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QUESTION N° : 1.2

Concept to reduce no-load losses in PV parks

Energy transition is currently a predominat factor when it comes to the question how to develop the existing energy supply networks to ensure a secure and affordable energy supply in the future. Besides energy generation by wind, generation by solar radiation in photovoltaic (PV) plant is one very important way of generating energy from renewable resources. Due to the growing demand of energy from renewable resources the number and size of photovoltaic plants is increasing constantly. One very good predictable aspect of energy generation by photovoltaic plant is that no electricity is generated at all between sunset and sunrise. In addition to this, the live transformers and lines cause no-load losses during the night, which need to be covered cost wise by the solar park operator. From the perspective of a PV-park operator, usually, the power purchase cost (e.g. €/kWh) to cover the no-load losses are much higher than the payment for a kWh. Both, cost and payment for one kWh defers all over the world.

Due to the increasing number and size of solar parks option to reduce levelized energy costs are getting more important.

There are different ways to do so. Two of them will be presented below by the example of a generic sketch of a PV park with approx. 120 MVA installed capacity, divided into 25 groups of each 5 MVA.

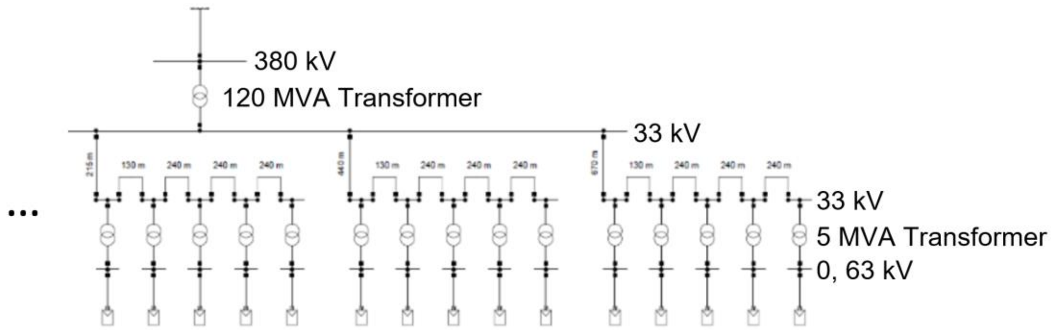

Figure 1: generic sketch of a PV park with approx. 120 MVA installed capacity, divided into 25 groups of each 5 MVA

1. **Option: switching off the 25 5 MVA transformers during the night-time**
   By use of circuit breakers to switch off the 5 MVA transformers (red dots) the no-load losses of the 5 MVA transformer can be avoided. The drawback of this solution is that a larger number of additional operating devices (OPEX, CAPEX) are needed, which are only good for approx. 10,000 switching cycles. Additionally, high inrush currents with heavy load on the transformer insulation will be opposed each day to the transformer.

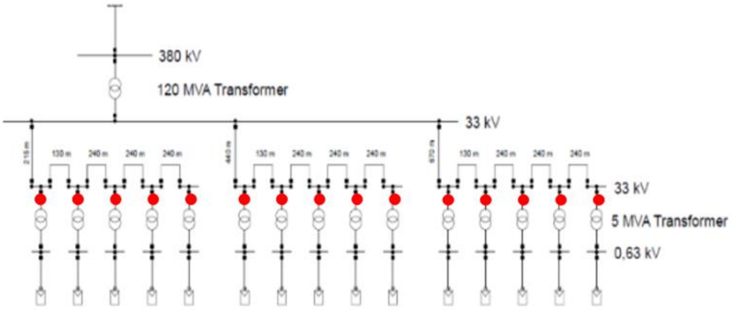

Figure 2: generic sketch of a PV park with circuit breakers (red dots)

2. **Option: reducing the 33 kV voltage close to zero.**
   By the use of a secondary-side on-load tap-changer on the network connection transformer (green dot), the voltage can be reduced on the secondary side near to 0 V, if required (e.g. PV park in no-load operation). In this case the transformer needs to be equipped with a tertiary winding to supply auxiliary equipment in the PV park (lighting, protection, monitoring, ...). The advantage of this solution is that only one operating device (network transformer) in the entire park needs to be redesigned. Additionally, high and frequent inrush currents are avoided and, therefore, stress on the transformer insulation.

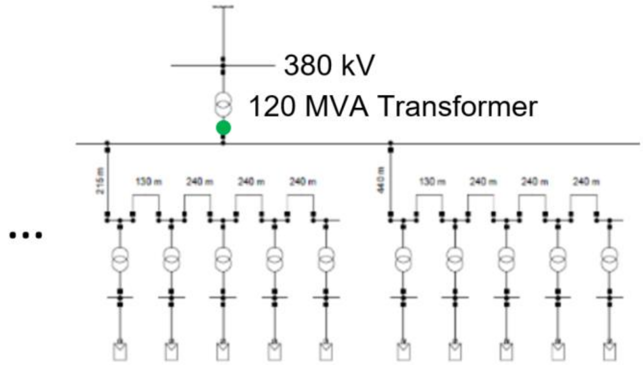

Figure 3: generic sketch of a PV park with on-load tap-changer on the secondary side (green dot)

In the following it is estimated how much money can be saved by reducing the no-load losses during night-time by the generic PV park layout shown above.

- Assumption: 0.07 % no-load losses for 5 MVA transformers.
- With 25 transformers, there are 25 x 5 MW x 0.07 % = 87,5 kW no-load losses.
- Sum of annual hours between sunset and sunrise between 4.209 h (e.g. Oslo) and 4.323 h (e.g. at the equator)
- Night-time electricity purchase to cover idle losses:

$$87{,}5\ \text{kW} \cdot 4.300\ \text{h/a} = 376.250\ \text{kWh/a}$$

Power purchase costs:	**5 Cent/kWh**	**10 Cent/kWh**	**15 Cent/kWh**	**20 Cent/kWh**
Total costs for no-load loss compensation	18.812,5 €/a	37.625 €/a	56.437,5 €/a	75.250 €/a

It should be mentioned that in reality the savings are even higher, if the cable no-load losses would be taken into account.