# 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

# Energy Management System For A Microgrid With Biomass Inclusion

Authors:
MSc. Albert Deluque Pinto
PhD. Ernesto Pérez González
PhD. Gail Gutiérrez Ramírez

Institutions:
Universidad de la Guajira
Universidad Nacional de Colombia Sede Medellín

# Contents

# I. Introduction

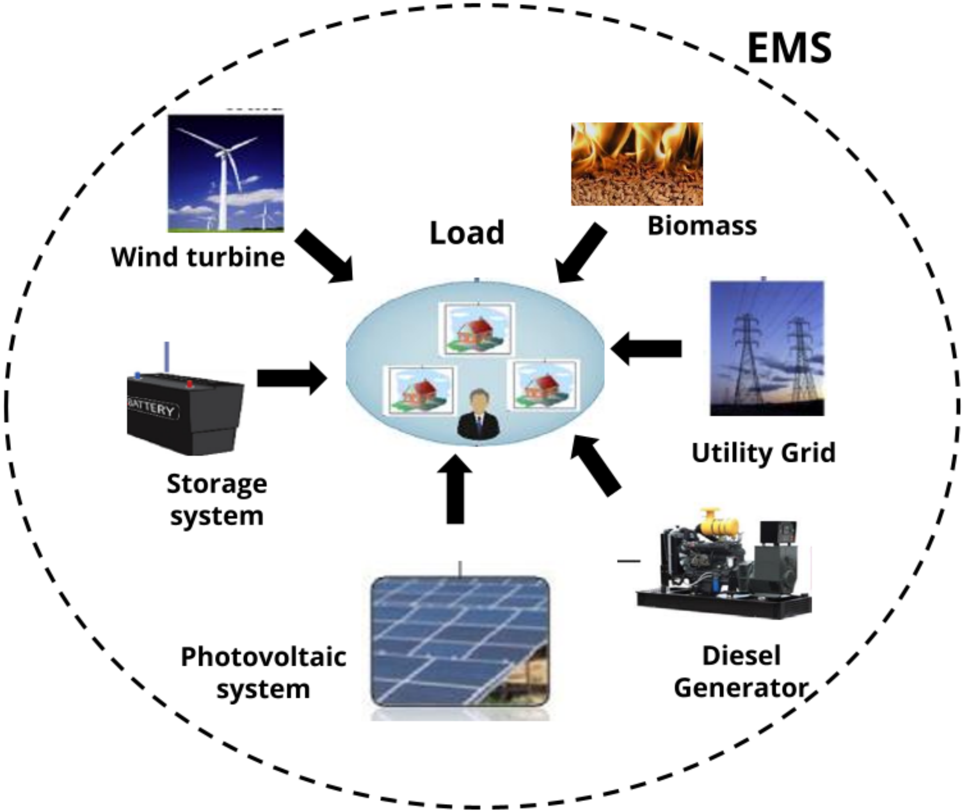



Figure 1. Different types of energy sources and storage system

Energy Management Systems (EMS) are used to optimize, monitor, and control the performance of the microgrid.

A study carried out by UPME (Unidad de planeación minero Energética) suggets that residual biomass could become an alternative source of renewable energy to Colombia.

# II. Theoretical aspects

- System description

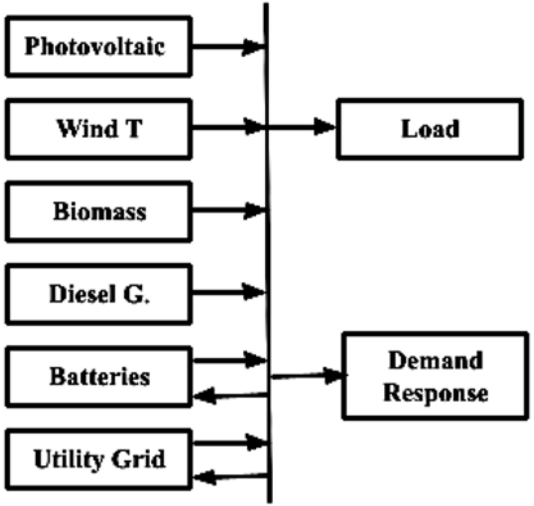



Figure 2. Sources used in the microgrid

| Component | | Minimum value | Maximum value | Unity |
|---|---|---|---|---|
| Photovoltaic | | 0 | 5.4 | kW |
| Wind Turbine | | 0 | 5.0 | kW |
| Biomass gen. | | 0 | 30 | kW |
| Diesel gen. | | 3 | 10 | kW |
| Storage system | | 33.6 | 48 | kWh |
| Utility grid | | 0 | 20 | kW |
| Demand Response | Non-critical load | 0 | 2 | kW |
| | Dryer demand | 0 | 1 | kW |

Table 1. Generation and demand response parameters

# II. Theoretical aspects

- ## Analysis of biomass in electric power generation

The calorific value of Synthesis gas depends on factors like, moisture content, gasification temperature, gas composition, air factor, etc.

In this study simulations were performed with rice husk biomass to obtain the electrical power output of the gasifier for different values of air factor and moisture content.

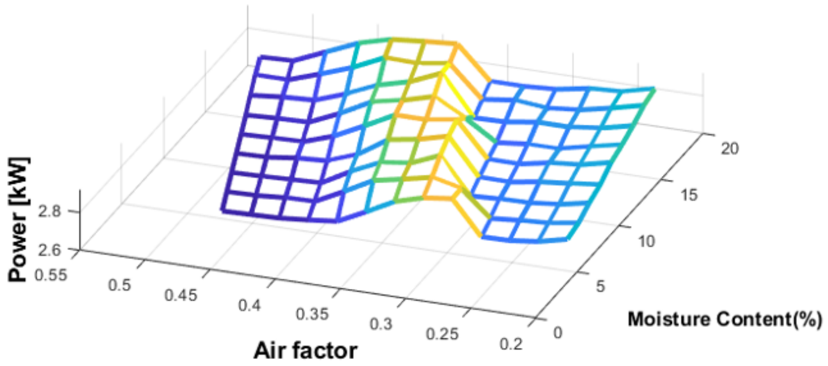



Figure 3. Variation of the engines' output power as a function of gasifier air factor and rice husk biomass moisture

# II. Theoretical aspects

- ## EMS Mathematic Formulation

Objective equation

$$Z = \min \sum_{t=1}^{Np} \left\{ \begin{array}{l} D_t^{PV} M_t^{PV} P_t^{PV} \\ + D_t^{WT} M_t^{WT} P_t^{WT} \\ + D_t^{BM} M_t^{BM} P_t^{BM} \\ + D_t^{DG} M_t^{DG} \left( a \left( P_t^{DG} \right)^2 + b P_t^{DG} + c \right) \\ + D_t^{BT} M_t^{BT-} \left( 1 - U_t^{BT} \right) P_t^{BT-} \\ - D_t^{BT} M_t^{BT+} U_t^{BT} P_t^{BT+} \\ + D_t^{RD} M_t^{RDr} \left( 1 - Y_t^{RD} \right) P_t^{RDr} \\ - D_t^{RD} M_t^{RDe} Y_t^{RD} P_t^{RDe} \\ - D_t^{DR} M_t^{DR} P_t^{DR} \\ - D_t^{DR} M_t^{TER} P_t^{TER} \\ + D_t^{PEN} M_t^{PEN} P_t^{UP} \end{array} \right\}$$

Restrictions considered.

- Power balance.
- Renewable sources restrictions.
- Diesel generator restriction.
- Power injected and imported from the grid.
- Demand response.
- Operating times and ramp-up and ramp-down times for diesel and biomass generators.
- Battery charge and discharge limits.

# III. Results

Simulations were performed in Matlab 2019a and the prices used are shown in Table 2. The price of a gallon of diesel fuel was taken as USD$2.29/gallon.

Simulations were performed for microgrid connected to the utility grid and for islanded microgrid.

| $\mathbf{M_t^{PV}}$ | $\mathbf{M_t^{WT}}$ | $\mathbf{M_t^{BM}}$ | $\mathbf{M_t^{BT-}}$ | $\mathbf{M_t^{BT+}}$ | $\mathbf{M_t^{PEN}}$ |
|---|---|---|---|---|---|
| 0.125 | 0.140 | 0.180 | 0.411 | 0.411 | 0.181 |

Table 2. Energy generation Tariffs in USD

# III. Results

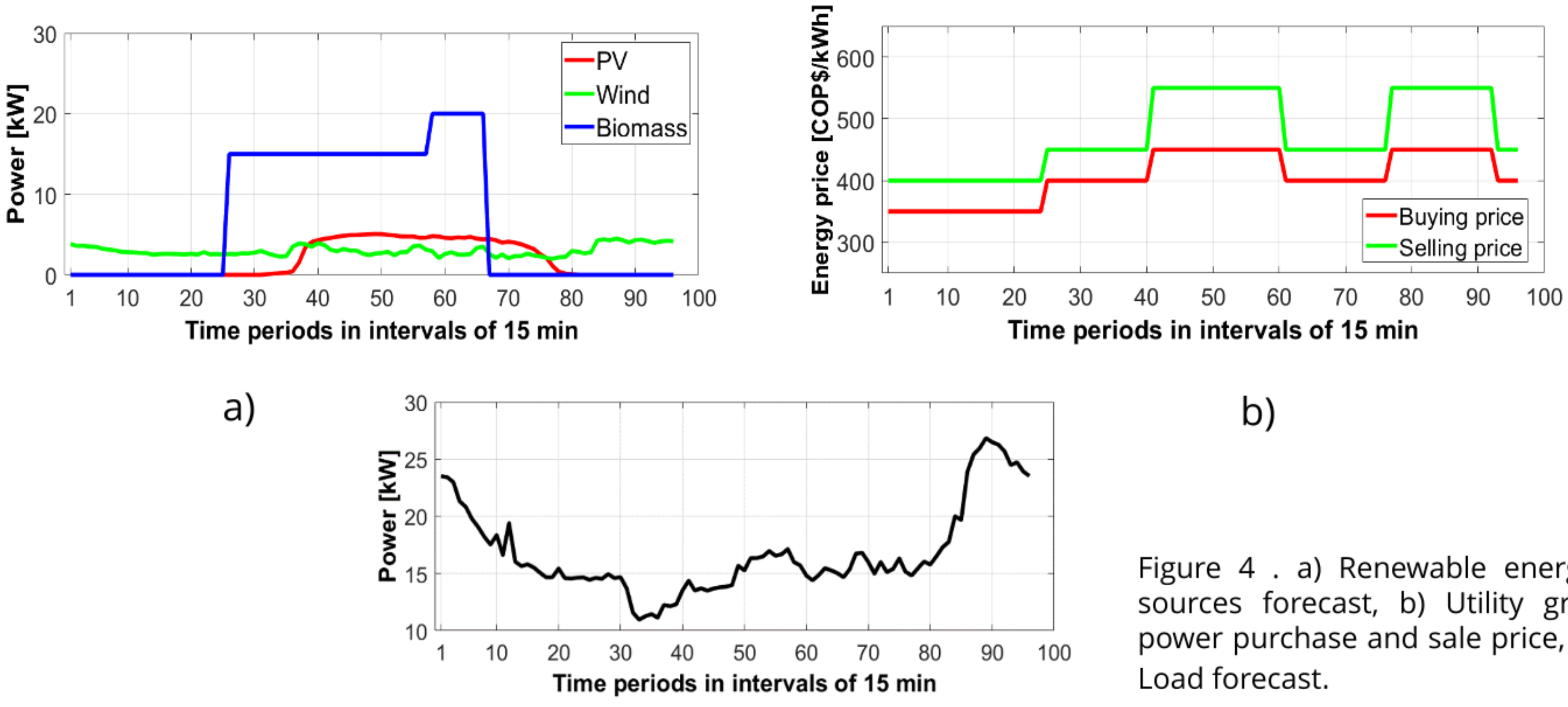
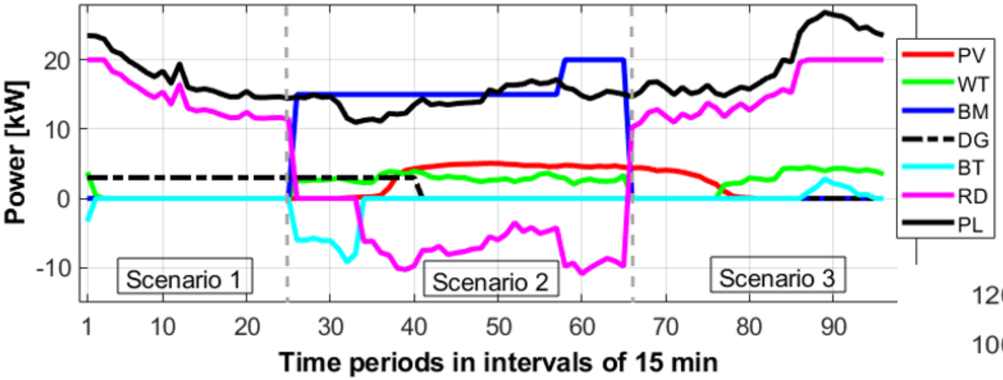


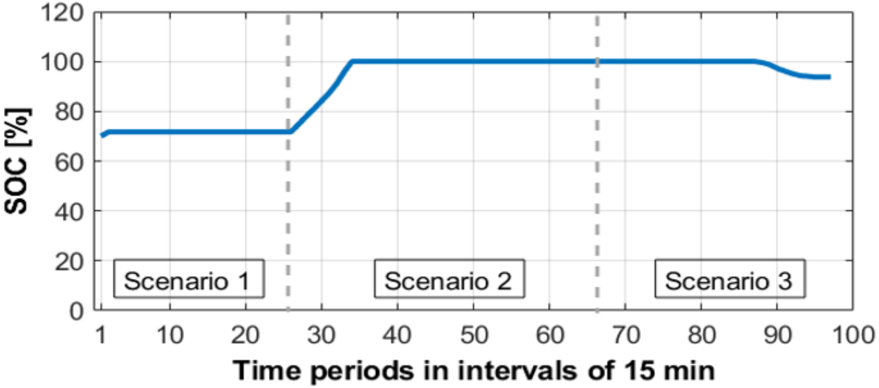

Figure 4 . a) Renewable energy sources forecast, b) Utility grid power purchase and sale price, c) Load forecast.

# III. Results

- Grid-Connected microgrid




a)

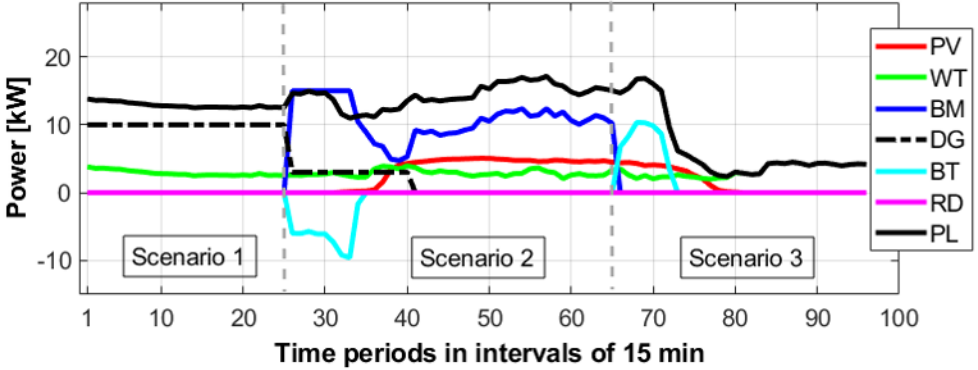



b)

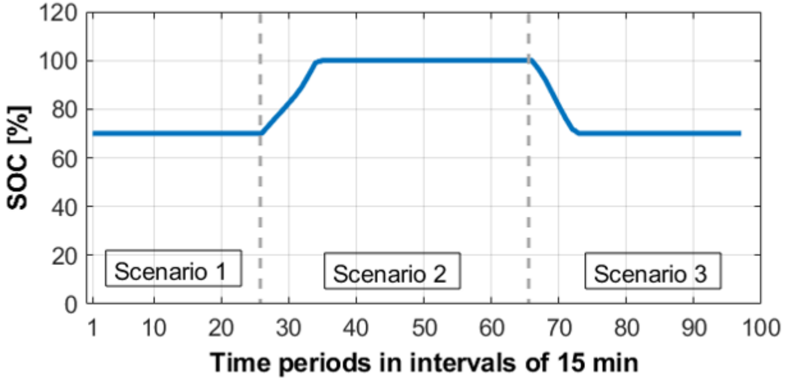
Figure 5 . a) Optimal power distribution, b) Battery state of charge for the grid-connected case

# III. Results

- Isolated Microgrid




a)




b

Figure 6. a) Optimal power distribution of the isolated microgrid, b) Battery state of charge for the isolated case.

# III. Results

- Isolated Microgrid

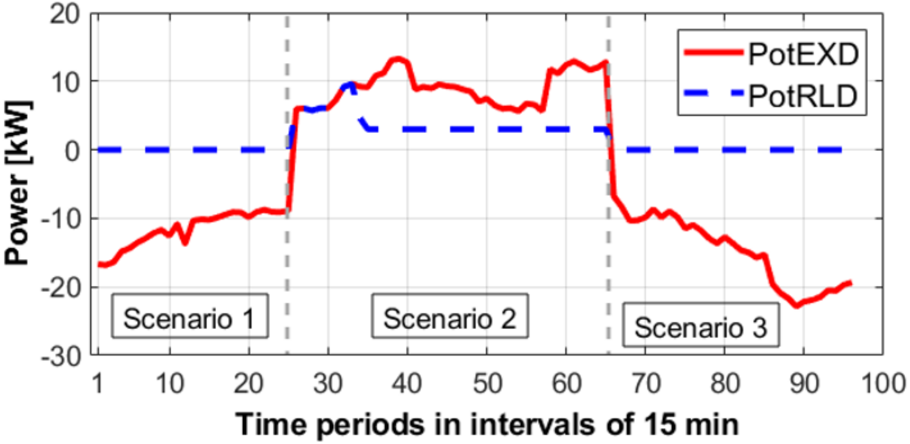



Figure 7. Demand response in isolated case

# IV. Conclusions.

For the microgrid connected to the utility grid, it can be seen that energy from the utility grid was used in scenarios where there was no generation surplus due to, in some cases, the fact that its price was lower than that of the other generation sources.

In the case of the isolated microgrid, the EMS performed well, complying with the restrictions established for each of the system's generators and maintaining the power balance.

The biomass source was essential to power both critical and non-critical loads at the times it was available to supply energy in both study cases

# V. References


- J. Shen, C. Jiang, Y. Liu, and X. Wang, “A Microgrid Energy Management System and Risk Management under an Electricity Market Environment,” IEEE Access, vol. 4, pp. 2349–2356, 2016.
- F. Z. Harmouch, N. Krami, and N. Hmina, “A multiagent based decentralized energy management system for power exchange minimization in microgrid cluster,” Sustain. Cities Soc., vol. 40, no. June 2017, pp. 416–427, 2018.
- F. Valencia et al., “Robust Energy Management System Based on Interval Fuzzy Models,” Ieee Trans. Control Syst. Technol., vol. 24, no. 1, pp. 140–157, 2016.
- Organización Latinoamericana de energía (OLADE)., “Informe de estadísticas energéticas,” 2006. [Online]. Available: http://biblioteca.olade.org/opac-tmpl/Documentos/old0104.pdf.
- Unidad de Planeación Minero Energética (UPME)., “Potencialidades de cultivos energéticos y residuos agrícolas en Colombia,” 2003. [Online]. Available: http://bdigital.upme.gov.co/handle/001/1287.
- Y. Zheng, B. M. Jenkins, K. Kornbluth, and C. Træholt, “Optimization under uncertainty of a biomass-integrated renewable energy microgrid with energy storage,” Renew. Energy, vol. 123, pp. 204–217, 2018.
- Y. Zheng, B. M. Jenkins, K. Kornbluth, A. Kendall, and C. Træholt, “Optimization of a biomass-integrated renewable energy microgrid with demand side management under uncertainty,” Appl. Energy, vol. 230, no. September, pp. 836–844, 2018.
- Y. Zheng, B. M. Jenkins, K. Kornbluth, A. Kendall, and C. Træholt, “Optimal design and operating strategies for a biomass-fueled combined heat and power system with energy storage,” Energy, vol. 155, pp. 620–629, 2018.
- S. Howell, Y. Rezgui, J. L. Hippolyte, B. Jayan, and H. Li, “Towards the next generation of smart grids: Semantic and holonic multi-agent management of distributed energy resources,” Renew. Sustain. Energy Rev., vol. 77, no. March, pp. 193–214, 2017.

# V. References


- F. Centeno, K. Mahkamov, E. E. Silva Lora, and R. V. Andrade, "Theoretical and experimental investigations of a downdraft biomass gasifier-spark ignition engine power system," Renew. Energy, vol. 37, no. 1, pp. 97–108, 2012.
- T. H. Jayah, L. Aye, R. J. Fuller, and D. F. Stewart, "Computer simulation of a downdraft wood gasifier for tea drying," Biomass and Bioenergy, vol. 25, no. 4, pp. 459–469, 2003.
- A. K. Sharma, "Equilibrium modeling of global reduction reactions for a downdraft (biomass) gasifier," Energy Convers. Manag., vol. 49, no. 4, pp. 832–842, 2008.
- D. Buttsworth, "Spark Ignition Internal Combustion Engine Modelling using Matlab." p. 41, 2002.
- S. Chalise, J. Sternhagen, T. M. Hansen, and R. Tonkoski, "Energy management of remote microgrids considering battery lifetime," Electr. J., vol. 29, no. 6, pp. 1–10, 2016.
- Zaheeruddin and M. Manas, "Renewable energy management through microgrid central controller design: An approach to integrate solar, wind and biomass with battery," Energy Reports, vol. 1, pp. 156–163, 2015.
- W. Shi, X. Xie, C. C. Chu, and R. Gadh, "Distributed Optimal Energy Management in Microgrids," IEEE Trans. Smart Grid, vol. 6, no. 3, pp. 1137–1146, 2015.
- M. Marzband, H. Alavi, S. S. Ghazimirsaeid, H. Uppal, and T. Fernando, "Optimal energy management system based on stochastic approach for a home Microgrid with integrated responsive load demand and energy storage," Sustain. Cities Soc., vol. 28, pp. 256–264, 2017.
- M. Elsied, A. Oukaour, T. Youssef, H. Gualous, and O. Mohammed, "An advanced real time energy management system for microgrids," Energy, vol. 114, pp. 742–752, 2016.

# VI. Questions.

Thanks for your attention