# X SICEL 2021

## Transición energética en la 4ta revolución industrial

Universidad Tecnológica de Pereira

UNIVERSIDAD NACIONAL DE COLOMBIA

XSICEL 2021
Transición energética en la 4ta revolución industrial

# Impacts of the Inclusion of Distributed Generation on Congestion of Distribution Networks and in the Islanding Operation Capability

Jose David Beltrán Gallego
Leidy Daniela Castro Montilla
Alexandra Castro Valencia
Camilo Augusto Giraldo Muñoz
Dahiana Lopéz García

Environmental energy and education policy (E3P)
Universidad Nacional de Colombia

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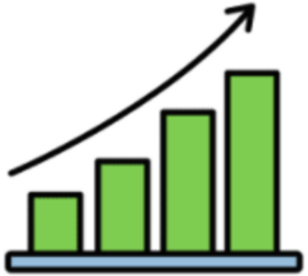
# I. Introduction



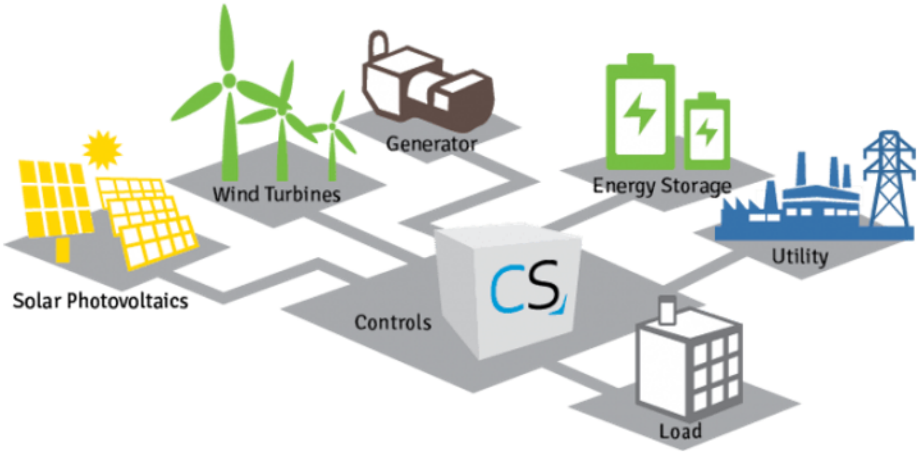
The search for sources of electricity generation with a smaller carbon footprint, harnessing local energy potentials, generated incentives for the inclusion of distributed generation near consumption centers.

Distributed generation changes the operating paradigm of the System and proposes new challenges for its planning, coordination and operation.

# II. Microgrid Operation

- It is an electrical network that presents distributed energy resources (DERs), loads, and control and monitoring systems.

- This grid can be an isolated network or part of a local electrical network that can be disconnected and reconnected to the central electrical system according to adequate previously planning



# Limitations and barriers

- Agreement between the stakeholders of the microgrid: Users, Network operator, Government, etc.
- Low inertia of the system.
- Frequency control.
- Voltage control.
- Dispatch and planning.
- System Security.
- Expansion of telecommunications networks and communication protocols.

# Global guidelines for proper design

- Topology of the distribution network and distributed generation.
- Voltage and frequency control.
- Local power system or charging requirements.
- Demand response.
- Cold load activation.
- Monitoring and control systems.
- Protection schemes.
- Reconnection to the power system.

# Operation by intentional islands

It consists of the separation of the distributed generation with its demand assigned to the central electrical network, these are not risky since they are planned and can be disconnected or connected to the electrical network according to the required need.

Benefits of microgrid operation including distributed generation

- Improvement security of supply.
- Reduction of greenhouse gases.
- Decrease of transport energy losses.
- Flexibility of investments.
- Reduction of congestion.

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- Reduction of greenhouse gases.
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- Flexibility of investments.
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# III. Case of Study

- IEEE 37 node test feeder.
- Typical distribution network with a radial topology.
- Installed load of 2,735 MVA.
- Voltage of 4.8 kV.

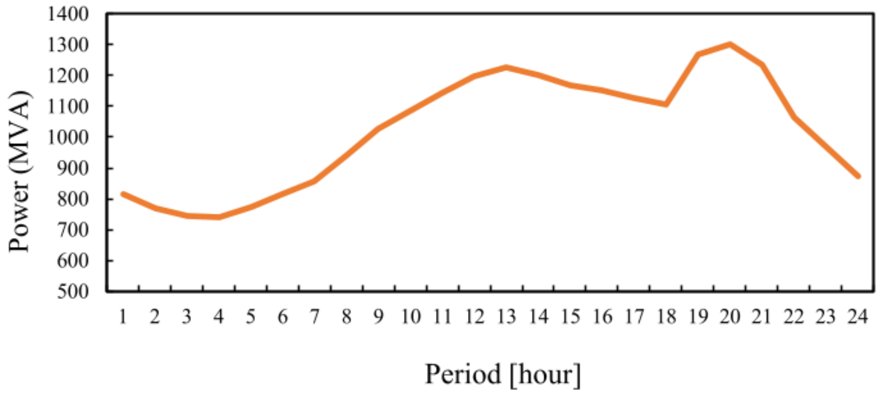


Fig. 1. Average demand curve October of 2020 in the Andean Region.

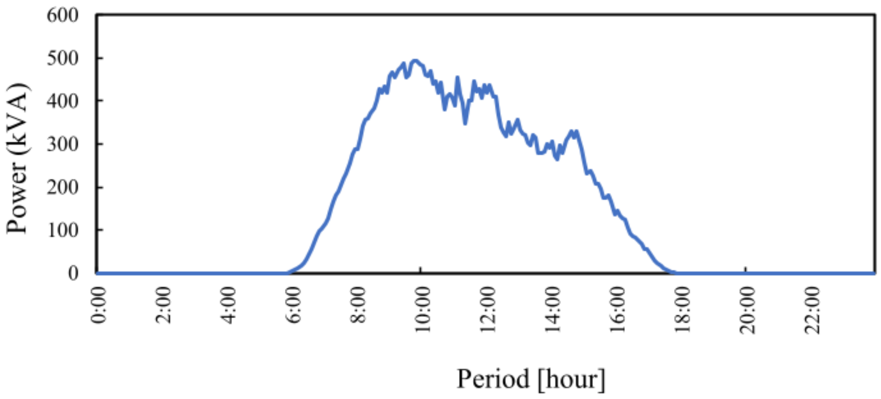


Fig. 2. Solar irradiance curve of a photovoltaic solar system within the Andean region.

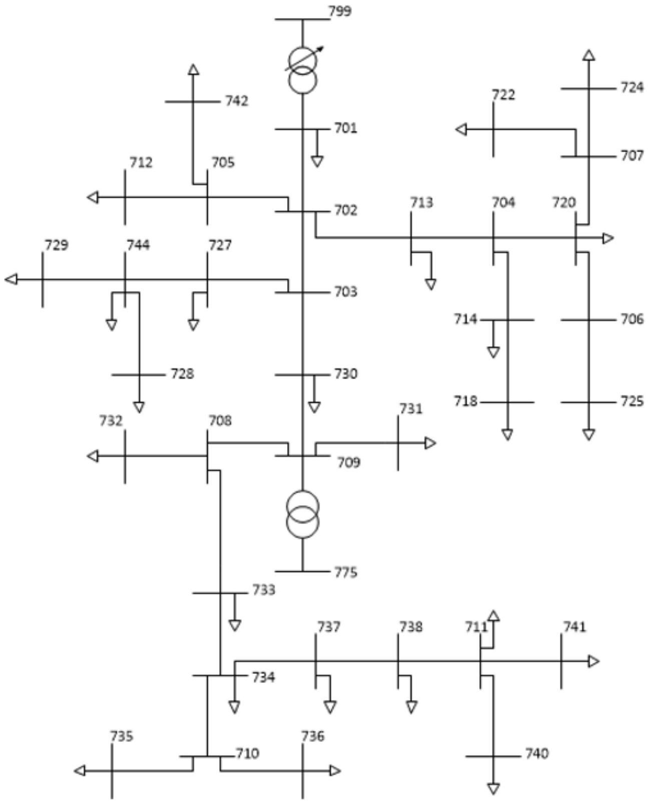


Fig. 3. IEEE 37 node test feeder.

# Scenario 1

- IEEE 37 node test feeder.
- Typical distribution network with a radial topology.
- Installed load of 2,735 MVA.
- Voltage of 4.8 kV.

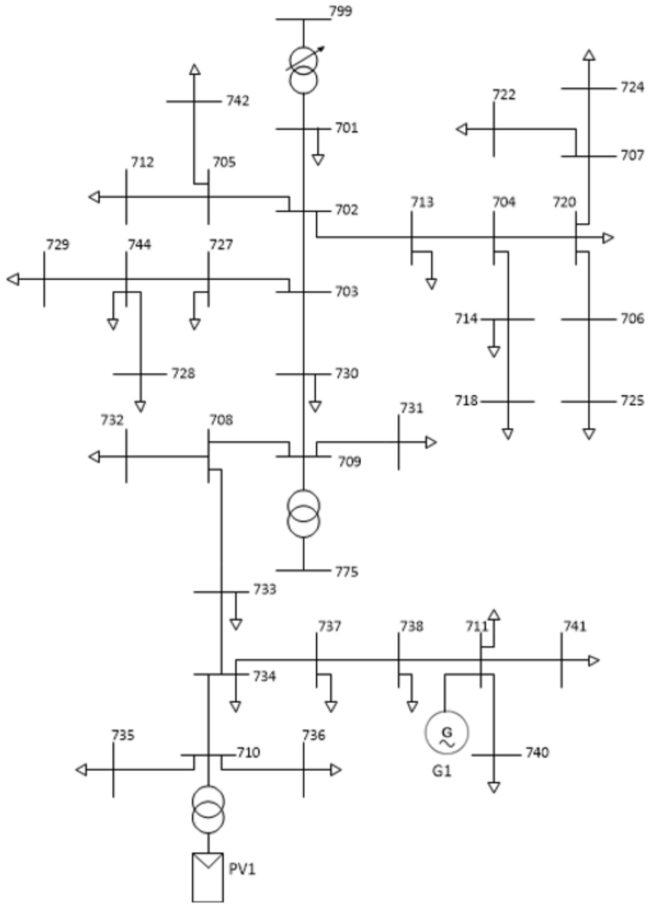


Fig. 4. IEEE 37 node test feeder with distributed generation.

# Scenario 2

- IEEE 37 node test feeder.
- Installed load of 2,735 MVA.
- Voltage of 4.8 kV.
- Synchronous generation plant with a capacity of 1,5 MVA on the 711-bus.
- Photovoltaic generation unit with a capacity of 500kW on the 710-bus.

# Scenario 3

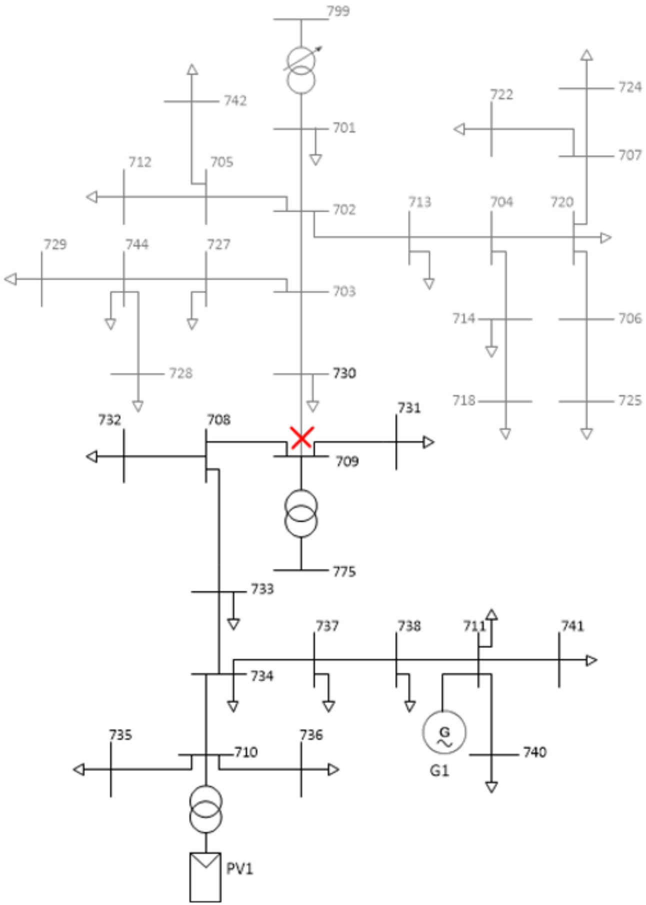


Fig. 5. IEEE 37 node test feeder with operating in island mode.

- IEEE 37 node test feeder.
- Installed load of 2,735 MVA.
- Voltage of 4.8 kV.
- Synchronous generation plant with a capacity of 1,5 MVA on the 711-bus.
- Photovoltaic generation unit with a capacity of 500kW on the 710-bus.
- Switch opening between bar 730 and 709.

# Proposed methodology for congestion analysis

To estimate the global congestion of the network, it begins by establishing a priority factor for all the lines of the system in each of the periods of the time horizon.

$$w_i = \frac{I_{n_i}}{\max\left(I_n\right)}, \qquad i = 1, \ldots, N_L$$

To estimate the global congestion of the network, it begins by establishing a priority factor for all the lines of the system in each of the periods of the time horizon.

$$TCF_k = \sum_{i=1}^{N_L} CF_{i-k} * w_i, \qquad k = 1, \ldots, N_K$$

# V. Results

## Scenario 1 - Passive distribution system

The typical behavior expected for a passive network in which the congestion will naturally follow the trend of the demand curve since the power consumption is the only determinant of the current flow in the lines.

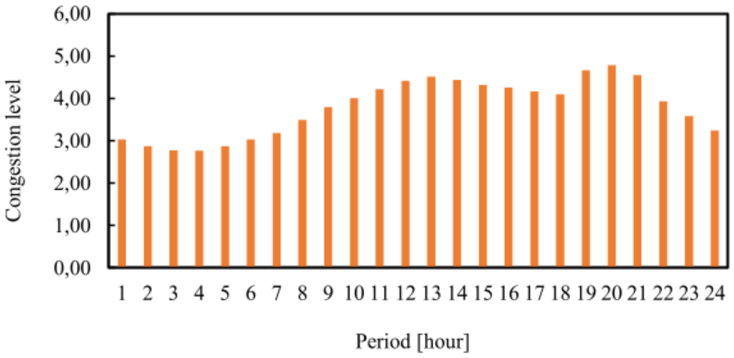


Fig. 6. Congestion in the system in each period of the time horizon for the first scenario.

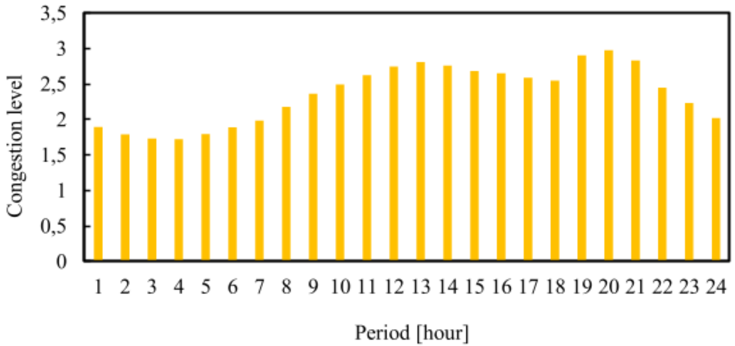


Fig. 7. Congestion of the portion of the network to be operated on the island for all periods of the evaluation horizon for the first scenario.

# Scenario 2 - Active distribution system

The inclusion of distributed generation and the correct location of its installation causes the overall congestion of the system to decrease in each of the periods of the time horizon.

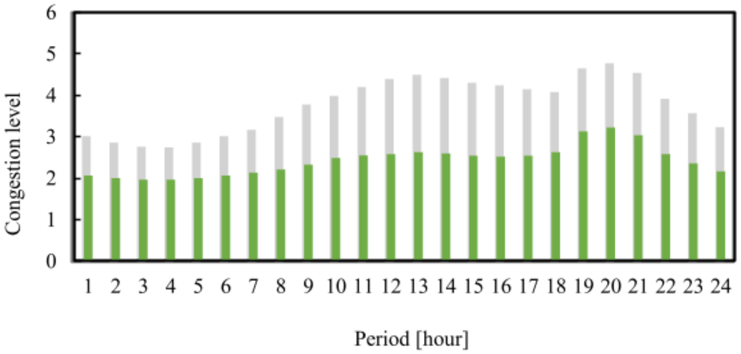


Fig. 8. Congestion in the system in each period of the time horizon for the second scenario. Source: Own elaboration.

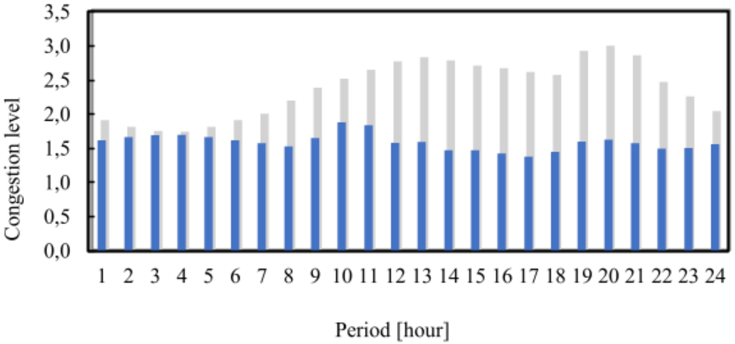


Fig. 9. Congestion of the portion of the network to be operated on the island for all periods of the evaluation horizon for the second scenario. Source: Own elaboration.

# Scenario 3 - Island operation mode

When the microgrid (formed downstream of bus 709) operates isolated from the main network (by opening the switch between busbars 709 and 730), a reduction in overall system congestion is achieved with respect to the system including DG and connected to the main network.

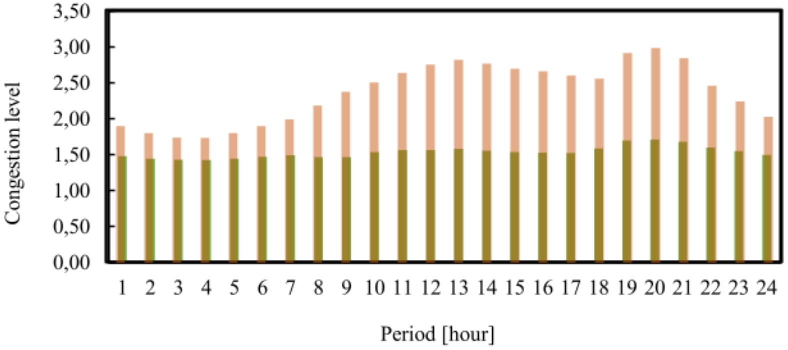


Fig. 10. Congestion of the portion of the network to be operated on the island for all periods of the evaluation horizon for the third scenario with respect to the first scenario.

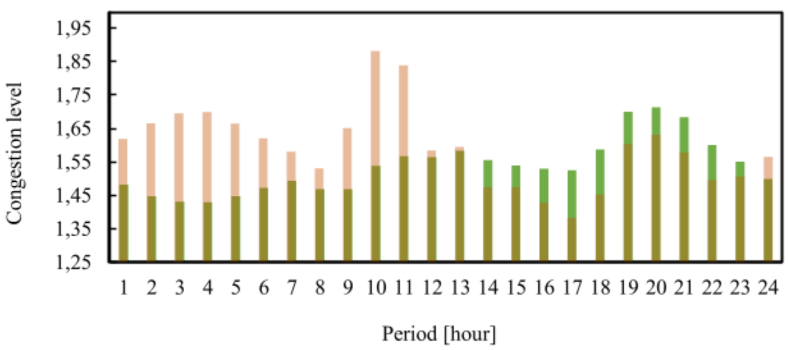


Fig. 11. Congestion of the portion of the network to be operated on the island for all periods of the evaluation horizon for the third scenario with respect to the second scenario.

A decongestion of the network occurs when distributed generation is immersed and when it operates in isolation compared to when the network is passive.

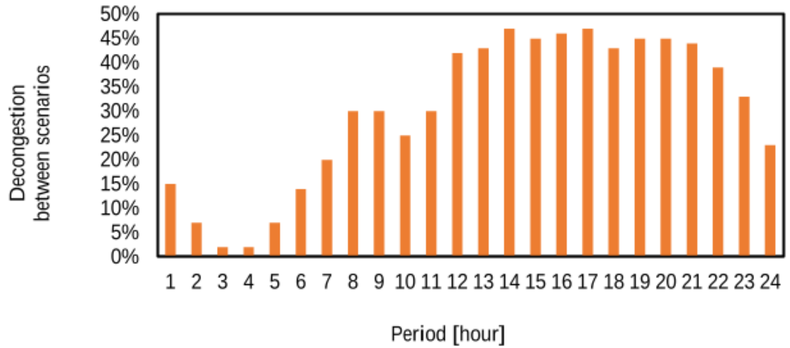


Fig. 12. Decongestion percentage of the second scenario compared to the base case (first scenario) for all periods of the evaluation horizon. Source: Own elaboration.

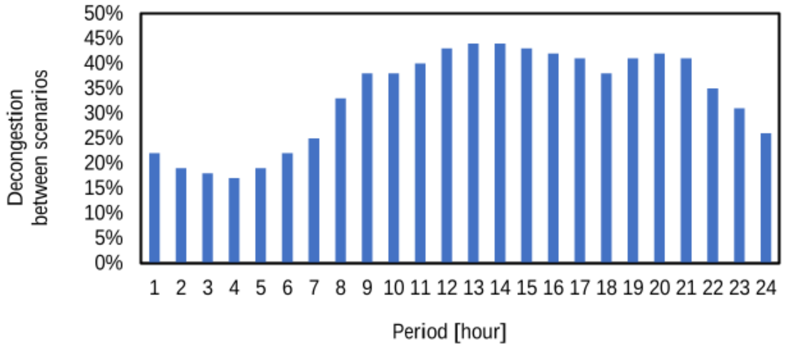


Fig. 13. Decongestion percentage of the third scenario compared to the base case (first scenario) for all periods of the evaluation horizon. Source: Own elaboration.

There is a decongestion on the island when it is operating in isolation from the central grid than when the island is connected to the main grid with distributed generation in the period that the island's demand is not very high.

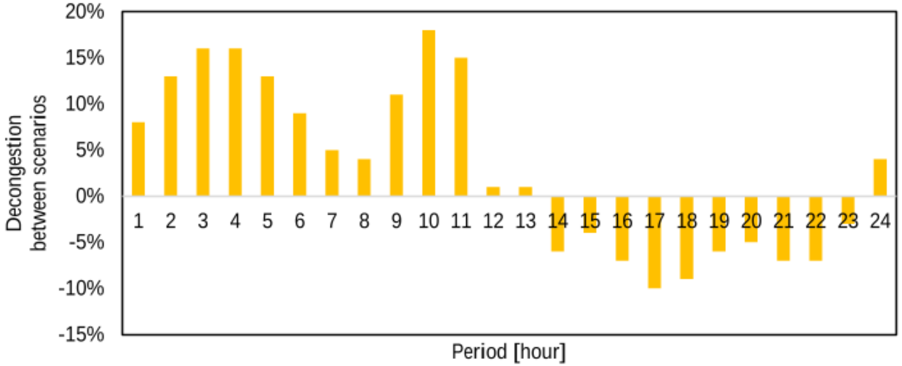


Fig. 14. Decongestion percentage of the third scenario compared to the second scenario for all periods of the evaluation horizon with the second priority factor. Source: Own elaboration.

# VI. Conclusions

- An appropriate location of the distributed generation reduces the overall congestion of the system, nevertheless, it is necessary to consider the capacity of the lines that communicate these generation assets with the rest of the network.
- Isolated mode operation generates a reduction in the congestion of the lines of the system, thus freeing up capacity in the principal supply network.
- The integration of DG units in the appropriate nodes allows to improve the voltage profile of the system.

- With the integration of distributed generation units in the distribution networks, the possibility of operating sections of these networks as intentional islands arises; however, it is recommended to carry out studies to maintain the quality and continuity of service.

- In future work, the protection schemes for the correct operation in island mode should be studied, since this work only focuses on the capacity supplied by the DG in case the island portion of the network is disconnected from the central network.

# Thank you

Camilo Augusto Giraldo Muñoz
cagiraldomu@unal.edu.co
Universidad Nacional de Colombia