A Centralized Power Management System (CPMS) for Grid-Connected Photovoltaic-Battery Distributed Generation Systems

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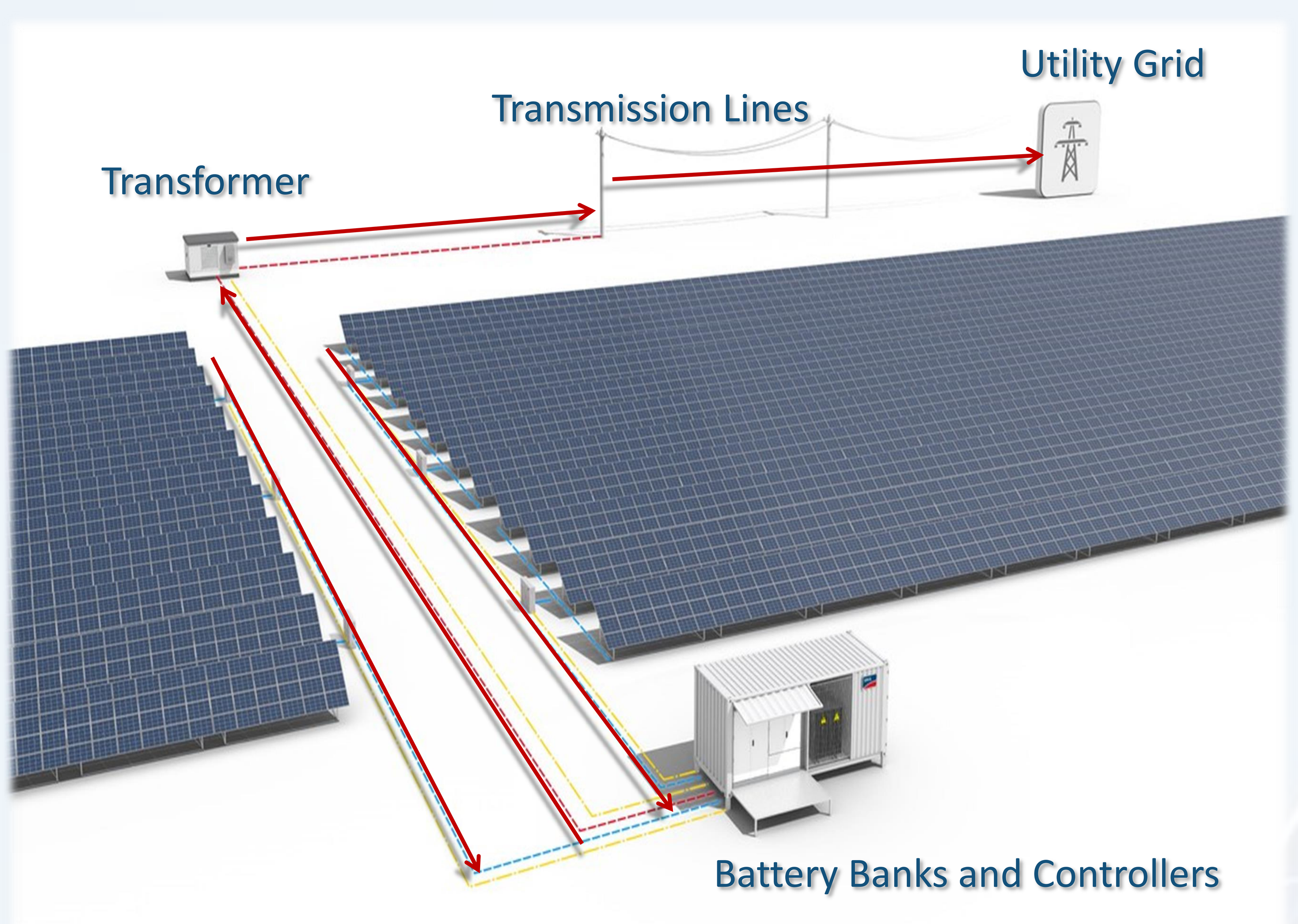
Abstract

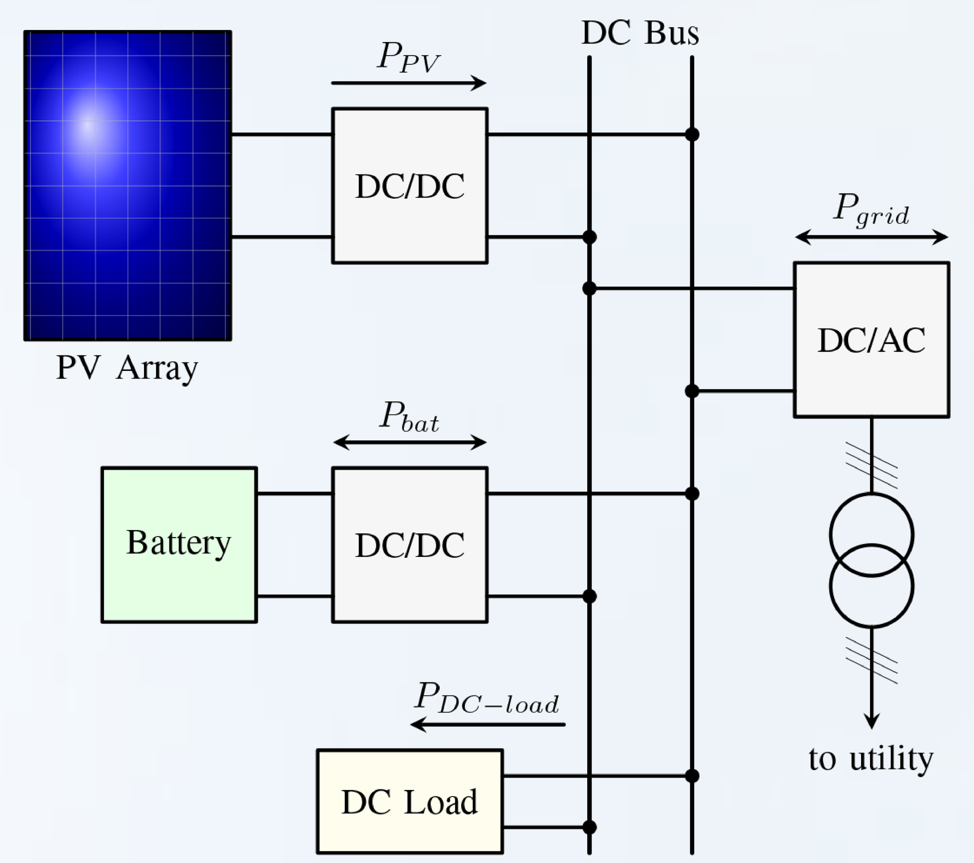
- Distributed generation (DG) is an effective way of integrating renewable energy resources to conventional power grids, which can improve the reliability and efficiency of the power systems.
- Photovoltaic (PV)-based DGs are becoming more and more popular in recent years due to their attractive features. Battery banks are employed in PV systems to eliminate power fluctuations due to changes of irradiance and temperature.
- To manage the power flows effectively, this research presents a power control and management system for grid-connected PV-battery systems. The proposed method realizes the maximum power point tracking (MPPT) of the PV panels, stabilizes the DC bus voltage for more convenient load access, balances the power flows among all components, and responds to the change of active or reactive power demands from the main grid quickly.

PV-Battery System

❖ **Typical Grid-Connected PV-Battery System Configuration**



- Main Components: PV arrays, battery banks, converters (DC/DC) for battery charging/discharging, inverter (grid interfacing), DC loads, AD loads, and main power grids.



Ppv
- Power generated by the PV array;
- Unidirectional.

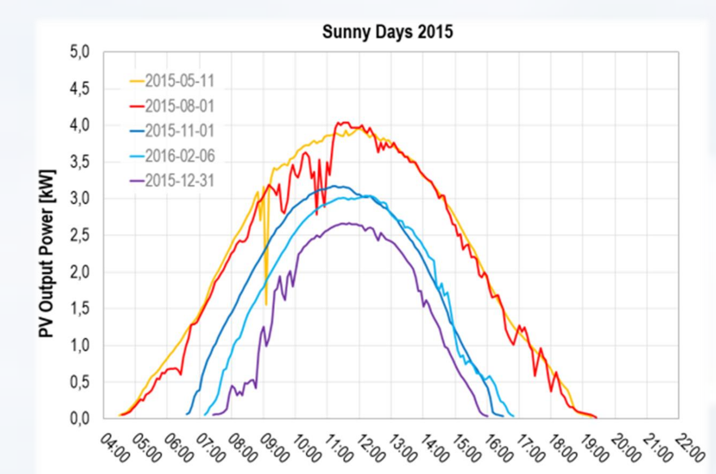
Pbat
- Power charging or discharging the battery;
- Bidirectional.

Pdc-load
- Power delivered to the DC loads;
- Unidirectional.

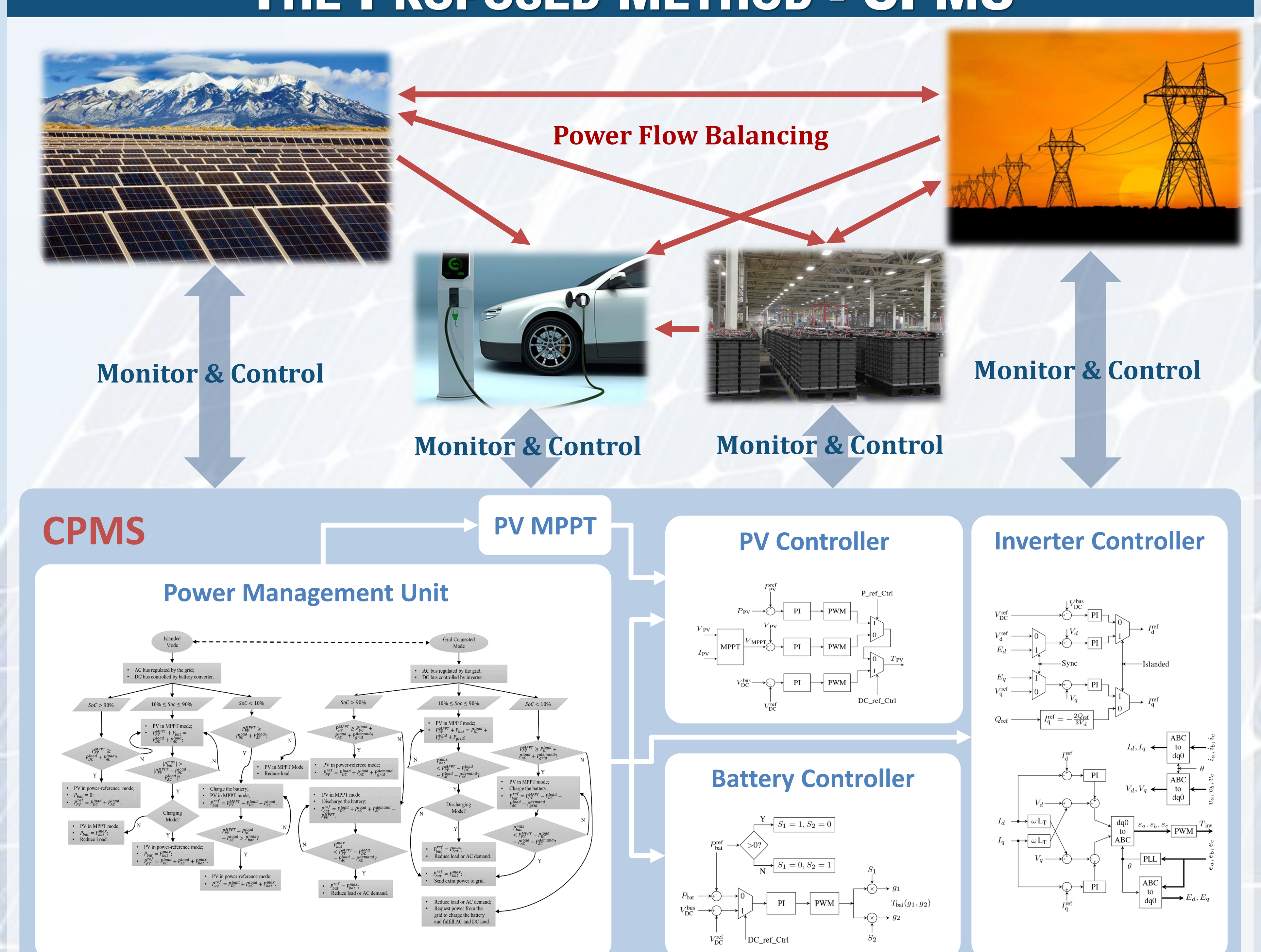
Pgrid
- Power exchanging with the main grid;
- Bidirectional.

➢ Power Equation: ***Ppv + Pbat = Pdc-load + Pgrid***

➢ Technical Issues:
- PV Power **Fluctuations;**
- Bus Voltage **Fluctuations;**
- System **Reliability;**
- Power Flow **Balance**;
- Battery **Protection**;
- Islanded / Grid-Connected **Mode Switching;**
- Other issues…



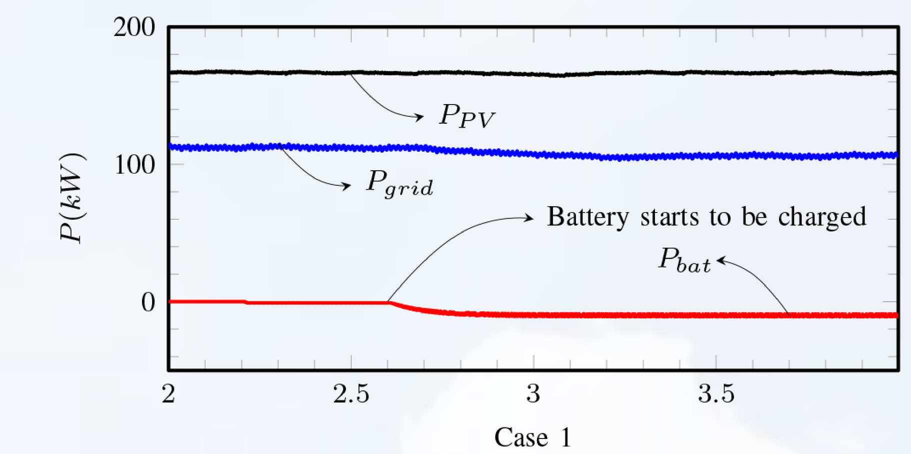
The Proposed Method - CPMS



Verification

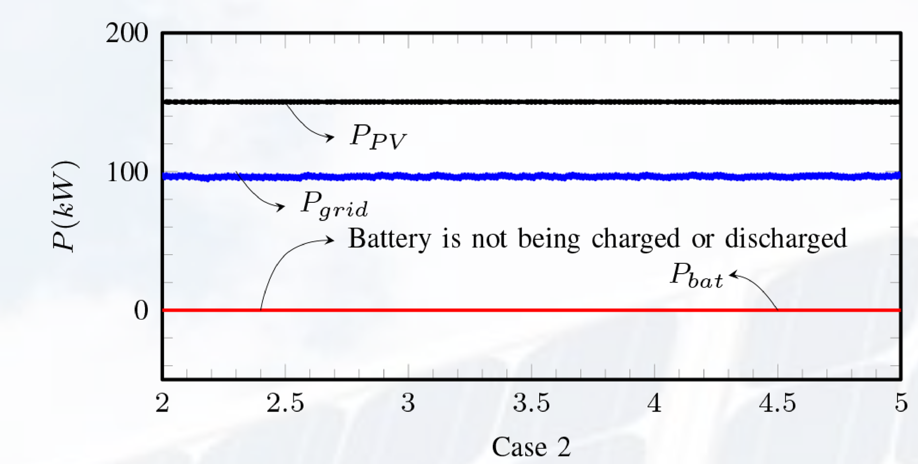
❖ **Case Studies (PV max power = 165 kW, DC load = 50 kW)**

Case 1: Ppv > Pdc-load+Pgrid, Battery not fully charged.



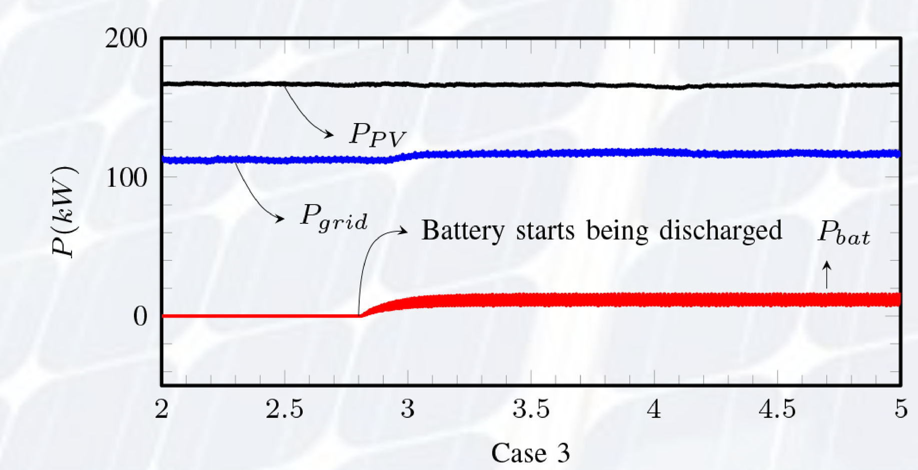
Store the excess power to the battery.

Case 2: Ppv > Pdc-load+Pgrid, Battery fully charged.



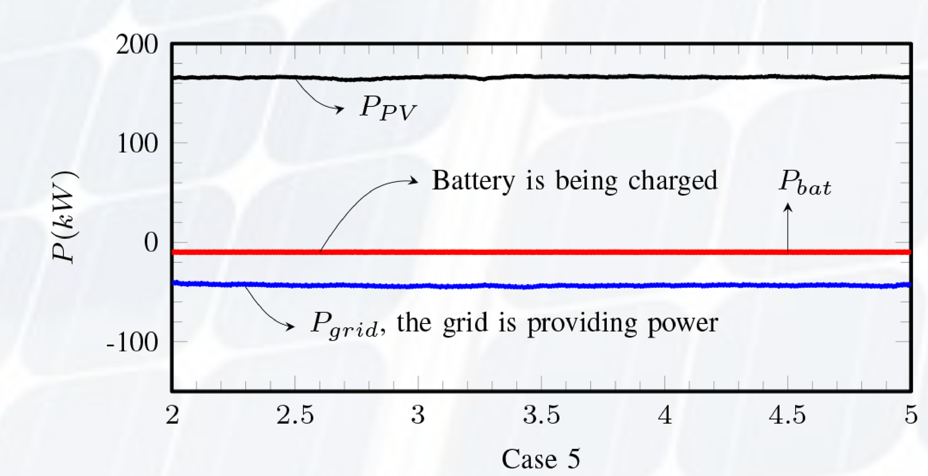
*Stop charging the battery, switch PV to **reference power control mode** to balance power flows.*

Case 3: Ppv < Pdc-load+Pgrid< Ppv+Pbat, Battery not full discharged.



Discharge the battery to balance the power.

Case 4: Ppv < Pdc-load, Battery full discharged. (DC load increased to 190 kW)



Request power from the main grid to balance the power and charge the battery.

References

[1] Z. Yi; A. Etemadi, "Fault Detection for Photovoltaic Systems Based on Multi-resolution Signal Decomposition and Fuzzy Inference Systems," in *IEEE Transactions on Smart Grid* , vol.PP, no.99, pp.1-1.
[2] Z. Yi; A. Etemadi, "A novel detection algorithm for Line-to-Line faults in Photovoltaic (PV) arrays based on support vector machine (SVM)," *2016 IEEE Power and Energy Society General Meeting (PESGM)*, Boston, MA, 2016, pp. 1-4.
[3] Z. Yi; W. Dong; A. Etemadi, "A Unified Control and Power Management Scheme for PV-Battery-Based Hybrid Microgrids for Both Grid-Connected and Islanded Modes," in in *IEEE Transactions on Smart Grid,* to be published.