Enhancing Resilience of the Maltese Distribution Grids Through Photovoltaics

Author | Somesh Bhattacharya

Power management with high renewable share is no mean feat! With Malta now having an appreciable renewable energy mix within its power system framework, decisions should be made, on how to efficiently utilize the available resources during emergency events.

Photovoltaics as rooftop based Distributed Energy Resources (DER) when procured by a customer/ consumer, it is mostly done keeping in mind, that the customer is contributing to reducing carbon emissions as well as trimming utility bills. Now, with several active schemes initiated by the Regulator for Energy and Water Services[1], further renewable energy integration is possible.

However, extreme heat events, which can potentially deter continuous grid operation, can also have an impact on the PVs. Most PVs, with no energy storage back-up solution, are generally disconnected from the utility grid in case of a power outage, rendering the power source unusable. However, this should not deter the power system operators from achieving a 100% renewable energy grid[2], especially, given the Islands' abundant sunshine.

During extreme events, a cable fault or a generator outage may cause the voltage to reduce substantially, and in even a worst-case scenario, interconnector outage event can cause a headache for the system operators. The delicate supply-demand balance is disturbed, and lower voltage may cause the PV inverters to trip, because, quite simply, they are not designed to work outside of the dedicated tolerance level for the inverter. Smart inverters[3] can prove to be a transformational solution to maintaining power balance, also helping in riding through faults, and maintaining the inverter voltage (to a certain extent!). Smart inverters are crucial because they can adapt to voltage changes and continue to operate when the grid is under stress.

Moreover, the concept of photovoltaic virtual inertia is gaining traction. Virtual inertia refers to the ability of inverter-based renewable energy sources, like PVs, to mimic the inertia of traditional synchronous generators. This is achieved through advanced control strategies that allow PV systems to provide a stabilizing effect on the grid, like that of conventional power plants[4]. By incorporating virtual inertia, smart inverters can further enhance grid stability and resilience, making them indispensable in our quest for a sustainable energy future.

The VirtualKES1.0 Project

The Virtual Kinetic Energy Provision from Solar Energy (VirtualKES1.0) project funded as part of the Fusion Research and Innovation Program by Xjenza Malta, explores the ability of Solar Energy to provide frequency response under such contingency events. The project conforms to several UN sustainability goals, such as climate action as well as affordable and clean energy.

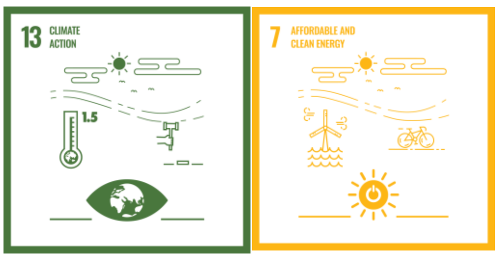

Figure: UN Sustainability Goals

VirtualKES1.0 is a proof of concept project, that delves further into harnessing frequency response from PVs. It uses the concept of Grid-Forming Inverters (GFM) for PVs, with the assumption that the future PV installations are Smart-Inverter based.

In case of faults in the grid, these GFM-PVs can help in stabilizing the grid frequency and voltage, especially if

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1 https://www.rews.org.mt/#/en/sdgr/581-2024-renewable-energy-sources-scheme

2 B. Kroposki *et al*., "Achieving a 100% Renewable Grid: Operating Electric Power Systems with Extremely High Levels of Variable Renewable Energy," in *IEEE Power and Energy Magazine*, vol. 15, no. 2, pp. 61-73, March-April 2017

3 https://dynapower.com/resource/advanced-smart-inverters/

4 N. K. Roy, S. Islam, A. K. Podder, T. K. Roy and S. M. Muyeen, "Virtual Inertia Support in Power Systems for High Penetration of Renewables—Overview of Categorization, Comparison, and Evaluation of Control Techniques," in *IEEE Access*, vol. 10, pp. 129190-129216, 2022

there are Islands formed within the grid. In this project, identification of optimal Grid-Forming inverters are performed for a Maltese Distribution system. Such GFMs have a good black-start capability, and during sun-hours, it is possible for the Distribution Operator to harness such PVs offering the GFM service to provide black-start in composite Islands. The project moves further into analysing the GFM controls, and their interactions with available PV systems for a typical Maltese feeder.

Case study GFM-PVs

An study was performed to provide an example of how GFM-PVs can provide frequency response in case of a grid outage event. A grid-outage (Eg: Interconnector outage) event essentially means that the power system on the Maltese side is now responsible for controlling the voltage and frequency of the grid. Figure shows the response of three PVs in a multi-feeder network resemblant of a low-voltage Maltese distribution system. In the simulation, which is concurrent with the objectives of VirtualKES1.0, a grid-outage was simulated at the 15th second, following which, the grid-forming PVs were able to withstand the low-load scenario, and therefore, the frequency increased to 50.3Hz, which all the PVs were synchronized to. A load change was observed at 20th second, following which, the PV frequencies settled to a new value. This concept shows that smart PV inverters, if controlled by the DSOs, can take part in frequency regulation, and therefore, can enhance the gid resiliency against faults, thus providing power to the consumers. In this study, the three PVs considered were assumed to be aggregated by several small scale PV inverters, who can respond to DSO requests, thereby de-rating their active powers. This helps the DSOs in two ways, one is to reduce powers from conventional energy sources, when a grid-outage occurs, and other is less dependency on such sources in case of black-starting.

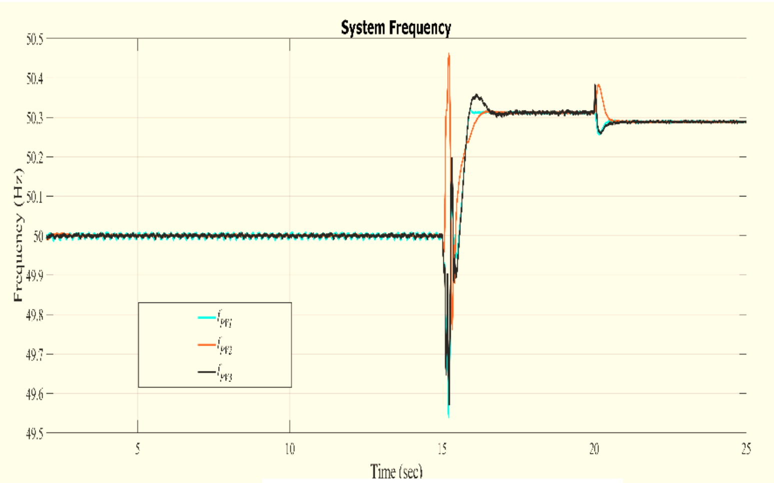

FIGURE 1: FREQUENCY AT PVS

The active powers of the PVs is shown in Figure . It can be seen, from the principles of demand and supply balance, that an increase in frequency means that the PVs powers are further reduced, which the GFM-PVs are able to do because they can set the system frequency. The powers between the PVs are shared according to the droop control principle.

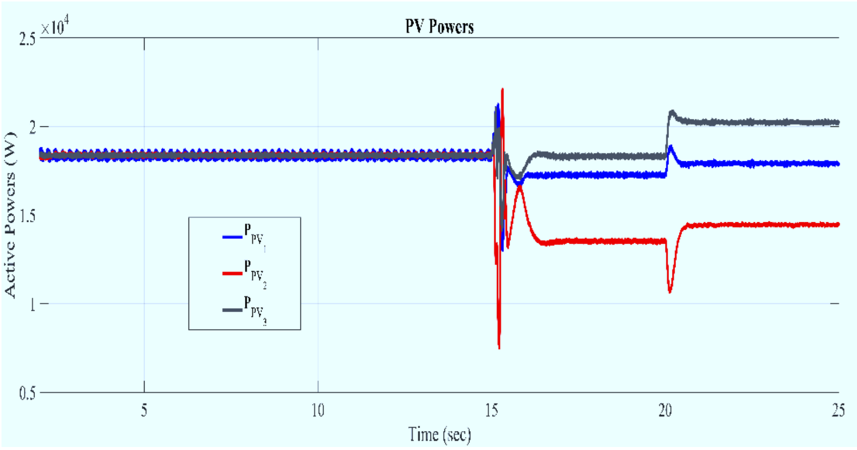

FIGURE 2: PV ACTIVE POWERS

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