

PV NETWORK INTEGRATION

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ABSTRACT: In the framework of the SUNRISE project a study work on the peak power supply by solar electricity is under evaluation. This paper shows the first results of the study work. The paper focuses on the possible match between the electricity peak power demand and the solar electricity generation by taking into account the technical constraints related to the PV network integration.

Keywords: Grid-Connected, Photovoltaic, Utilities

1 SUNRISE PROJECT

The SUNRISE project (Strengthening the European Photovoltaic Sector by Cooperation with important Stakeholders) aims to improve the interaction between the PV sector and all the relevant stakeholders such as construction sector and utilities.

The co-operation with these important stakeholders and networking with the European PV Industry needs will lead to a cost reduction of the PV systems as the market of these products will be increased. This represents an indispensable aim for the PV sector. Indeed, with reduced levels of subsidies the production of PV systems has to be more cost-effective if the PV industry wants to be competitive with conventional energy production in the liberalised market of the future.

The SUNRISE project is a Coordination Action co-financed by the European Commission within the 6th Framework Programme for the Research and Technological Development (Directorate-General for Energy and Transport, DG TREN).

2 PV NETWORK INTEGRATION - OBJECTIVE AND APPROACH

In the framework of the SUNRISE project, the Work Package “PV Network Integration” focuses on the interaction between the European utilities and PV sector. Within this Work Package it will be defined the impact of the integration of PV in the network keeping in mind grid stability and system control.

The methodology will be based on:

- added value of PV for the utilities - Study work on peak power supply by solar electricity
- optimising the role of solar electricity in marketing campaigns of European utilities
- first draft on recommendations for unified technical regulation for grid-connected PV systems

The aim of the Work Package “PV Network Integration” is to start a dialogue between the PV industry and the utilities on how the integration of PV into the European electricity supply can be managed in a win-win situation for all parties.

3 STUDY WORK ON PEAK POWER SUPPLY BY SOLAR ELECTRICITY

For the utility Electricité de France (EDF) a study work will analyse the impact of solar electricity generation on the utility's economics for peak power supply. In Europe the excellent match between electricity peak power demand and the supply of solar electricity leads to a reduced peak power purchase need for the utility.

This holds true for markets that do have a feed in tariff for solar electricity which is financed through a contribution by all electricity consumers. This effect of course depends heavily on the installed PV capacity in the utility's distribution area. Therefore, the impact will be described as a function of the installed PV capacity. By assuming certain levels of installed PV capacity and by taking the production curve, the economics of the utility for peak power will be analysed.

The study work will give an indication on how PV can contribute to the reduction of the peak power supply and, therefore, of the costs as avoided costs of network investments and reduction of network losses.

This paper presents the first results of the study work on peak power supply by solar electricity, which led to an evaluation of the possible match between the electricity peak power demand and the solar electricity generation. Moreover, the technical restrictions of the electrical grid (see section 3.2 Technical Constraints to take into account) were taken into account to give an objective overview of the impact of the PV distributed generation on the network.

3.1 Peak Power Demand

One of the added values of the integration of PV systems into the network is defined by the relevance of PV to meeting electrical grid peak demand, which depends on the correlation between daily and seasonal load characteristics of the electrical grid and peak solar generation. Therefore, the first objective of the study was to compare the solar electricity profile with the peak power demand of the electrical grid.

An example of the solar electricity profile generated by a roof top PV system (Fig. 1) is shown in Figure 2.



Figure 1: Roof top PV system - Car park at the Munich fair center in Munich-Riem, Germany. Source WIP-Renewable Energies [1]

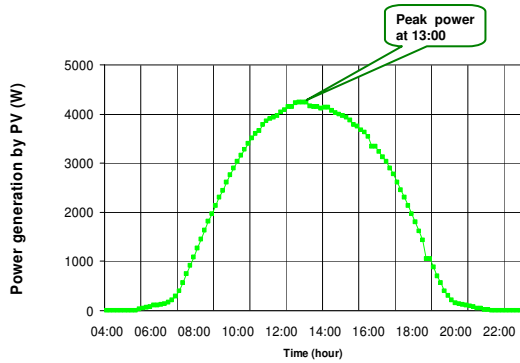


Figure 2: Typical solar power profile generated by a PV array of the roof top PV system at the Munich fair center (Munich-Riem, Germany) on a clear sky summer day in June 2006 (source WIP-Renewable Energies [1])

As shown in the graph of Figure 2, a PV power plant offers peak power production during the day's central hours. In order to investigate the contribution of the solar electricity profile generated by PV systems to the peak power demand, the peak power demand of the French electrical grid was analysed during the day time at three different voltage levels and for two different seasons:

- national level (High Voltage, HV) (winter season Figure 3 and summer season Figure 4)
- substation level (High Voltage / Medium Voltage, HV / MV) (Fig. 5)
- customer level (Low Voltage, LV) (Fig. 6)

The range for HV, MV and LV is defined as:

- 63 / 90 / 225 / 400 kV for High Voltage (HV)
- 20 kV for Medium Voltage (MV)
- 0.4 kV for Low Voltage (LV)

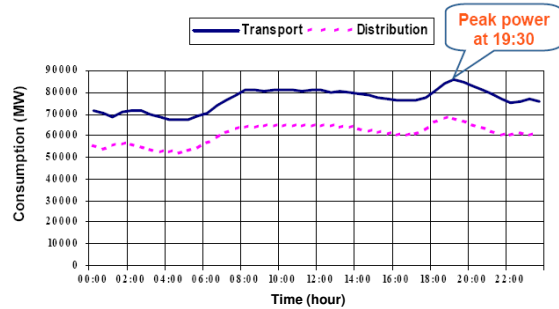


Figure 3: French peak power demand at national level (Transmission and Distribution networks), winter, January 2007 (source EDF)

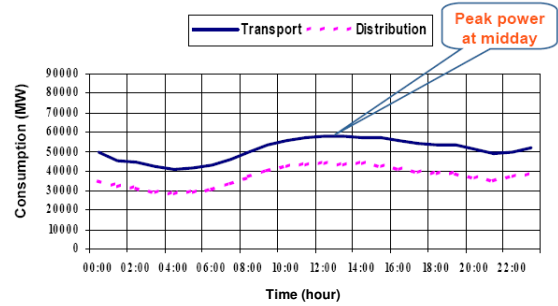


Figure 4: French peak power demand at national level (Transmission and Distribution networks), summer, July 2006 (source EDF)

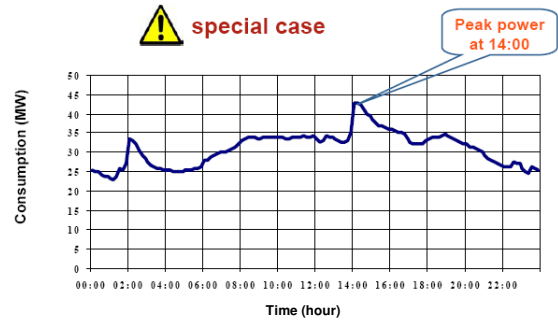


Figure 5: French peak power demand at substation level (HV / MV), winter, January 2007 (source EDF)

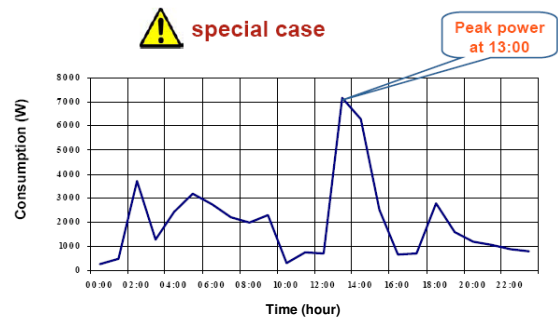


Figure 6: French peak power demand at customer level (LV), winter, January 2007 (source EDF)

Note that curves given in Figures 5 and 6 represent special cases especially chosen for the study.

At national level, Figures 3 and 4, the French electrical peak power was reached at 19:30 during the winter season for the year 2007 and at 12:00 during the summer for the year 2006.

During the year 2007 the French electrical grid presented the highest consumption demand in January at 14:00 at substation level (Fig. 5) and at 13:00 at the customer level (Fig. 6). The behaviour of the load demand shown in the graphs of Figures 5 and 6 is due to a "special" low tariff introduced by EDF for the electrical consumption during the day's central hours.

By comparing the electricity profile generated by a PV power plant (Fig. 2) and the electrical load profiles of the French grid (Fig. 3, Fig. 4, Fig. 5 and Fig. 6) it is possible to assume that at national level PV can contribute in covering one part of the French peak power demand especially in the summer months. At substation

level and at customer level PV can contribute to reduce the French peak power demand during the winter season.

As network investments are based on the peak power demand (reached in winter as shown in Figures 3 and 4), PV cannot contribute to reduce these investments at the national level. At the opposite, Figures 5 and 6 show that it is possible to find locally special cases where PV plants could contribute to the reduction of network investments. It means that more studies have to be done

In order to give an exhaustive overview of the peak power demand generated at national level in other Member States, the graphs of Figure 7 and 8 show the peak power demand for Germany, France, Italy, Spain and Poland respectively for the winter and the summer season.

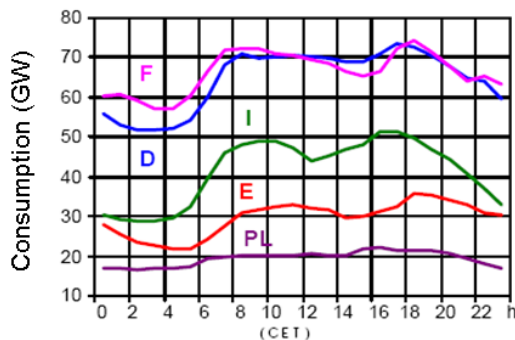


Figure 7: Peak power demand at national level for Germany (D), France (F), Italy (I), Spain (E), Poland (PL) on the 3rd Wednesday of December 2003, winter (source CESI RICERCA [2])

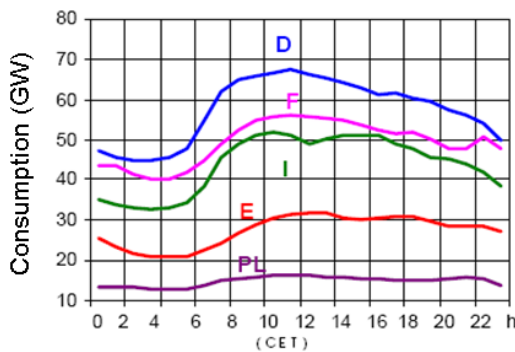


Figure 8: Peak power demand at national level for Germany (D), France (F), Italy (I), Spain (E), Poland (PL) on the 3rd Wednesday of July 2003, summer (source CESI RICERCA [2])

As shown in the graph of Figures 7 and 8, the peak power demand at National level for other Member States (Germany, Italy, Spain and Poland) presents a similar profile of the French case both in winter and summer seasons. During the winter season of the year 2003 (Fig. 7) the peak demand is reached around 18:00 for Germany, Spain and France; around 16:00 for Poland and around 17:00 for Italy.

In the summer season of the year 2003 (Fig. 8) the peak demand is reached around 11:30 for Germany and France; around 11:00 for Italy, around 13:00 for Spain, while Poland presents a smooth peak around 11:00. The different behaviour of Italian electrical power

demand at midday could be due to the different habits and working condition.

Information related to the peak power demand at substation and customer level is not public and therefore not easily obtainable for the other Member States. However, the comparison between the peak power demand at national level of different Member States (Fig. 7 and Fig. 8) and the solar electricity profile (Fig. 2) leads to assume that also in other Member States PV can contribute in covering one part of the peak power demand especially in the summer months.

3.2 Technical Constraints to take into account

Technical constraints are related to voltage constraints in LV networks and increase of losses in MW networks. Only when a large amount of PV power is fed into the network the HV network must be considered as well. However, the problems at HV levels are not much different in nature than the problems at the LV levels [3]. As shown in the Figure 9, PV decentralized generation causes voltage rise at the point of interconnection. This voltage rise limits the admissible power for the PV systems connected to the grid (Standard EN 50160 and Standard DIN VDE 0126-1-1).

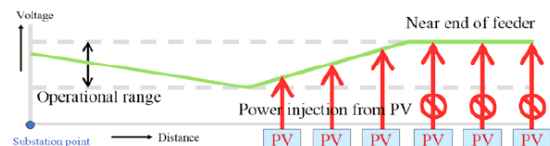


Figure 9: Voltage constraints in Low Voltage (LV) network (source NEDO [4])

Different solutions have been proposed to deal with these technical restrictions [3], [5]:

- to limit the effective output of the inverters when overvoltage occurs
- to turn the inverters to voltage regulators as soon as the upper voltage limit is reached
- to adapt the MV/LV transformers to the expected periods of load demand (i.e. when maximum load situation are/not expected)
- to include PV Distributed power Generation (DG) in distribution systems planning, by limiting the amount of generation allowed by each customer, in a similar way as it is done for sizing the distribution transformer

However, modern network sections in Germany have shown to accept about 6 kWp per household without violating the relevant standard EN 50 160 in LV networks [5].

4 CONCLUSIONS

A PV power plant offers peak power production during the periods with high demand in summer and day's central hours. PV systems can lower the PV owner's daytime demand and therefore contribute to reduce the overall demand for power. For the future, further planned distribution systems should take into account the technical constraints related to the PV network integration.

PV can also reduce transmission costs if PV power production is close to the consumer demand level and storage is integrated to supply electricity if no PV electricity is available.

5 PROJECT WEBSITE

Further information on the SUNRISE project is available for free on the project website www.pvsunrise.eu.

6 REFERENCES

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