COMAR CONDENSATORI S.p.A
Via del Lavoro, 80 – Loc. Crespellano
40053 VALSAMOGGIA (BOLOGNA)
Tel. +39 / 051 / 733.383 - Fax. +39 / 051 / 733.620

Title: **Photovoltaic plant and Power Factor Correction**

Level: **BASIC - EXPERT**

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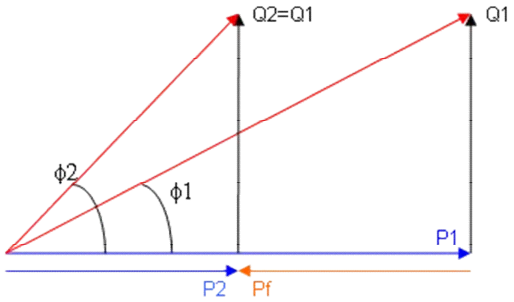
Author: Engineering Department of COMAR Condensatori SPA

1 Summary

The diffusion of photovoltaic systems increasingly sets the goal of integrating it with the power factor correction system already installed or to be installed.

The action of the photovoltaic system is to generate active power, reducing the request to the energy supplier; the reactive power instead remains unchanged because it is determined by the loads, consequently the power factor decreases and the need for power factor correction increases.



Graphically, to the active power absorbed without photovoltaic P1 (required by the users) the power generated by the photovoltaic Pf is subtracted giving as a result P2 (active power absorbed in the presence of photovoltaics) and an increase in the phase displacement angle $\varphi 2 > \varphi 1$, $\cos\varphi 2 < \cos\varphi 1$.

2 Practical example

Taking concretely for example a company located in the province of Venice (Italy), we find in the electricity bill:

- mains voltage 15/0,4kV
- power used 950kW
- average monthly active energy Ea = 103MWh
- average monthly reactive energy Er = 90.5Mvarh
- detail of consumption:

May			June			July		
	E active (kWh)	E reactive (kvarh)		E active (kWh)	E reactive (kvarh)		E active (kWh)	E reactive (kvarh)
F1	86873	71570	F1	85913	71020	F1	87911	72443
F2	9856	10883	F2	9714	10501	F2	9920	11896
F3	6581	9947	F3	6415	6404	F3	6843	7005
Tot	103310	92399	Tot	102042	87925	Tot	104674	91344

In order to reduce the reactive energy circulation along its electricity lines, the distributors establish a lower limit to the load power factor, charging the user with penalties that are not always specified, for $\cos\varphi$ values lower than 0.95 (penalties for reactive energy in compliance with AEEG 180/2013/R/EEL e AEEG 778/2016/R/EEL). With the

previous data it is possible to obtain the average cosφ, any consequent penalties and to size the power factor correction system.

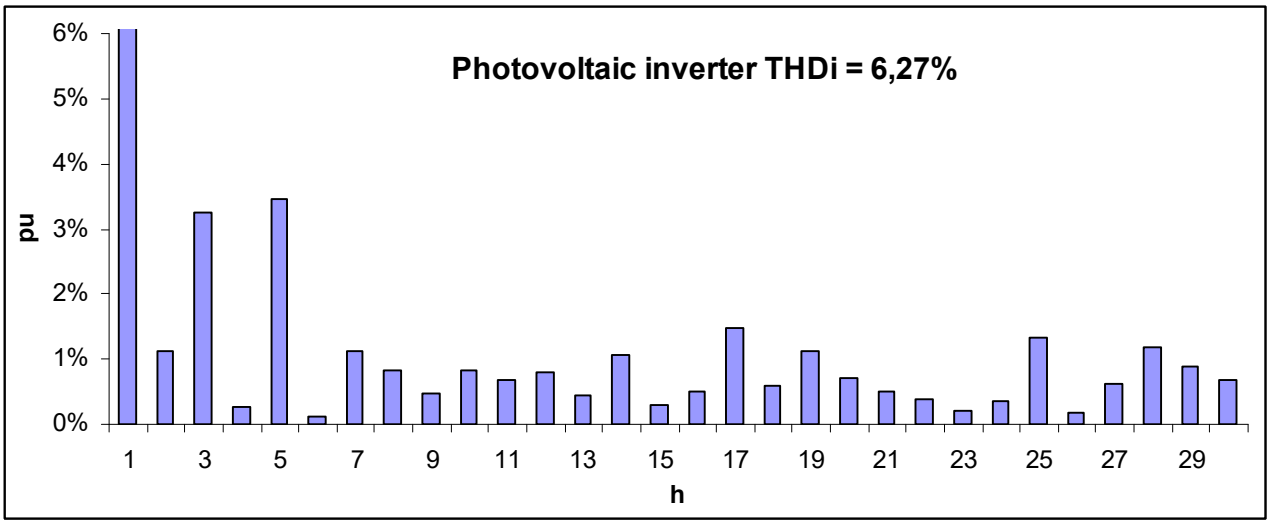
3 Impedance of the capacitor banks compared

- $\cos\varphi_{average} = \frac{E_{active}}{\sqrt{E_{active}^2 + E_{reactive}^2}}$ = 0.76, considering only the F1 and F2 bands

- monthly penalty for reactive energy over 33% of the active energy = 286 € (0,00704 €/kvarh)
- monthly penalty for reactive energy over 75% of the active energy = 90 € (0,00905 €/kvarh)
- target cosφ = 0.97
- PFC power Qr = 0.60 * P used = 574kvar

If a 300kW photovoltaic system is installed on the roof of the building with a 33 ° inclination and -2 ° orientation, we can estimate using the software http://re.jrc.ec.europa.eu/pvgis/apps3/pvest.php?lang=it that the average monthly energy production is 25MWh, therefore when the inverter operates with a Unit Power Factor, the active energy drawn from the grid is lowered to 78MWh, with relative variation of the line cosφ.

- average cosφ = 0.66
- penalty for reactive energy over 33% of the active energy = 55 € (0,00704 €/kvarh)
- penalty for reactive energy over 75% of the active energy = 619 € (0,00905 €/kvarh)
- target cosφ = 0.97
- PFC power Qr = 0.89 * P used = 843kVar to install.



In order to introduce the energy generated by the solar panels into the grid, the photovoltaic system uses inverters with switching technology which also determines the generation of harmonics that stimulate the capacitor banks present in the power factor correction. Therefore:

- The existing PFC device could be of insufficient power.
- The type of capacitors present may not be suitable for use.
- We recommend the use of a power factor correction equipped with metallized polypropylene film capacitors, designed to guarantee the electrical characteristics in particularly heavy-duty applications and built according to the latest quality standards.

If the installed photovoltaic system has a power greater than that of the utilities and / or there is the possibility that active power is fed into the grid, the Power Factor Controller must be able to operate on "4 quadrants": two standards relating to the operation of the system in absorption, two additional quadrants related to the operation of the system as a generator. The PF controllers designed for this function are those of the BMR and HPR series.

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COMAR Condensatori products, according to the harmonic distortion present on the electrical network:

a) DMP-FTV Series
- Maximum harmonic distortion in current allowed in the network THDI(r) = 40%
- Maximum harmonic distortion in current allowed in the capacitors THDI(c) = 90%

b) AAR/100, AAR/600 e AAR/D20 Series, equipped with blocking reactors
- Maximum harmonic distortion in current allowed in the network THDI(r) = 100%
- Maximum harmonic distortion in voltage allowed in the network THDV(r) = 3%, 6% e 20%

We recommend that you contact the Technical Department of COMAR Condensatori to assist you in the choice.

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