XSICEL 2021

Transición energética en la 4ta revolución industrial

Universidad Tecnológica de Pereira

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Transición energética en la 4ta revolución industrial

Estimation Of Variations Of Electrical Parameters In Low Voltage Networks Due To Rapid Fluctuations Of Solar Irradiance: A Case Study Of A Photovoltaic System In Bucaramanga, Colombia.

Eng. Néstor Alejandro Balaguera – Ph.d German Osma

Universidad Industrial de Santander

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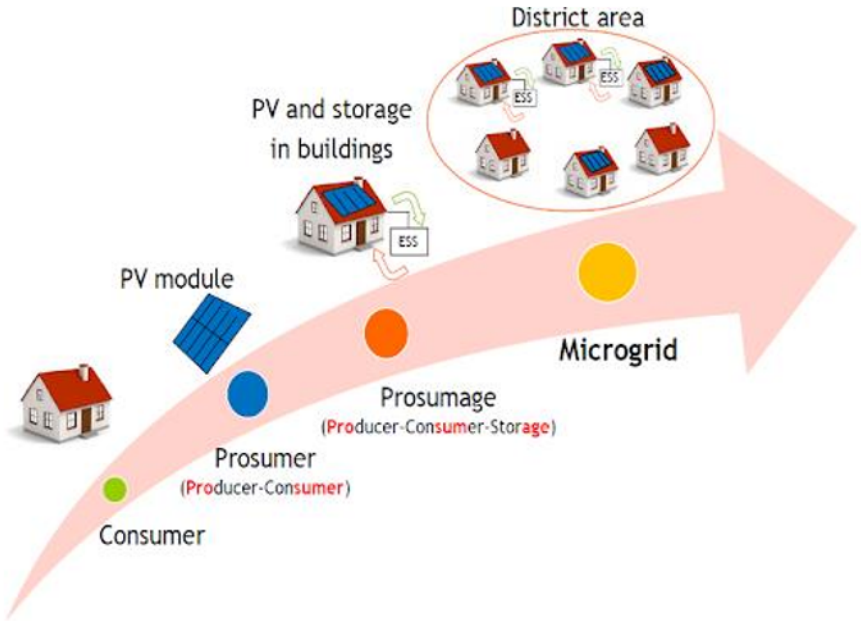


Taken from: http://www.laenergiadelcambio.com/que-es-microgrid/

I. Introduction - Problem

- The power injection of photovoltaic (PV) systems depends on the varying behavior of solar irradiance on site.
- Some studies analyze the impact that rapid fluctuations in solar irradiance can cause on the operation of electrical networks, but there is a lack of **methodological proposals** to apply.
- This work proposes a procedure to estimate voltage variations, power flows, and power losses in conductors due to such fluctuations of a case study

Taken from:https://weather.com/science/weather-explainers/news/common-weather-terms-used-incorrectly

I. Introduction - Basics

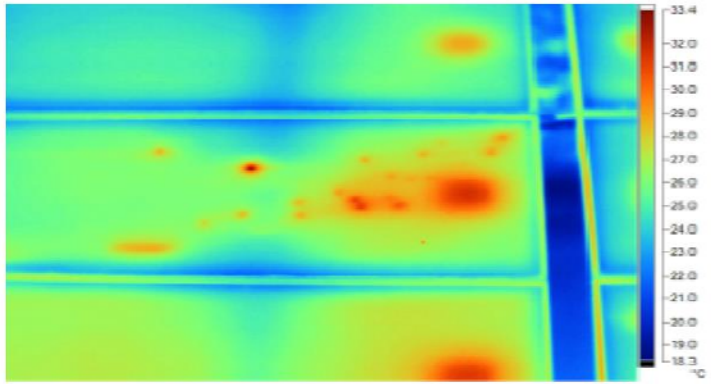
- The **intermittence** in solar irradiance due to the cloudiness can cause negative impacts on the operation of the electrical networks.
- The sudden passage of clouds partially obstructs the **incident solar irradiance** on the surface of the photovoltaic panels and affects the power injected into the grid and the connection point voltage

PV panels

- Mono and polycrystalline silicon
- Thin Film

Inverters

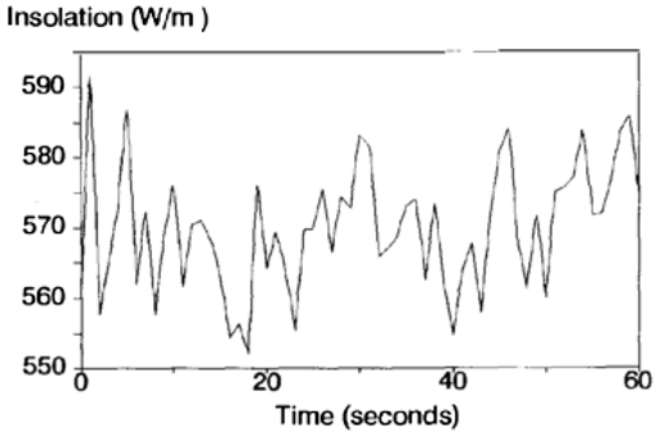
- Isolated systems with battery banks
- Interconnected systems



Taken from: N. G. Dhere, E. Schneller, and A. Kaul, "Effect of shading on CIGS thin film photovoltaic modules," 2015 IEEE 42nd Photovolt. Spec. Conf. PVSC 2015, no. 321, pp. 0–2, 2015

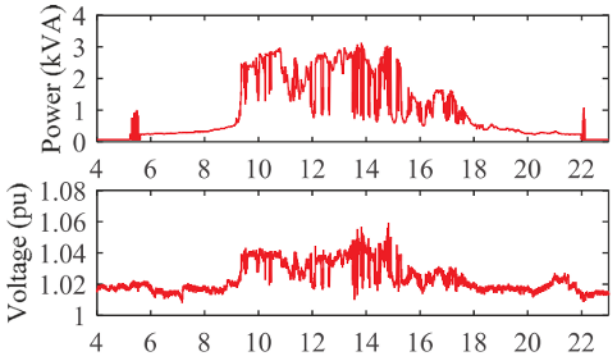
I. Introduction - Electrical variations

The electric current variations **directly follow the curve** of solar radiation seen by the PV panel.
Each drop in solar radiation produces a proportional drop in the current delivered by the system



Taken from: W. T. Jewell and T. D. Unruh, "Limits on cloud-induced fluctuation i photovoltaic generation," IEEE Trans. Energy Convers., vol. 5, no. 1, pp. 8–14, 1990.

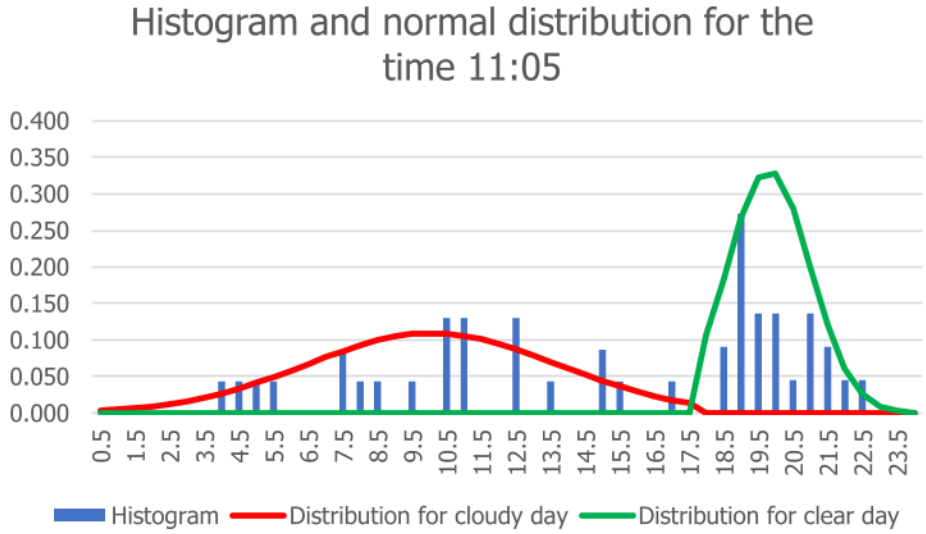
The **correlation** between voltage drops and intermittences due to cloudiness is one
Each voltage drop will last as long as a cloud takes when passing through a PV panel

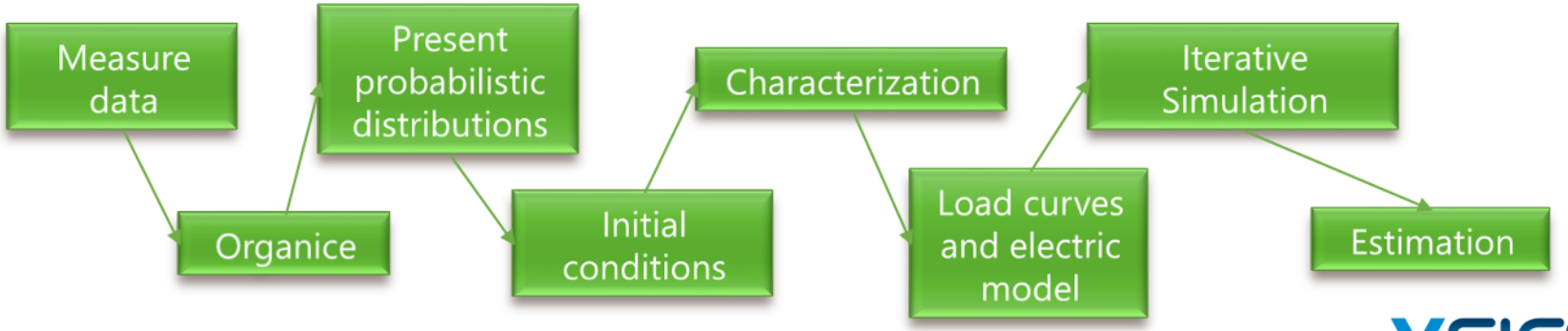


Taken from: P. Pakonen, A. Hilden, T. Suntio, and P. Verho, "Grid-Connected PV Power Plant Induced Power Quality Problems – Experimental Evidence DEPARTMENT OF ELECTRICAL ENGINEERING Keywords," 18th Eur. Conf. Power Electron. Appl. (EPE'16 ECCE Eur., pp. 1–10, 2016.

II. Methodology

A. Procedure for estimating variables
   1. Irradiance characterization (by measuring and data disposition)
   2. Electric system modeling and load behavior
   3. Iterative power flow analysis





II. Methodology

B. System studied

The PV system that works in the Electrical Engineering Building of the *Universidad Industrial de Santander* was studied to achieve a characterization of intermittent cloud cover for the tropical climate of the city of Bucaramanga, Colombia.

There is a smart measurement system to determine demand curves and load behaviors

The PV system is integrated by 37 PV panels for self-generation (9.63 kWp)

The smart metering system is integrated by 8 meters on the upper terrace.

The measurement of the electrical variables was carried out with intervals of one (1) minute.

A total of 67,882 records were taken from November 2018 to January 2019.

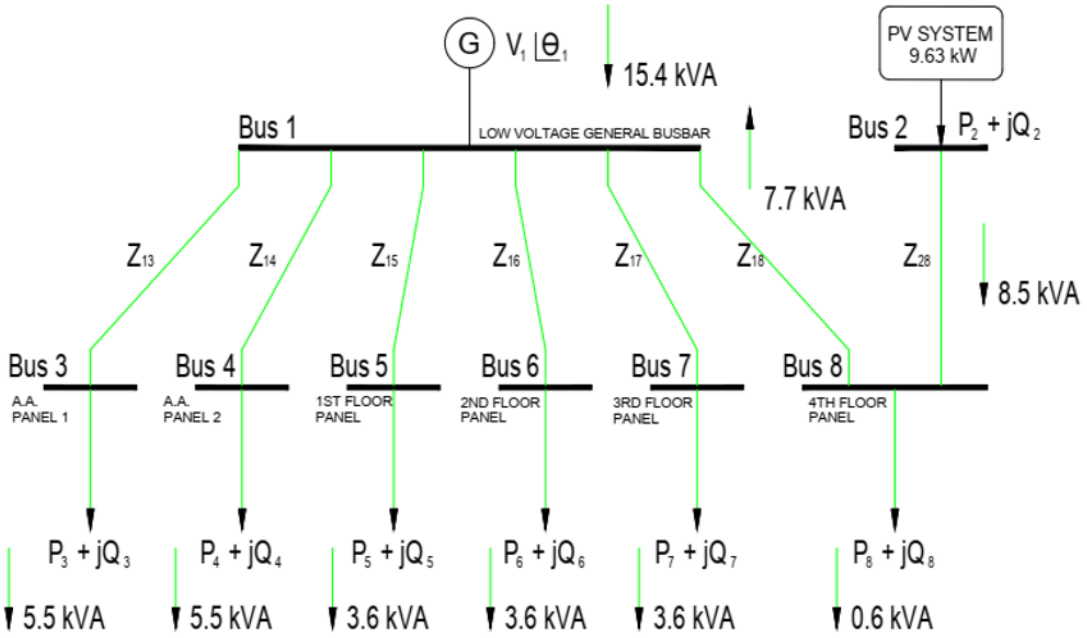
Photovoltaic system in the electrical engineering building, Universidad Industrial de Santander. Taken from http://e3t.uis.edu.co/eisi/

II. Methodology

C. Simulation

With the load and PV power injection curves, plus the impedance values of the Electric Power Distribution System (EPDS), the iterative process is carried out **every minute**.

- Bar 1 is the EPDS transformer, its objective will be to supply the general demand and relieve the PV system when it suffers the effects of solar intermittency.

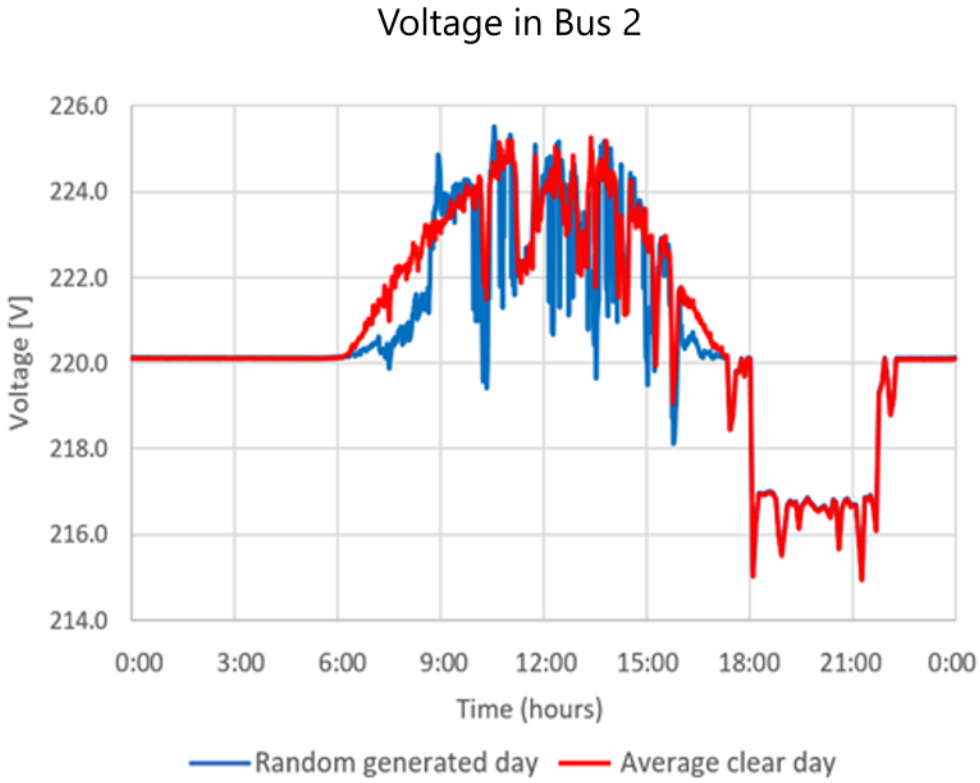


Busbars diagram representing the studied EPDS

III. Results

A. Voltage results

- The PV system is integrated in Bus 2.
- The increase in voltage can be observed at the moments when the power injection into the system occurs.
- An expected result is obtained where the voltage **tracks proportionally** to the irradiance curve, depending on the load that feeds.

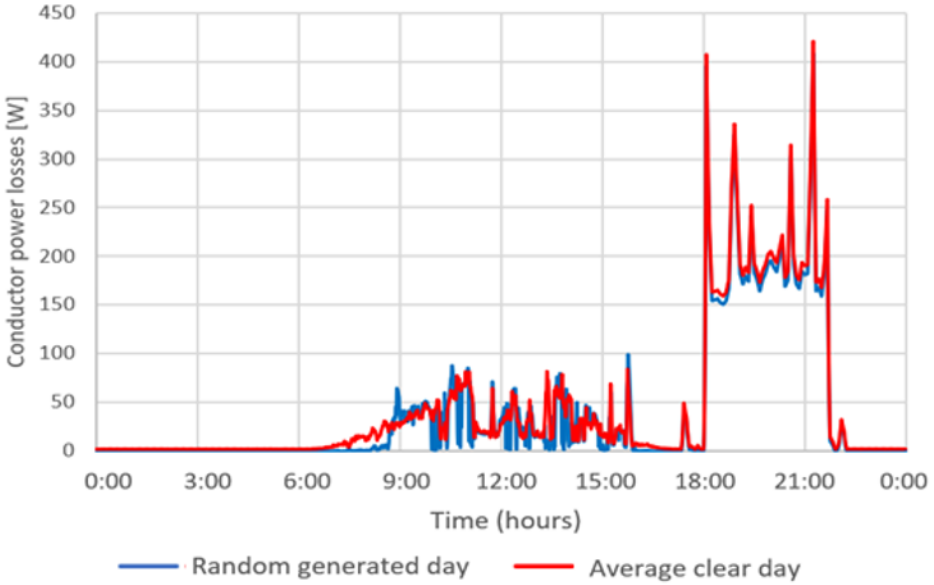


III. Results

B. Conductor power losses results

- Power losses in conductors occur as a consequence of the Joule effect.
- Its magnitude depends on the **conductor's resistivity**, the **connection distance**, and the **power flow** between bars.
- It can be seen that when there is power injection by the PV system, the losses in the line that feed Bus 8 from the transformer are reduced.

Power losses between Busbars 1 and 8

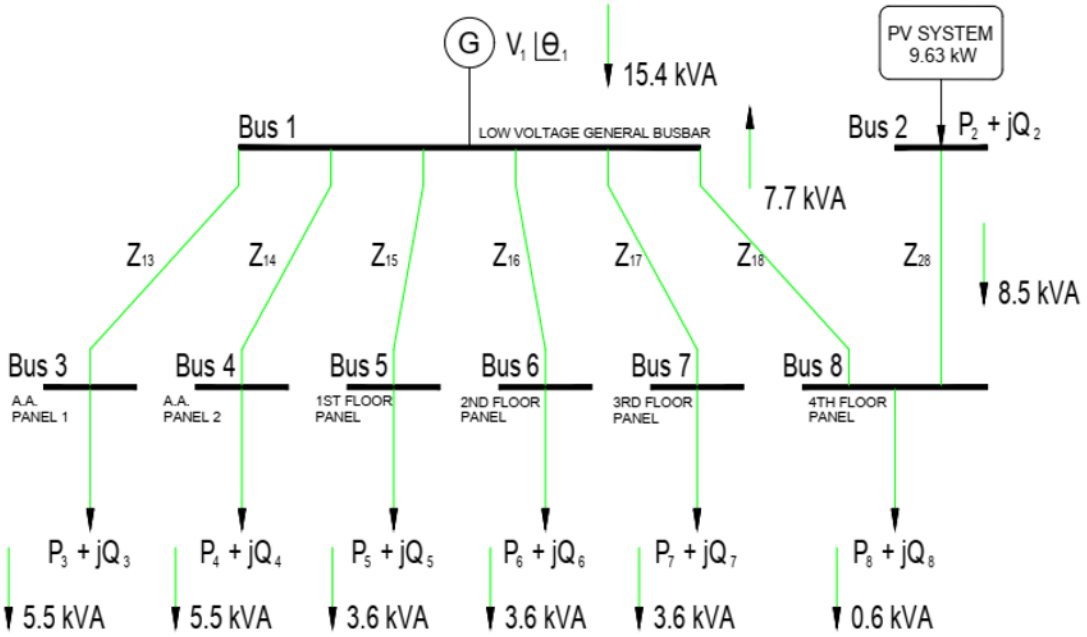


III. Results

C. Power losses and flows relation

This relation is given when the energy generated by the PV system is not consumed in Bar 8. This can result in **really high percentual losses**, considering it is feeding the other busses

Busbars diagram representing the studied EPDS and power flows in the electrical system for 11:01 a.m

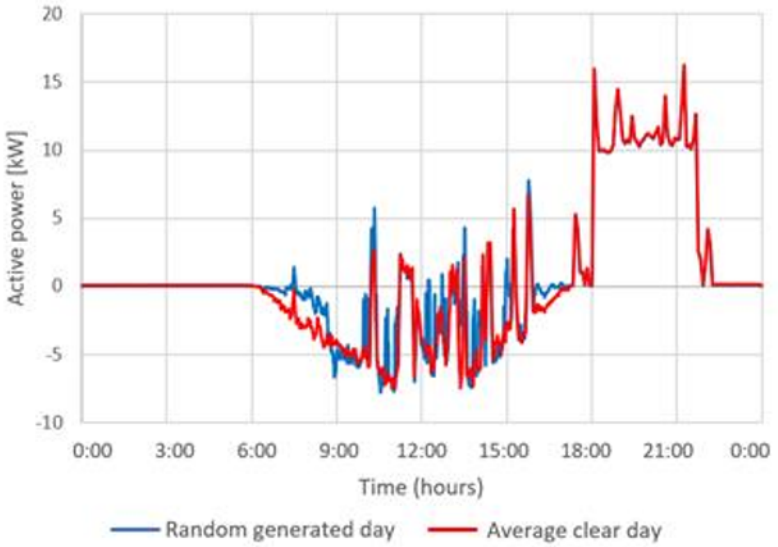


III. Results

D. Transmission and power flow results

- The power flow in the lines that join Bar 1, with Bars 3, 4, 5, 6, and 7 are not affected by the variations in the photovoltaic injection.
- In the power flow in the line that joins Bar 1, with Bar 8, it is possible to fully identify the change in the direction of the power flow when the **PV generation exceeds** the load demanded in Bar 8.
- When the flow is positive it indicates a flow from Bar 1 to Bar 8 and vice versa.

Active power flow between Busbars 1 and 8



IV. Conclusions

- The procedure for the estimation of electrical parameters performed in this work adjusted to the **real behavior** of the Electrical Power Distribution System studied.

- The characterization of intermittent cloudiness carried out in this work can be scaled to any climate because it is a **probabilistic analysis** of measurements made.

- It can also be scaled to **different work scenarios**, such as completely cloudy or clear days, specific schedules, and probabilities.

- Any project derived from the **characterization carried out in this work** must be sustained in warm tropical contexts

- The variations by solar intermittency are in the temporal order of seconds and the electrical transients in the order of milliseconds. It is recommended to review the study of these rapid variations and the possible transient effects in electrical machines.

V. Questions