and offshore wind parks to centers of consumption located some distance away places new demands on the power supply grids. Variable shunt reactors can play an important role in overcoming both of these challenges.

Siemens variable shunt reactors counteract the undesirable consequences of this development in the following ways:

• Compensation of the higher capacitive reactive power
• Reduction of network-frequency overvoltages in case of load variations
• Compensation of sudden load shedding incidents and/or networks operating with no load
• Balancing out of network instabilities
• Increased cost-effectiveness thanks to reduced transmission losses
• Perfect adaptability to changing network conditions

Siemens can provide flexible solutions that react quickly and reliably to abruptly changing network conditions.

Applications for variable reactors

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Construction

Variable reactors are shunt reactors acting as an inductive load for controlling voltage, and are connected between the transmission voltage and ground.

They are designed to combine the highest possible inductive power with compact size. For this purpose, Siemens relies on iron-cored reactance coils with air gaps. The iron core conducts and concentrates the magnetic flux produced by the winding, which has to bridge the air gap.

Due to the large difference between the permeability of magnetic sheet steel and oil (oil has the same permeability as air or a vacuum), it is sufficient to use the magnetic resistance of the air gap for the series connection of the iron and air path. The air gaps reduce inductance and increase the power output of this configuration.

Changing the number of windings is the most practical operating principle for variable shunt reactors. The coil winding is provided with tapping points. Via these tapping points sections of the coil can be connected or disconnected. These winding sections can also be arranged separately in the same way as the control windings of power transformers. The same reliable tap changer utilized in power transformers is used for switching.

Operating principle

Overhead lines or cables constitute a distributed capacitive load, with cables representing considerably higher capacitive loads compared to overhead lines of the same length.

The capacitive charging power must be compensated. More serious are the effects of changing the level of the voltage as a function of the load at the end of the transmission line. The capacitive load of the transmission line leads to voltage rises on lines operating with no load (Ferranti effect), whereas ohmic or inductive loads result in a voltage drop. Abrupt load shedding on a long line is therefore particularly critical. For these reasons shunt reactors are employed. They compensate for the effects of constant loads and the capacitive charging power of the transmission line. The design of a shunt reactor can only be optimized to a constant load and generation condition. Since there are fewer and fewer cases where this is guaranteed due to the impact of renewable energy generation on the transmission networks, the use of variable shunt reactors could be a possible solution. Losses are kept as low as possible through the best possible matching of the shunt reactor to the existing reactive power. This not only optimizes the networks but also ensures increased cost-effectiveness of the lines, which results in cost savings for the operator.