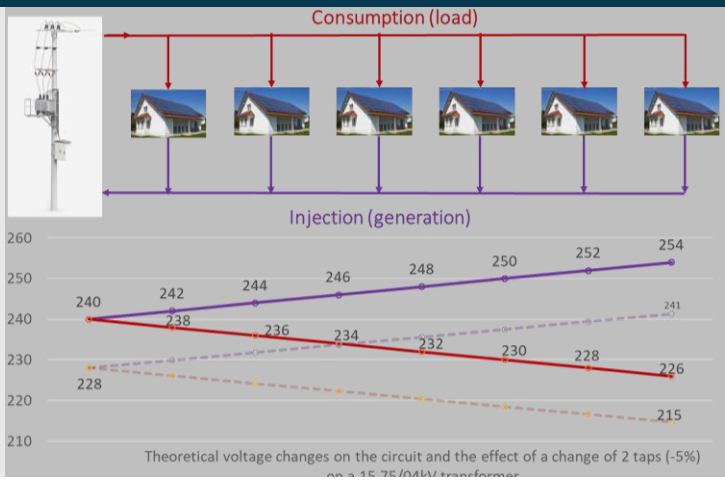
SUCCESS CASE 29.2024

Transformer Voltage Control Automation (TVCA)

VOLTAGE REGULATION OF HV/SN STATIONS TAKING INTO ACCOUNT THE IMPACT OF RES



THE CHALLENGE

Distributed renewable energy sources (RES) have significantly increased the range of voltage variations in networks at all voltages, often beyond the permissible range. This is mainly due to the significant network impedance and flow asymmetry both within the low voltage (LV) phases of the same circuit, within the LV circuits of the same MV/LV substation and the medium voltage (MV) lines from the same MV/LV substation. The high impedance of the network at the point of connection of the sources, in addition to other factors, is largely due to the design of the network with a coincidence factor of 0.3 and above, while the power of photovoltaic (PV) sources would require the adoption of a factor of 0.8-0.9. Hence, the previously used settings for voltage levels in the HV, MV and LV networks, approaching the upper permissible values, are no longer appropriate due to the varying directions of current flows and, consequently, the reversal of voltage drops.

THE SOLUTION

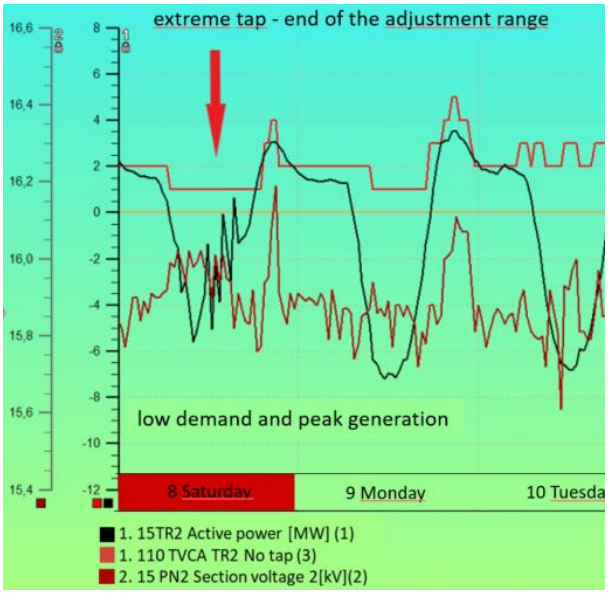
Transformer voltage control automation systems should be able to **sustain voltage changes in the LV and MV networks**. Currently, these depend not only on the load but also on the level of generation of distributed sources, the vast majority of which are PV installations. The low levels of online monitoring capabilities on the parameters of LV and MV network operation require the operation of the transformer voltage control automation system based on the available measurement parameters. The use of the criterion of the value and direction of power flow through the HV/MV transformer seems to help maintain the optimal voltage level on MV buses.

As part of a test conducted by PGE Dystrybucja, a **Transformer Voltage Control Automation (TVCA) system** in the range of 15.6 - 16.0 kV was launched at three transformer stations. The control for voltage increase is carried out by applying a signal to the input of the TVCA system relay

from the output contact of the protection of the 15kV side of the 110/15kV transformer. The normally open contact closes when the set active power flowing through the transformer is exceeded (depending on the station, this ranges from 3 MW to 4.5 MW), allowing the tap to switch in the direction of the expected voltage. The analysis deals with 115/16.5kV transformers with ±10% control by a switch with 6, 8, 9 or 12 taps in both control directions. The 15kV network has been in operation since 2003 (following a change of LV voltage from 220 V to 230 V) with a TVCA setting of 15.8 kV at night and 16.2 kV during the day.

MAIN ACHIEVEMENTS

By taking into account the parameter of power flow direction, PGE Dystrybucja knows if generation is occurring and, despite the acceptable value of the voltage on the MV buses, this voltage must be lowered so that there are no overshoots in the network, both at the MV and LV level. Thus, even without extensive metering infrastructure in the depth of the network, PGE Dystrybucja can maintain the required energy parameters for energy consumers by applying group voltage regulation on the MV side (i.e., on the buses of the 15 kV switchgear of the HV/MV transformer). This optimises the level of generation by reducing the voltage on the inverters.



Operation of TVCA with power-dependent control on HV/MV transformer.

KEY SUCCESS FACTORS

- **Equipping the transformer with digital protection** allows implementing the power flow direction criterion.
- A small amount of measurement data provides relatively **high efficiency in controlling voltage overshoots**.

WAY FORWARD

After an analysis confirming the validity of this solution as a complementary element to other technical solutions, further steps will be decided according to the feasibility of implementation throughout the network operated by PGE Dystrybucja.