

XSICEL 2021

Transición energética en la 4ta revolución industrial



Universidad
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A Framework for Resilience of LV Electrical Networks with Photovoltaic Power Injection

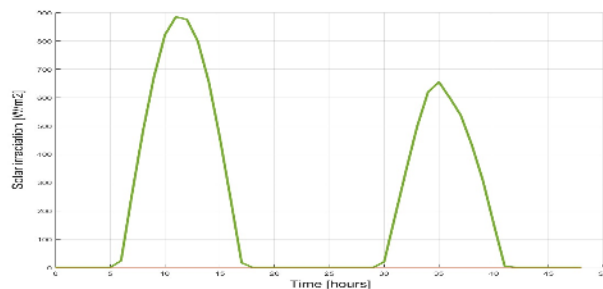
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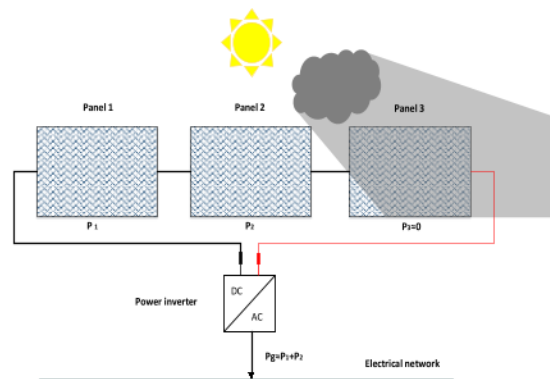
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I. Introduction



Irradiance intermittency

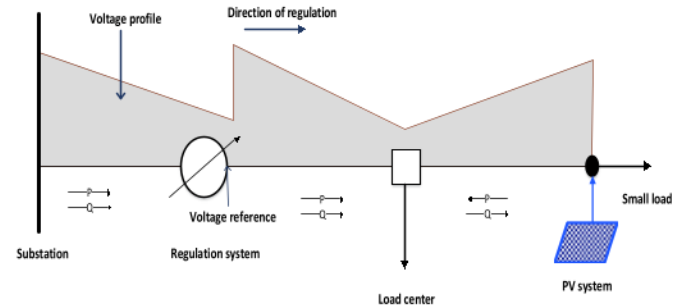


Shading in PV

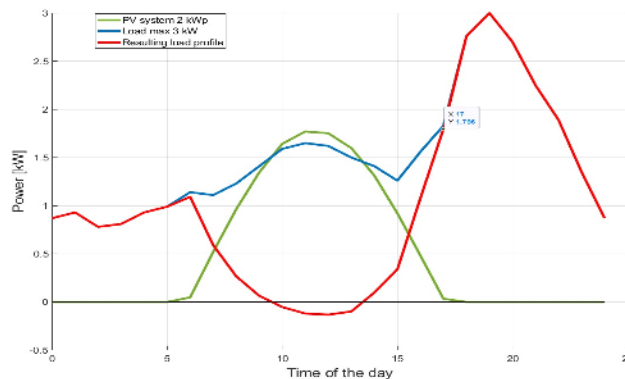
Solar radiation intermittency and cloudiness affect PV systems



This could act on the grid in an interconnected system.

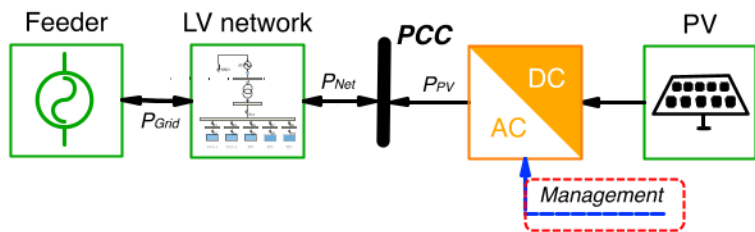


Voltage regulation problems



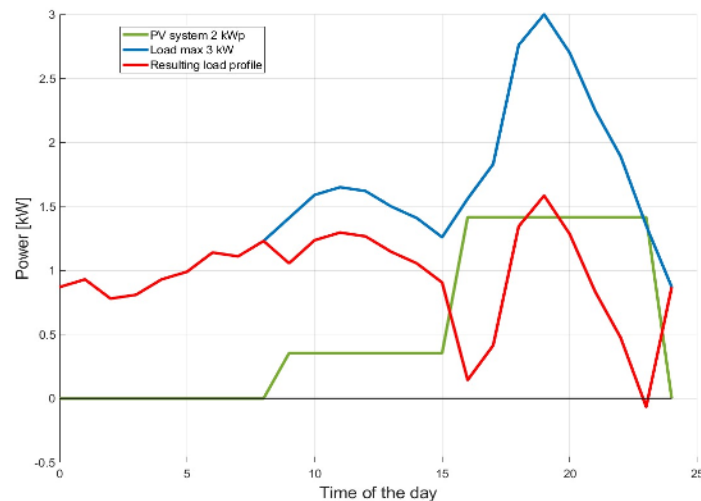
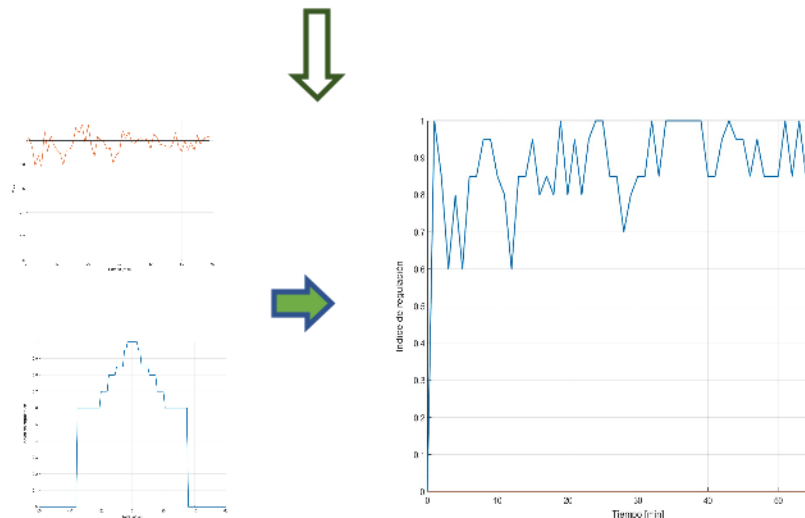
Overpower load

I. Introduction



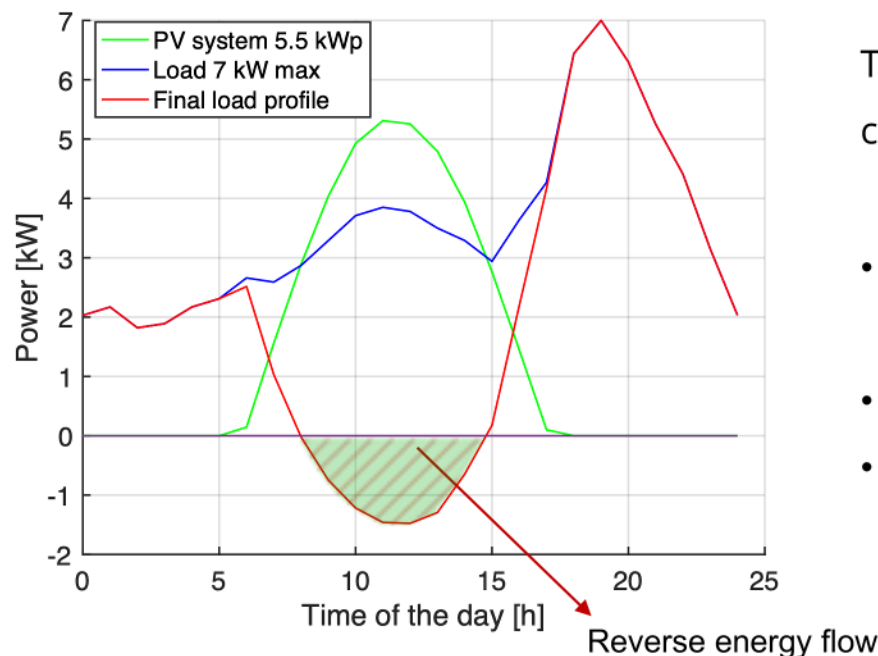
Assess resilience level of an electrical grid to determine the impact of PV systems.

Apply a management strategy



II. Concepts: effects of PV on LV networks

About 30% of the problems generated by PVs are due to reverse power flows. 20% to low quality of operation of the inverter systems and to inadequate facilities or bad designs [1-2].



To avoid reverse power flows, it is necessary to curtail the extra power generated.

- Some negative effects of PV systems could be mitigated.
- Efficiency cuts down.
- The curtailed energy, can be used for extra processes.

II. Concepts: Resilience

Capacity of a material, mechanism or system to recover its initial state when the disturbance to which it had been subjected has ceased.

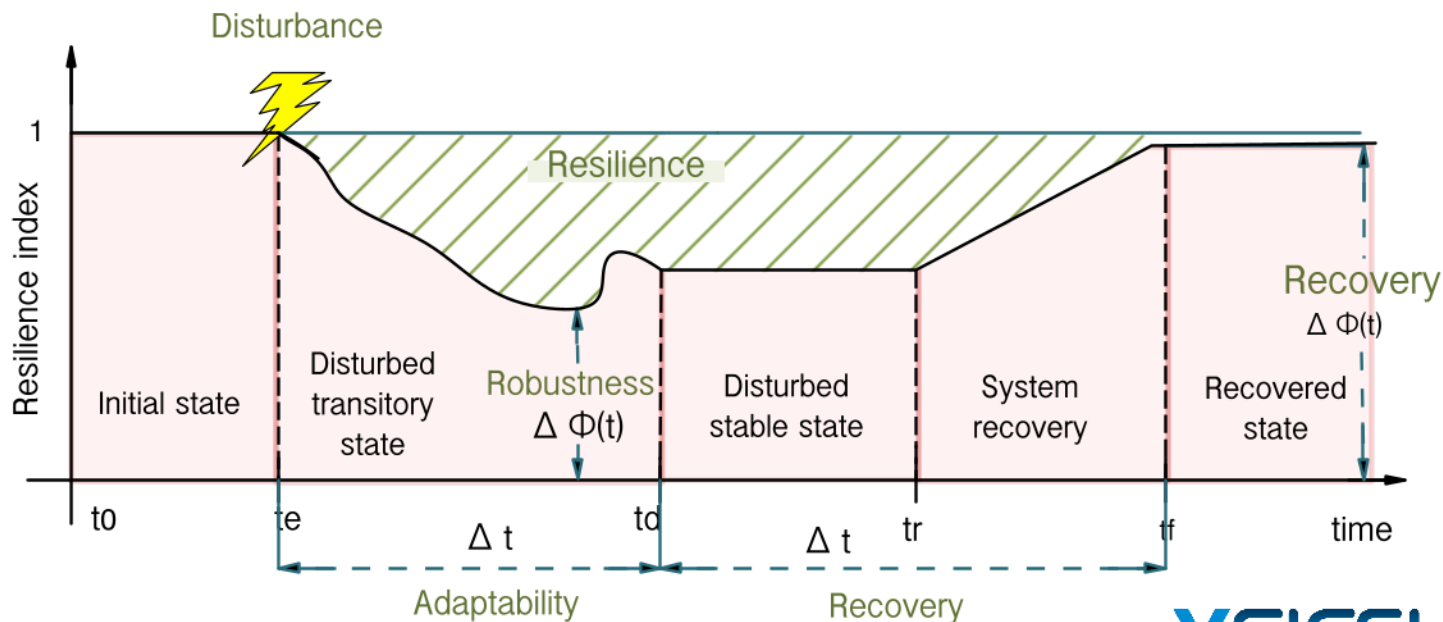
Disturbance	Evaluation indicators	Ref.
Natural disasters and human-made attacks	Service capacity and Restoration Time, Generation Cost	[4], [25]
	Reliability, Island Mode Operation Capability, and Transition Times	[5], [7]
Power outages in LV networks	Power supply to critical loads	[8], [9]
Daily operation of LV networks	Voltage variations and unbalance	[10], [11]

II. Concepts: Resilience

Ability of a network to withstand events that alter its operation, minimize the effects, continue in operation and recover normal operation when the event has ended.

integrates:

- Reliability
- Robustness
- Adaptability
- Recovery



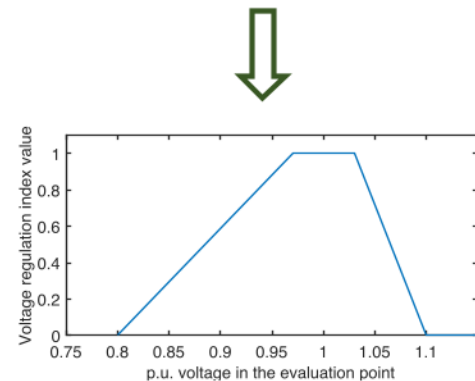
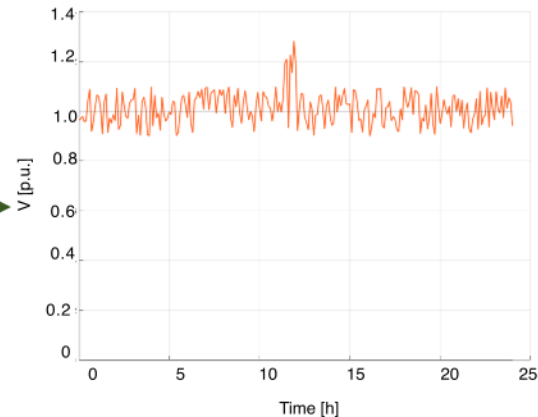
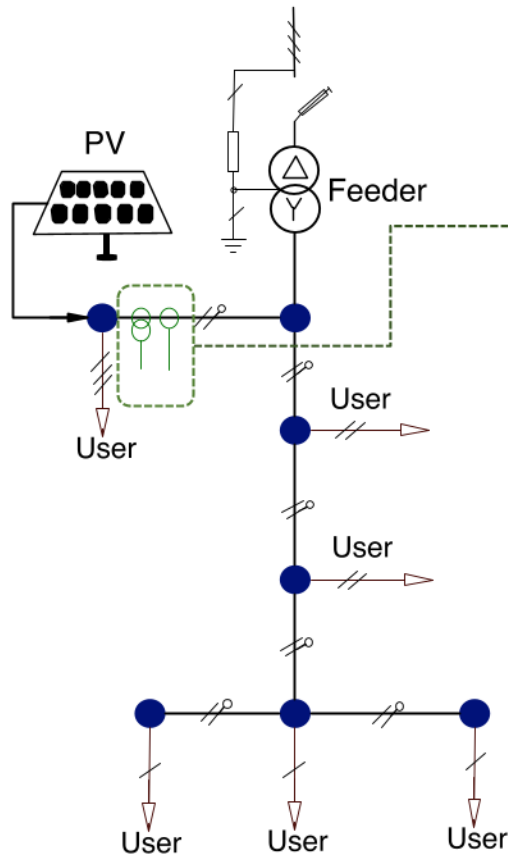
Measurement

- Voltage

- Transformation
 - Normalized index of resilience

- Management
 - Curtailment

Improvement



III. Methodology

Measurement

- Voltage



Transformation

- Normalized index of resilience

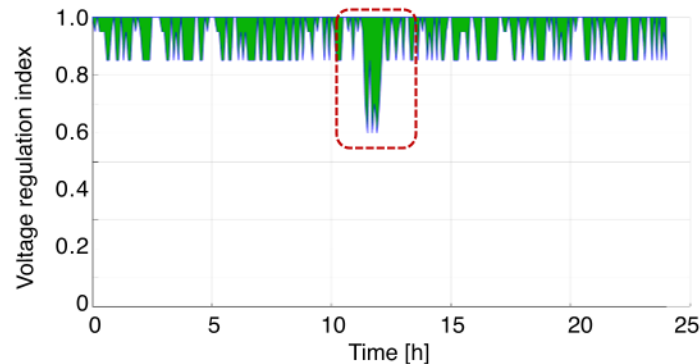
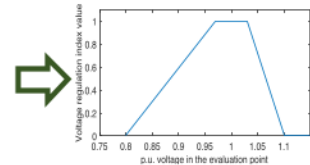
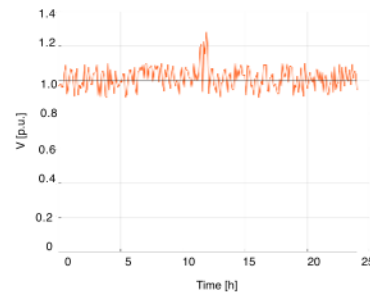
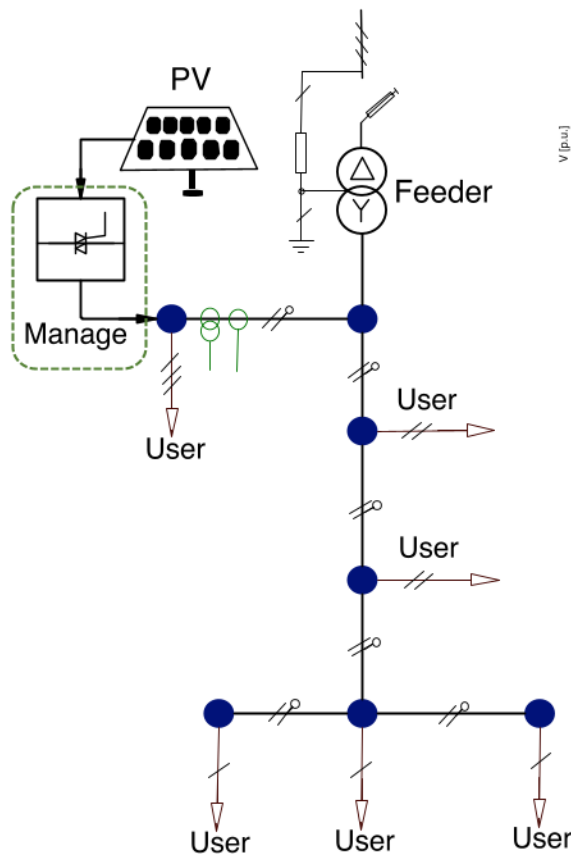


Management

- Curtailment



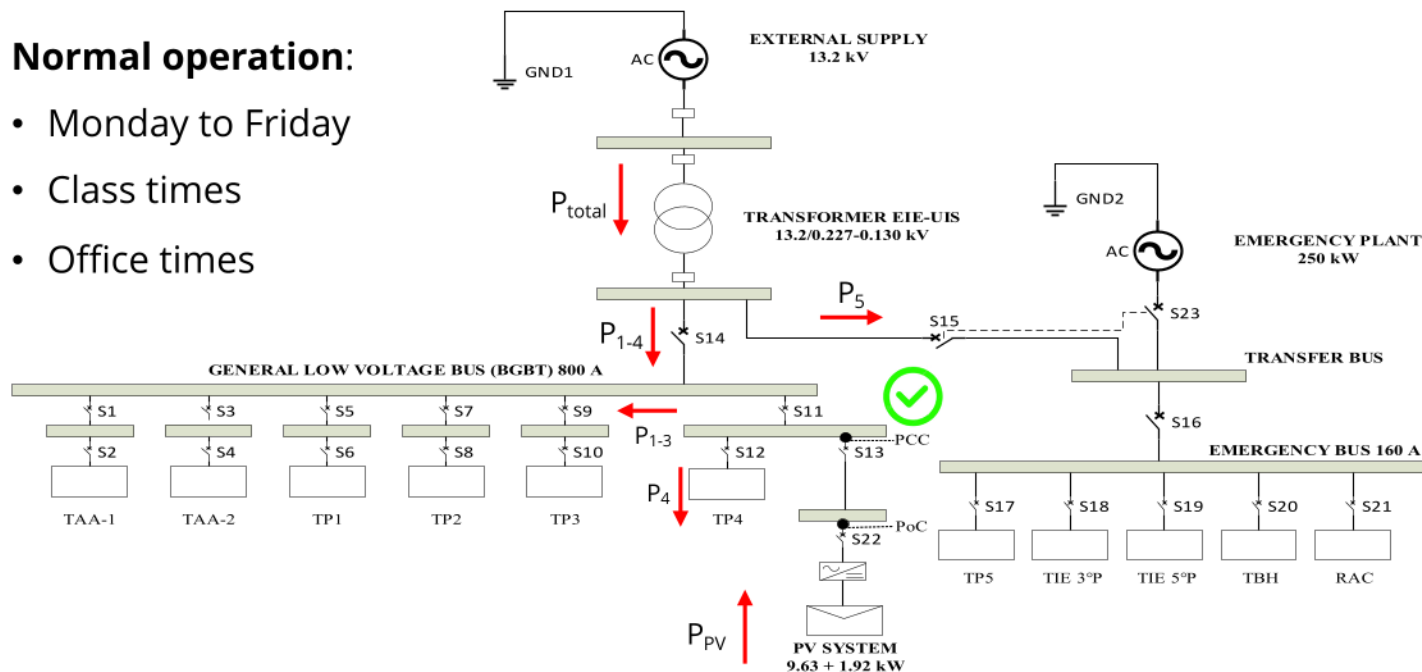
Improvement



IV. Results: Study case

Normal operation:

- Monday to Friday
- Class times
- Office times

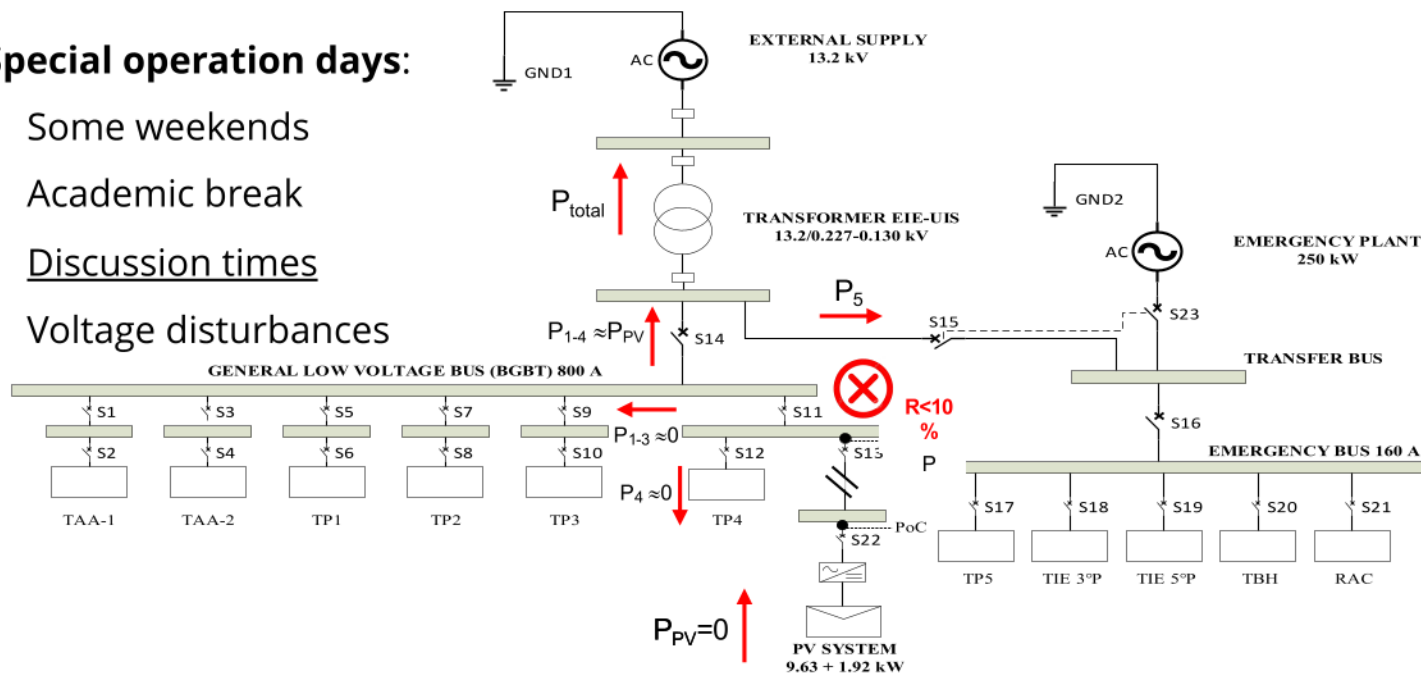


Electrical connection diagram of Electrical Engineering Building

IV. Results: Study case

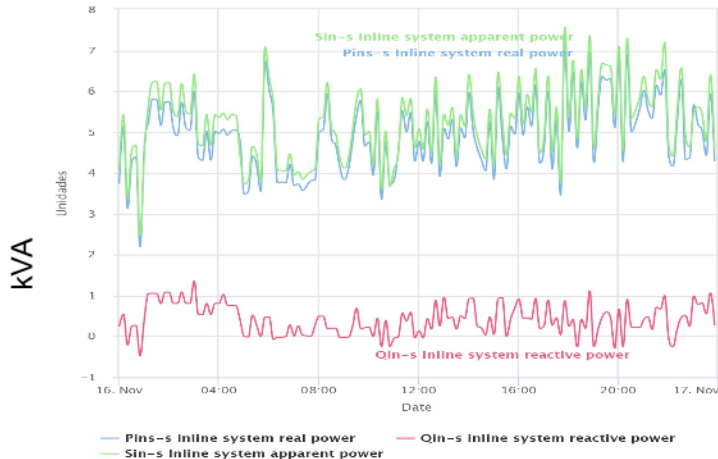
Special operation days:

- Some weekends
- Academic break
- Discussion times
- Voltage disturbances



Electrical connection diagram of Electrical Engineering Building

IV. Results: Study case



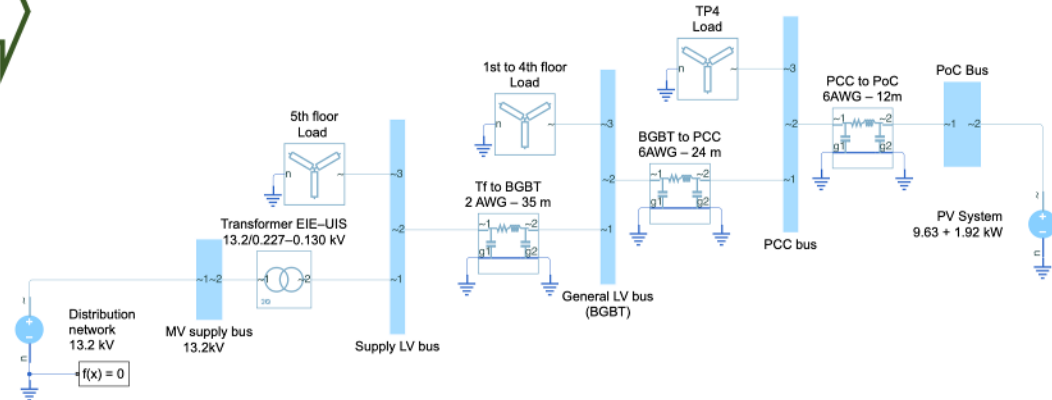
- **Period:** October 17 – November 16, 2019
- **Time step:** 10 minutes
- **Total samples:** 4 464



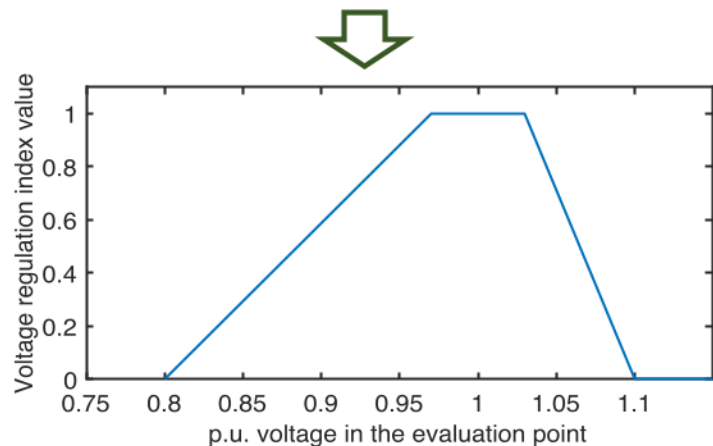
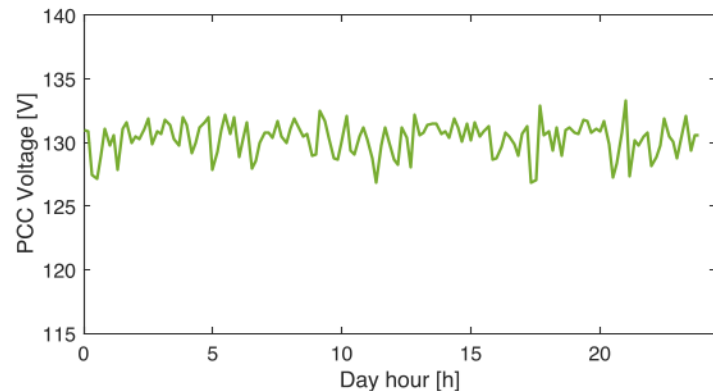
Model:

- Constant power loads
- Constant impedance wire
- Maximum power PV

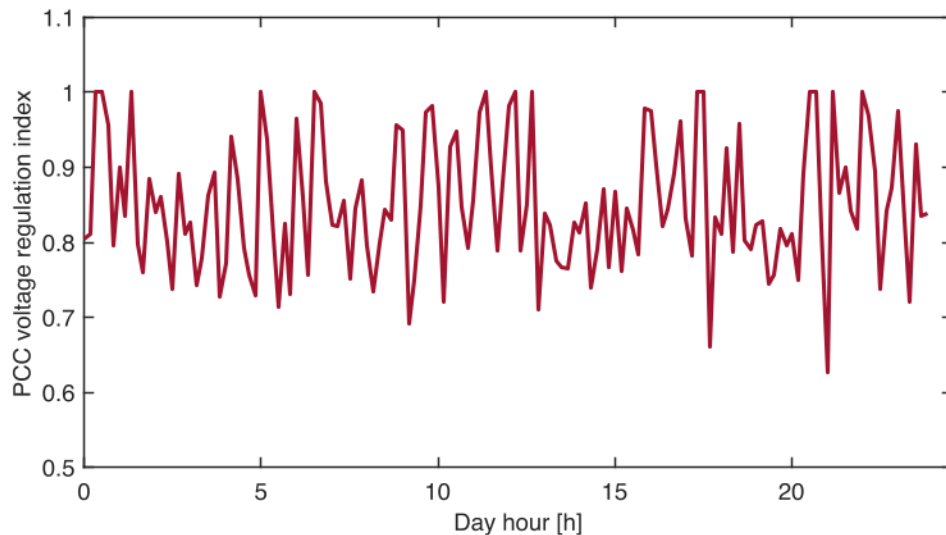
Quasi static power flow – MATLAB/Simulink:



IV. Results: Voltage resilience index

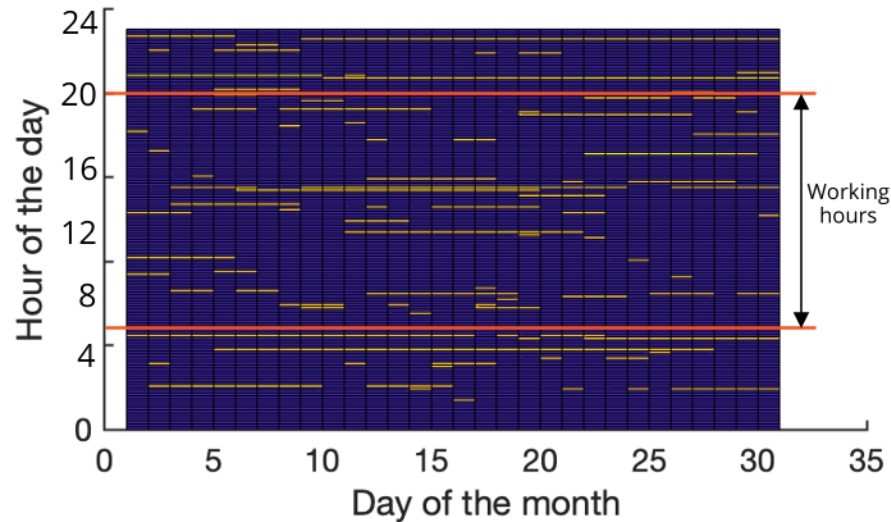


Evaluation of the voltage resilience index
(Actual case 17/10/2019)

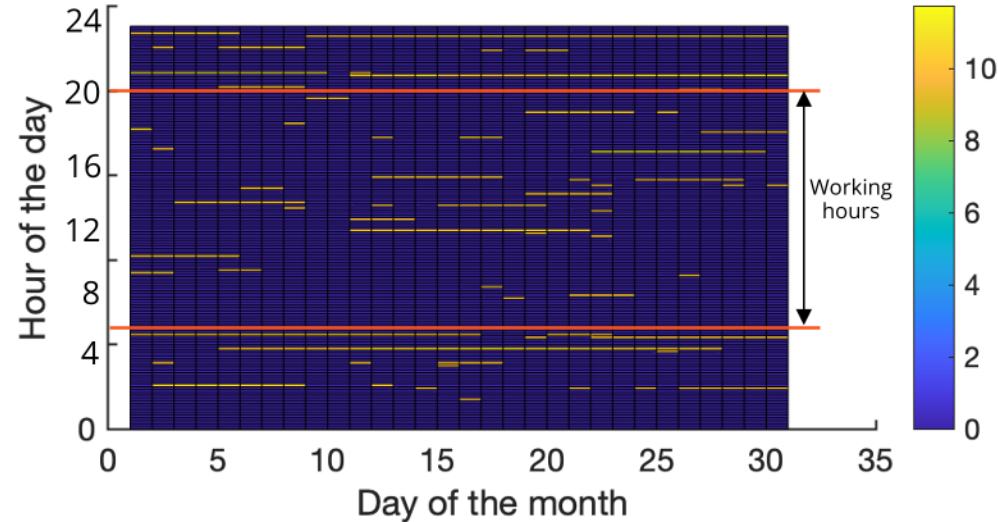


IV. Results: Voltage resilience index

Voltage regulation in the PV system PCC during the test month



Actual condition network



Curtailment Strategy Implementation

IV. Results: Voltage resilience index

Summary Of the results found for the case study

Strategy	OV Total hours [h]	OV working hours [h]	PV generation [MWh]	Unused PV energy	Voltage resilience Index
Actual system	59,8	31,0	1,6	7,4%	0.84
curtailment	42,0	15,8	1,6	7,4%	0.85

V. Conclusions

- The resilience of an LV network with PV integration before disturbances has not been evaluated directly in the consulted literature. However, it can be approached from the perspective of the variation of the response in the networks to the disturbances.
- Energy management strategies have a positive effect on grid resistance and the use of PV energy. The combination of strategies could show a more convenient result.
- The case study shows congruence between the value found in the voltage regulation index and the overvoltage in the network.

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- [11]Karimi, M., Mokhlis, H., Naidu, K., Uddin, S., and Bakar, A. H., "Photovoltaic penetration issues and impacts in distribution network -a review,"Renewable and Sustainable Energy Reviews, vol. 53, pp.594–605, 201.



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Feedback and questions

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