Renewable Generation

The power from renewable solarPV generation can fluctuate and unless the var flow fluctuates in proportion to the power then the subsystem voltage will fluctuate. The voltage fluctuation needs to be kept under the IEC voltage irritation curve. One method is to use the solarPV subsystem tie transformer reactive power losses to absorb vars in approximately proportional to the power through the tie transformer. This article looks at the tie transformer’s reactive power effects on the subsystem.

The subsystem is reduced to a few basic elements to highlight only the essential quantities. The loadflow elements are solarPV generation and busbar, the tie transformer, a subsystem substation, two subsystem lines and a main system substation that are part of a ring subsystem. The solarPV generation tie transformer has impedance between 10 per cent and 20 per cent leakage inductance and no on load tapchanger. The other series inductance is the main system transformers and they are assumed to have a parallel inductance of 4 per cent. An assumption made is that the solarPV generation will generate power at unity power factor.

The subsystem’s voltage drop effects can be viewed from the formula.

\[ \Delta V = \frac{(R_P + X_Q)}{V} + j\left(\frac{X_P - R_Q}{V}\right) \]

where \( (R_P + X_Q)/V \) is the magnitude component of voltage drop.

The var flow \( Q \) in the subsystem is mainly from the \( i^2X \) losses in the SolarPV generation tie transformer. The var flow is opposite the power flow and the var flow has the effect of reducing the voltage drop as the SolarPV power increases. The subsystem examples shown have a tie transformer with 10 per cent inductance with 50MW, 100MW and 150MW SolarPV generation. The 150MW represents the limit of a subsystem.

The voltage fluctuation at the subsystem substation is below one per cent for 50MW power variation. However the var flow fluctuations through the main system transformers will cause excessive tap-change operations if the SolarPV tie transformer inductance is greater than 10 per cent.

The main system transformer will need to be made to have a flat voltage drop compensation characteristic otherwise the fluctuations in power flow through the transformer from the changing subsystem generation will cause excessive number of main system transformer tapchanges.

In the simplified examples shown the main system transformer would have reverse power flow and voltage regulation scheme would block tapchanging.
Simplified subsystem with 50MW from SolarPV generation

Simplified subsystem with 100MW from SolarPV generation.

The main system transformers voltage regulation error changes from near zero to $-0.5$ per cent. The tie transformers $I^2X$ losses cause only a $0.5$ per cent error between 50MW and 100MW while $1.0$ per cent between 100MW and 150MW

Simplified subsystem with 150MW from SolarPV generation.

The main system transformer voltage regulation with a flat volts drop compensation characteristic will cause a tap-change due to the change in var flow from the tie transformer reactive power losses