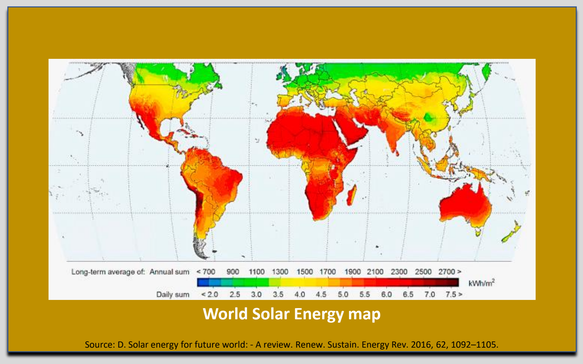
Grid Connected Solar Photovoltaic Plant System

Challenges and Mitigation Measures

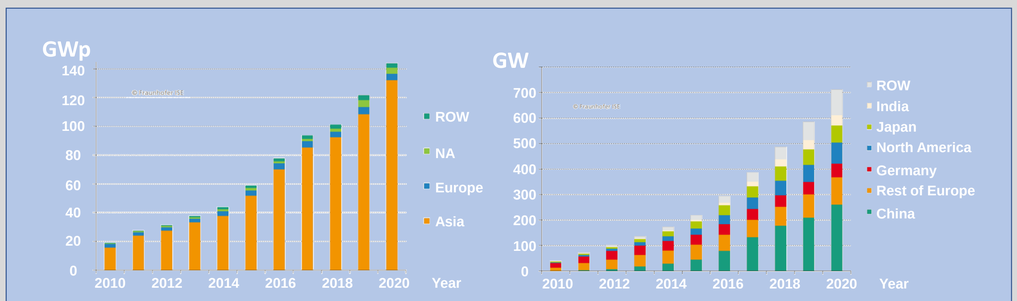
Main drivers behind Solar Photovoltaic Plants popularity

- **Immense Solar Potential**
- **Sharp decline in PV technology prices**
- **Government initiatives for renewable technology to mitigate climate change**



World Solar Energy map

Source: D. Solar energy for future world: - A review. Renew. Sustain. Energy Rev. 2016, 62, 1092–1105.



PV Global Annual Production in GWp

PV Installed capacity in GW

Source: Photovoltaic Report, Fraunhofer Institute for Solar Energy Systems, ISE https://www.ise.fraunhofer.de/

Challenges in a Grid Connected Solar PV Plant

Unpredictability & Inconsistency

One of the main challenges in utilizing renewable sources for power generation is there unpredictable and intermittent nature as opposed to conventional power production.

Imbalance

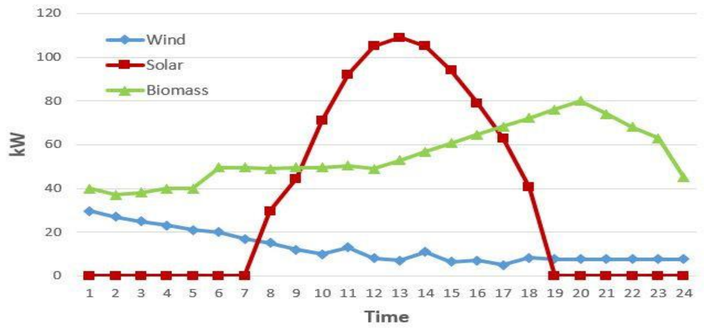
Due to intermittent nature of renewable energy, it can create imbalance on the utility side if the penetration levels of renewable source is substantial.

Voltage and Frequency Regulations

When you are connected to a utility grid, in order to create balance, you must maintain a certain set point for voltage and frequency but due to inconsistency in energy supply, this balance is disturbed thus creating voltage and frequency fluctuations beyond set limits.

Additional Challenges
(Power Quality, Harmonics Distortion, Protection Challenges etc.)

Problems arising mainly regarding power quality issues and harmonics due to inverter-based technologies and certain protection challenges since now the system is not radial anymore as it used to be.



Example of Renewable Energy Power Generation Patterns

Source: Zaheeruddin; Manas, M. Renewable energy management through microgrid central controller design

Why are Grid Codes important?

The power generated by renewable technology fluctuates thus creating imbalance in utility grid if PV penetration levels are substantial. In order to make sure that these fluctuations won't create instability, grid codes are defined, describing a set of rules and standards that generation facilities need to fulfil for the power in-feed into grids to facilitate power quality, system stability, and supply reliability.

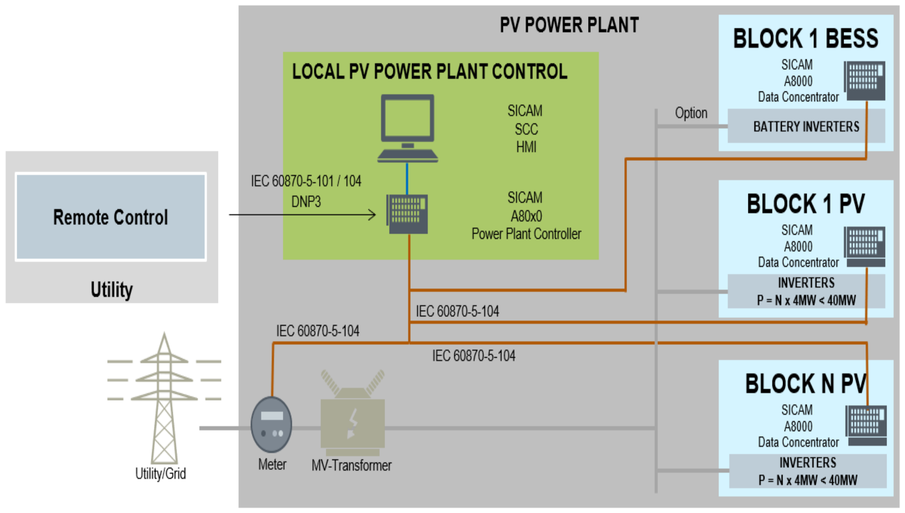
What is a Photovoltaic Plant Controller (PPC)?

The Photovoltaic Plant Controller PPC is responsible for the power feed-in management at point of common coupling (PCC) to meet grid code, utility and/or power purchase agreement related requirements, it sends commands/ new set points to the inverters or sub control systems of the power plant.

This Controller also plays a vital role in mitigating the challenges faced by grid connected solar plants

How does SICAM based PV Plant Controller work

PV Plant Layout



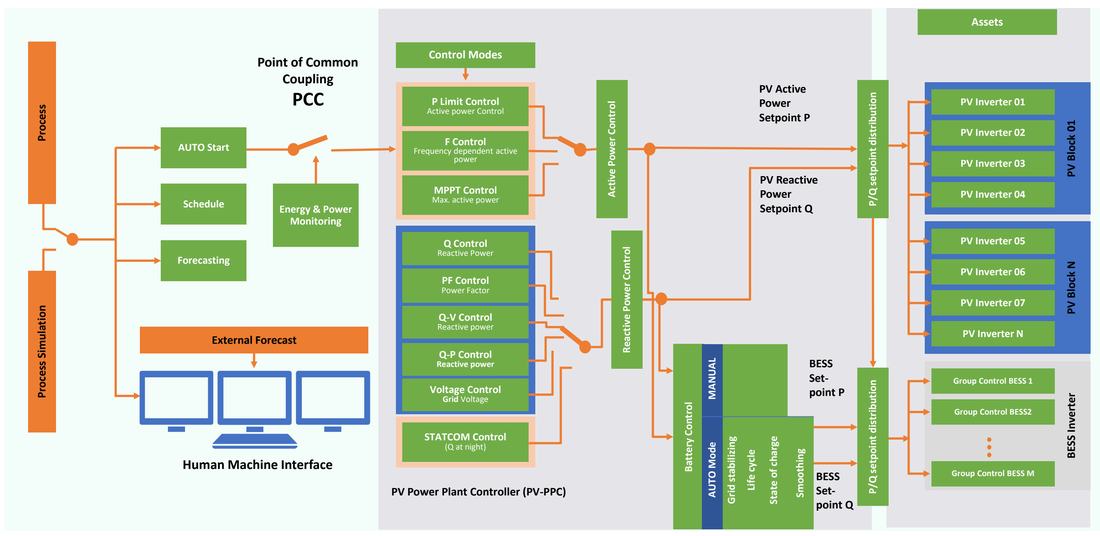
The Photovoltaic Plant Controller PPC shown in green block on the left side picture, serves as the heart of PV Power Plant.

PV Controller is connected to a meter at the POC to get information of the voltage, frequency and phase angle at the PCC

PV Controller is also connected to various field devices like PV inverters and Battery Energy Storage systems BESS.

This controller ensures that grid codes are complied with at all times by adjusting active and reactive power set points individually on each PV/BESS block.

Functional Overview of PV Controller



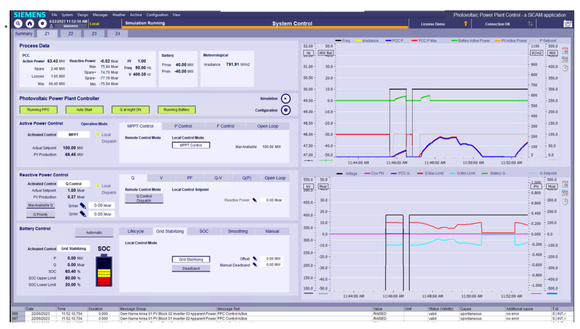
Addressing the challenges by SICAM based PV Plant Controller

Generation Forecasting feature to account for unpredictability

Unpredictability of solar power can be accounted for by equipping the solar plant with generation forecasting feature. Siemens PV Plant Controller can provide PV generation forecasting by gathering the data from Weather Forecast station thus making generation predictable.

Battery Energy Storage to account for inconsistency

Renewable energy is inconsistent and depends on varying solar irradiation or wind speed. To compensate these fluctuations of power generation a Battery Electrical Storage System (BESS) supports a balanced power generation. Siemens PV Plant controller offers various modes that helps for efficient dispatch of power from BESS.

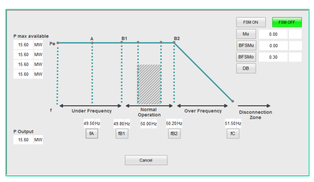


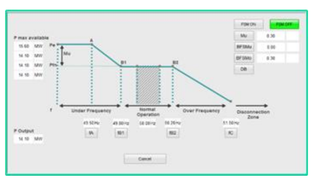
Voltage and Frequency Regulations to account for Grid imbalance

When a solar plant is connected to a utility grid, it must maintain a certain set point for voltage and frequency so that no instability is created at the point of common coupling. Siemens PV Plant Controller offers various modes for Active and Reactive Power Control to account for imbalances

Active power control

- Ramp control (MPPT mode)
- Active power control
- Frequency-dependent active power control



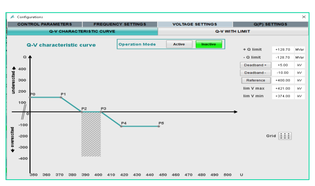


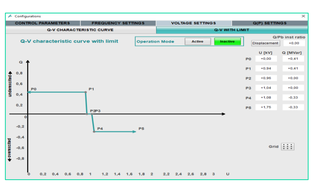
Reactive power control

- Advanced reactive power control functions (Q limitation, Q-V-characteristic in over- and undervoltage range, Q-P-characteristic)
- Power Factor control (PF control, cos phi)
- Grid voltage & Zone control

Grid stability support functions

- Reactive power at night / STATCOM operation
- Dynamical power reserve for frequency stabilization





104 MW PV plant
Intelligent zone controller at its best

Customer environment

- Grid code compliance
- Distributed system divided in 7 blocks in distances up to 15 km summarized in one single interconnection point
- Different tariff systems with different prices for infeed
- "Q at night" for grid stability reasons demanded by the grid operator

Solution

PV Controller application was installed to manage the 103MWp PV Plant controlling the 22 power inverters in line with the grid code

- Redundant PV Controllers
- SICAM SCC (HMI)
- STATCOM
- GRID CODE - Terna A68

Benefits

- Maintaining performance ratio and grid availability through KPIs monitoring and alarm management
- Integrated Monitoring & Control System
- Customized reporting of production data for individual tariff schemes for each site