Challenge
Decentralised and volatile power generation today is nowadays common practice in many regions. At the same time the fluctuating infeed of solar- and windpower is comes along with very different load conditions in the day- or nighttime and on working days or the weekend.

The Electricity Authority of Cyprus (EAC) is covering the whole power demand of cyprus – and is confronted with a rapid extension of solarpower generation. Unti 2030 nearly 50% of the Cypriot power demand shall be covered by solar power.

As in Cyprus underground cables are very common, especially in urban areas, already for short distances and low voltages additional compensation devices are reasonable.

Electric Authority of Cyprus (EAC)
The Electricity Authority of Cyprus (EAC) is the partly governmental utility of Cyprus. It feeds approximately 6000 GWh annually in the Cypriot grid and is thus covering the complete demand of Cyprus. While the energy mix of today is mainly based on fossile, the EAC is anticipating a rapid extenstion of solar power.

The Idea
To be able to provide the flexible reactive power needed today and be prepared for the future changes, variable shunt reactors (VSR) are the favoured solution. They are similar in size and only a marginally higher investment than fix shunt reactors. With their regulating unit they provide a variable reactive poer and thus allow for a quick adaption that is always suiting the current need for reactive power.

Unregulated shunt reactors can only be designed optimal for constant load- and generation-conditions. Contrarily, variable shunt reactors can keep the voltage in the defined voltage band even with big voltage fluctuations. Having the best adaption to the reactive power currently needed, losses are minimized to the maximum. This optimized the transmission capability of the grid as well as the cost effectiveness and thus results in cost savings for the operator of the VSR.

“Both units are now in operation for nearly one year. We have achieved with this state-of-the-art-solution exactly what we had planned. The variable compensation of the grid is working excellent. The contractor Siemens handled the Variable Shunt Reactor Project in a very satisfactory way fulfilling all of the project requirements.”

Christos S. Kyprou, Project Manager (EAC)
**Design**

For variable shunt reactors an iron core shunt reactors with air gaps is designed. The iron core leads and concentrates the magnetic flux that needs to bridge the air gaps. As the difference in permeability of electrical steel and oil (permeability of oil is equal to air or vacuum) is very big, it is sufficient to work with the magnetic resistance of the air gaps when calculating the series connection of iron- and air-path. They reduce inductivity and increase the performance of this arrangement.

The active principle of variable shunt reactors is based on the change of the numbers of windings. Therefor the windings are equipped with taps that allow for parts of the windings to be switched on or off. For the switching operations the tap changers known from power transformers are used.

**Mode of operation**

Cables and open wires are a capacitive load, whereas cables have higher capacities at the same length and voltage than open wires do because of the dielectric of the isolation coats. When the line is compensated with a variable shunt reactor, the load of the line can be minimized due to the capacitive charging capacity and the transmission losses are reduced.

Bigger issues are the effects of changing the voltage in dependency of the load at the end of a transmission line. The capacitive load of the line is leading to voltage exaggerations at the end of the line that can cause damage in connected assets (Ferranti-effect). When stressed, the inductive resistance instead leads to a voltage drop in the line. The additionally added inductivity of the VSR is counteracting voltage exaggeration.

**Transfer to other countries**

With the increasing power demand and the extension of renewable power generation, there is a need for reactive power in many countries. As VSRs need less space than phase shifters or converter stations this is an attractive solution for network operators. The cost effectiveness in comparison to larger grid extension measures as well as their robustness and low-maintenance needs are further advantages of VSRs.

**Test: Can a VSR be cost effective for your grid?**

If you can answer one or more of the following questions with "yes", a VSR might also be interesting for you.

- Parts of the grid / lines are facing a change of idle / low load and load operation
- Parts of the grid / lines are regularly overloaded with reactive power of secondary network operators
- There are tight borders for keeping the voltage and acquiring reactive power agreed upon with a preceding network operator
- In my grid there is a large share of distributed generation and / or wind/solar power generation.
- My grid or the conditions of my grid will face considerable changes in future, but I cannot define those changes exactly at the moment.
- I already use fixed shunt reactors in different voltage levels and need a flexible spare unit.

You would like to receive additional information on this topic? Contact us!