

A Study of the Superposition of a Hybrid PV/CPV Utility-Scale Power Plant

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1. Objective and issues

CPV panels transform only direct normal irradiance (DNI) into electricity, whereas flat PV panels can transform a more available source of irradiance, the global normal irradiance (GNI). In the event of a cloud or shadow cast on the panels, this leads to immediate interruption of the CPV production but a maintained production by PV panels. For CPV, this phenomenon is amplified by the grid-tied inverter which enters “stand-by” mode while the voltage available from the panels is not sufficient (<200V), and takes time to restart the power injection after the situation is back to exploitable irradiance. Therefore, the aim of this article is to determine whether a hybrid connection of PV and CPV on the same inverter could reduce the time of zero energy yielding, in order ultimately to inject more energy into the grid.

2. Approach

The experiments are performed in 1MWp solar park of Université de Sherbrooke, that includes 8 CPV trackers from STACE. Each bi-axial tracker is composed of 144 panels connected in series-parallel configuration to a grid-tied inverter with a capacity of 25kW, by the mean of 3 DC/DC converters performing MPPT (see figure 1), referred in the following sections as the three inputs. The 144 panels are divided into 2 groups of 72 panels connected to inputs 1 and 2 respectively, leaving the third input unused (named “not connected” in figure 1.a). To estimate the benefit of hybridizing PV and CPV on the same inverter, we connected to the third input of one inverter (tracker #5) 4.4 kWp of bifacial PV panels mounted on a 1-axis tracker. The term tracker in the following sections will refer to the whole electrical assembly described previously (figure 1).

To compare the production data between the hybrid production (tracker #5) and full-CPV production, we identified the tracker #4 as the best candidate, given both of them have similar power-to-irradiance behaviors. The criteria and the choice of the tracker will be detailed in the full paper. The comparison is done over several days corresponding to the same irradiance pattern: a day with intense DNI drops but a non-zero GNI. We expect this to be the most favorable condition for PV / CPV hybridization.

3. Results

At the bottom of figure 2, we see that PV panels help maintaining the DC bus voltage of the corresponding inverter above the threshold value of 200V, while the voltages in full-CPV configuration (tracker #6) plummet below this threshold, hence disabling the inverter. Therefore, they allow immediate power-to-irradiance response when the DNI is above zero. The yellow areas represent the energy gained during the time in which only the hybrid tracker is functioning and the full-CPV trackers are reconnecting to the grid. Figure 3 displays the daily yielded energy of trackers #6 and #5. This last is broken down into its CPV and PV productions. We can see that the CPV-only production of tracker #5 is not superior to the one of the other tracker. Therefore, though a hybridizing effect is indeed present, there would be few economic interests in mixing PV and CPV in our situation. Future work will be conducted to quantify the impact of the localization of the CPV plant to study the frequency of the voltage drop to determine whether this effect can have an economical perspective. The analysis of the energy gained will be detailed in the full paper.

References

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- [2] Algora, Carlos, Rey-Stolle, Ignacio, *Handbook of Concentrator Photovoltaic Technology*, 2016.

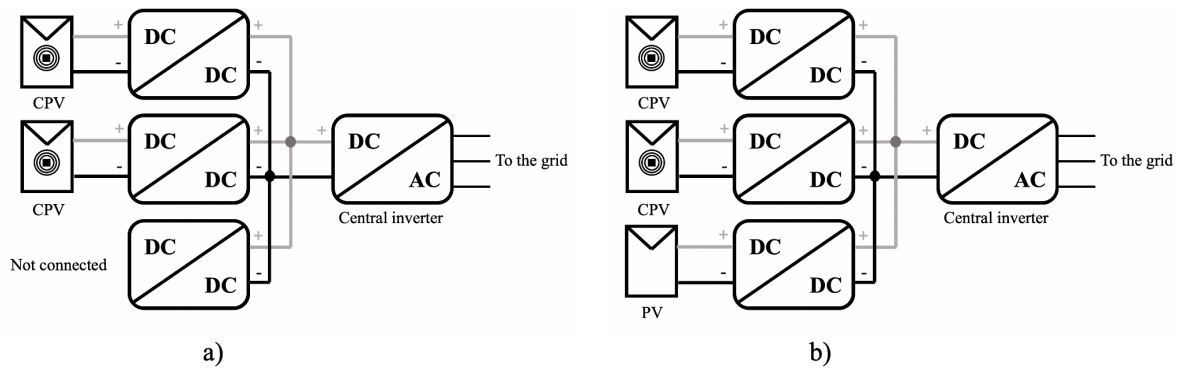


Figure 1 Configuration of the tracker in case of full-CPV conversion (a. , tracker #6) and hybrid CPV & PV conversion (b. , tracker #5)

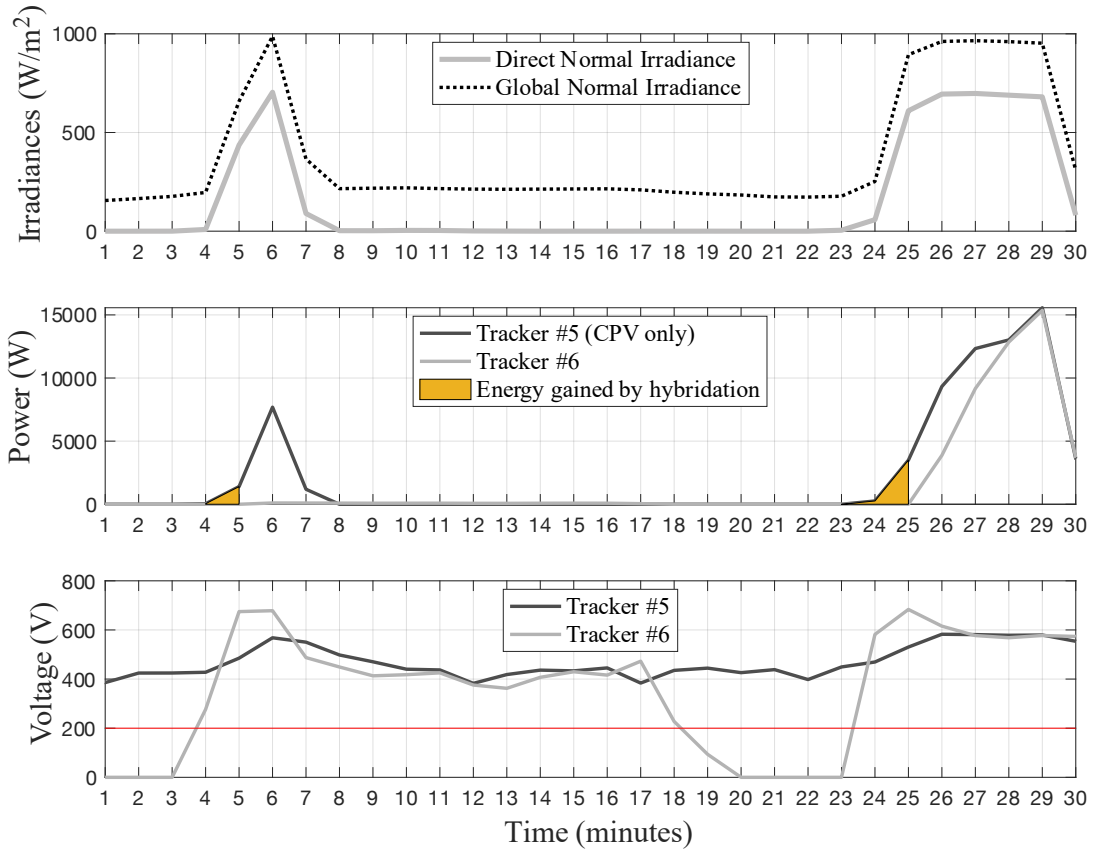


Figure 2 GNI and DNI (top), power of trackers #5 and #6 (middle) and voltage across one input of the corresponding inverters (bottom), the red line corresponds to the trigger voltage of the inverter

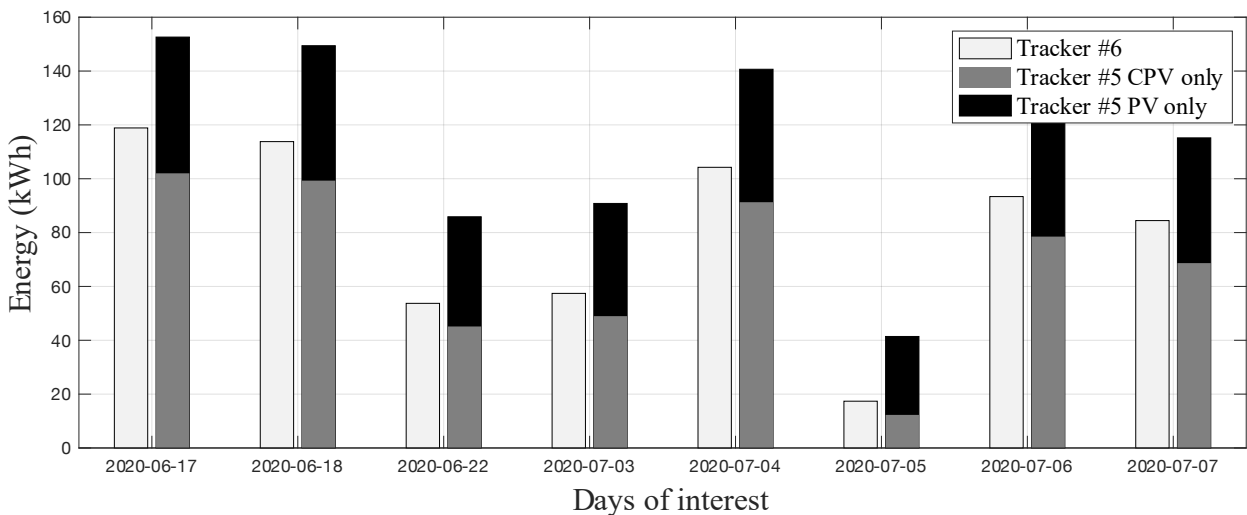


Figure 3 Energy yielded by trackers #5 and #6 during 8 days with intense DNI drops