X SICEL 2021

Transición energética en la 4ta revolución industrial

Universidad Tecnológica de Pereira

Universidad Nacional de Colombia

Open Source Tool for Sizing Hybrid Islanded Microgrids in Colombia

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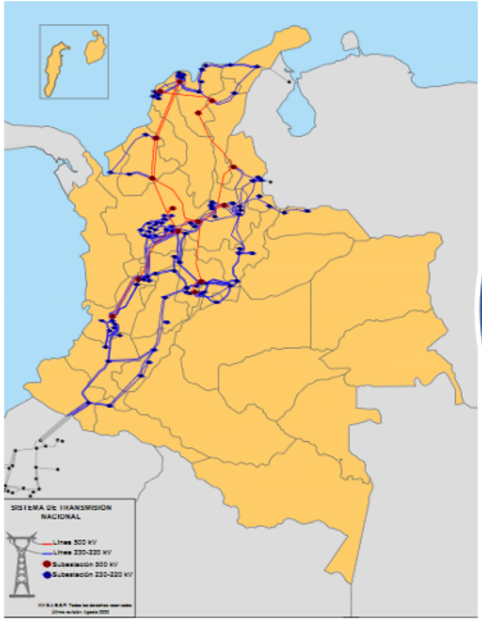
Institutions: Universidad de Antioquia

Contents

I. Introduction

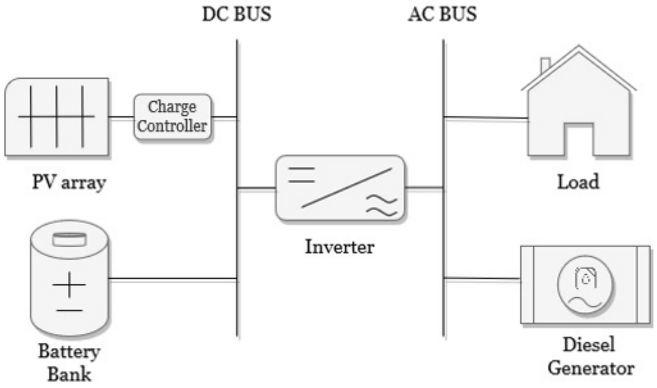
According IPSE (Institute for Planning and Promoting Energy Solutions for Non-Interconneted Zones) in Colombia:



National territory.	• **53 %**
Users with service.	• **228.295**
Users without service.	• **441.000**
Total capacity	• **299.394 kW**
Capacity of diesel	• **89%**
FNCER	• **11%**

II. Theoretical aspects

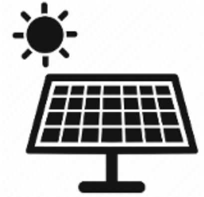
Architecture considered



optimization technique

Classical	Metaheuristics	Software
•LP •**MILP**	•MOGA, MOPSO, ABC, ACO, PSO, GA ...	•HOMER

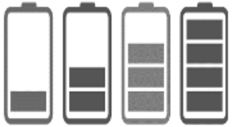
II. Theoretical aspects



$$Ppv_t = Npv \cdot Ppv_{stc} \cdot \frac{G(\beta,\alpha)}{Gstc} \cdot T \cdot fpv$$

$$T = \left(1 + \frac{\alpha_p}{100} \cdot (Tcell_t - Tstc)\right)$$

$$Tcell_t = Tamb + G(\beta,\alpha)_t \cdot \left(\frac{NOCT - 20}{800}\right)$$



$$SoC_t = (1-\sigma) \cdot SoC_{t-1} + Ebat_t^{+} \cdot \eta_c - Ebat_t^{-} / \eta_{inv}$$

$$Ebatn = Nbat \cdot Pbat_{cell}$$

$$N_{bat} = Nb_p \cdot Nb_s$$

$$N_{bs} = \frac{Vdc_{sist}}{Vdc_{bc}} \qquad B_{cycles} = \frac{\sum_{t \in T} Ebat_t^{-}}{Ebatn}$$

$$SoC^{\max} = Ebatn$$

$$SoC^{\min} = Ebatn \cdot (1 - DOD^{\max})$$

$$Pdg = \eta_{dg} \cdot Pdg^{rate} \cdot Ndg$$

$$Fdg_i = \sum_{i=1}^{N} a_i + b_i \cdot Pdg_i + c_i \cdot Pdg_i^{2}$$

II. Theoretical aspects

Objetive function:

$$\sum_{t\in T} \begin{array}{c} cpv \cdot (Ppv_t + Pbat_t^{pv}) + \\ cdg \cdot (Pdg_t + Pbat_t^{dg}) + \\ cbat \cdot Ebat_t^{-} + cens \cdot PENS_t \end{array}$$

Reliability constraint:

$$\frac{\sum_{t\in T} P_{ENS,t}}{\sum_{t\in T} P_{load,t}} \leq LPSP^{\max}$$

Meet the load.

$$Ppv_t + Pdg_t + Ebat_t^{-} + PENS_t = Pload \ \forall t \in T$$

Photovoltaic panel output:

$$Ppv_t + Pbat_t^{pv} \leq Ppv_t^{\max}$$

$$Ppv_t + Pbat_t^{pv} \geq Ppv_t^{\min}$$

$$Pbat_t^{pv} \leq Ppv_t^{\max} - Ppv_t$$

Diesel generator output:

$$Pdg_t + Pbat_t^{dg} \leq Pdg^{rate} \cdot Bdg_t$$

$$Pdg_t + Pbat_t^{dg} \geq Pdg_t^{\min} \cdot Bdg_t$$

$$Pbat_t^{dg} \leq Pdg^{rate} - Pdg_t$$

Battery bank State Of Charge:

$$SoC^{\min} \leq SoC_t \leq SoC^{\max}$$

Battery Bank Charge and Discharge constraints.

$$Ebat_t^{+} = Pbat_t^{pv} + Pbat_t^{dg} \cdot \eta_{inv}$$

$$Mb \cdot Bc_t \leq Ebat_t^{+} \leq E\max \cdot Bc_t$$

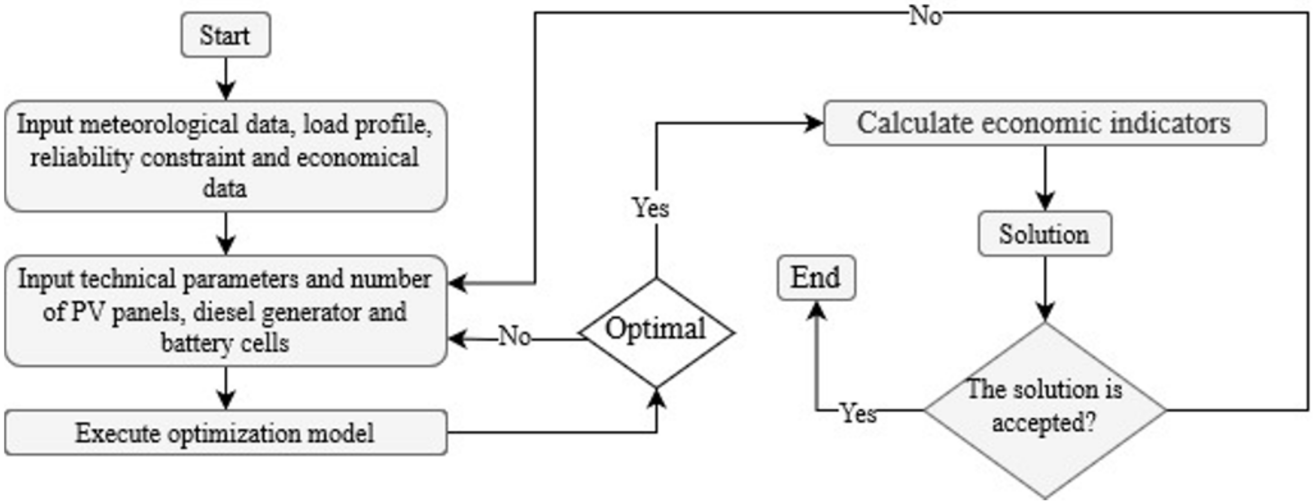
$$Mb \cdot Bd_t \leq Ebat_t^{-} \leq E\max \cdot Bd_t$$

$$Ebat_t^{-} \leq SoC_t - SoC^{\min}$$

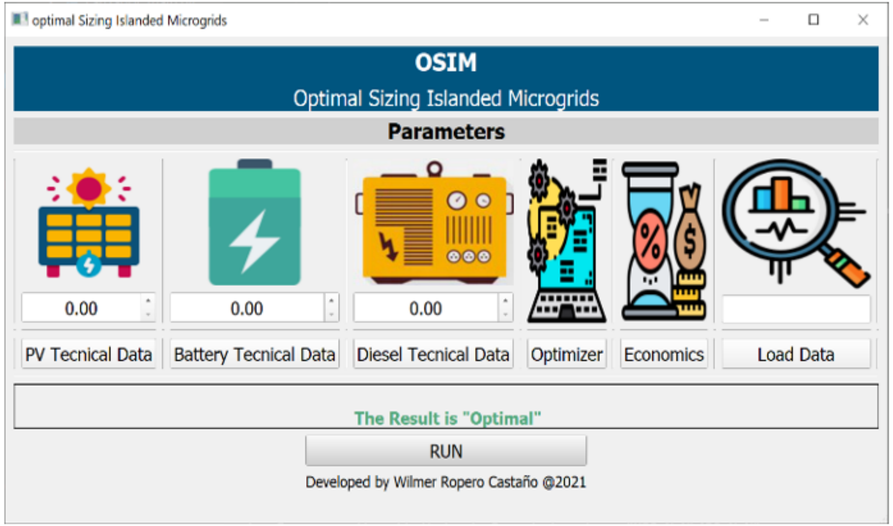
$$Ebat_t^{+} \leq SoC^{\max} - SoC_t$$

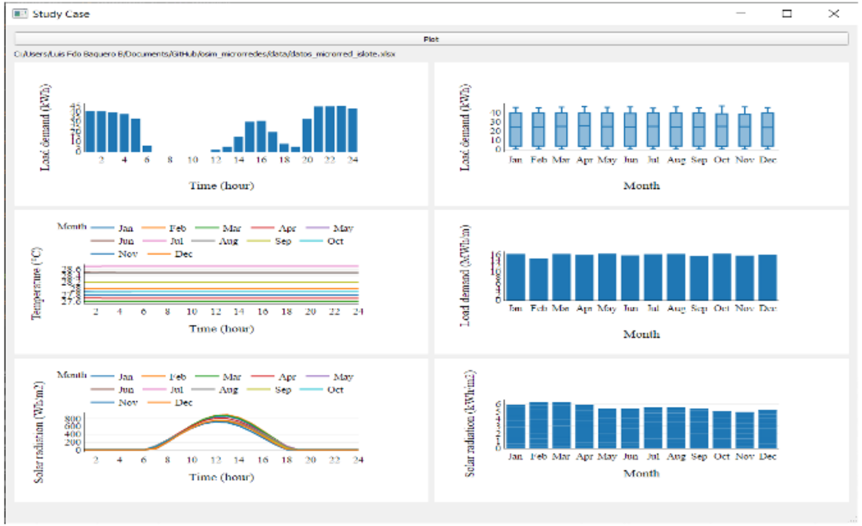
$$B_{cycles} \leq cycles^{\max}$$

III. Proposed methodology



IV. Results





https://github.com/osim-microgrid-tool/osim_islanded_microgrids_sizing.

IV. Results

PV

Parameters PV	
Maximum Power Wp	300.0000
Module Efficiency(%)	0.1833
NOCT(◦C)	0.4500
Price per kWh generated(USD/kWh)	0.0030
Photovoltaic derating factor(%)	0.8500
O&M factor initial investment(%)	0.0100
Price per kW installed (USD/kW)	1.5000
Power Temperature Coefficient (%/◦C	-0.3900

Save

Diesel Generator

Parameters Diesel Generator	
Price per kWh installed(USD/kW)	95.5000
Minimum ratio allowed	0.7500
Diesel efficiency(%)	1.0000
Price per kWh generated(USD/kWh)	0.2200
Factor of the initial capital cost invested(%	0.7000
Specific consumption of fuel(gal/kWh)	0.0974
Specific consumption of oil(gal/kWh)	0.0005
Lifecycle(years)	10.0000
Average price of oil(USD/gal)	21.4000
Average price of fuel(USD/gal)	2.4000

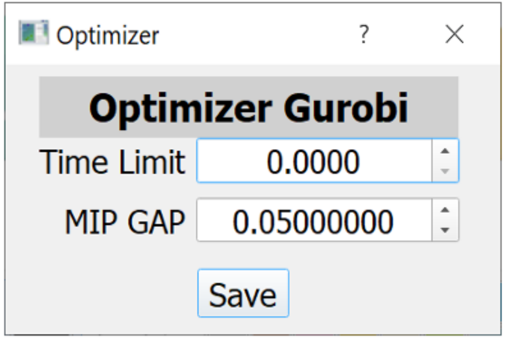
Save

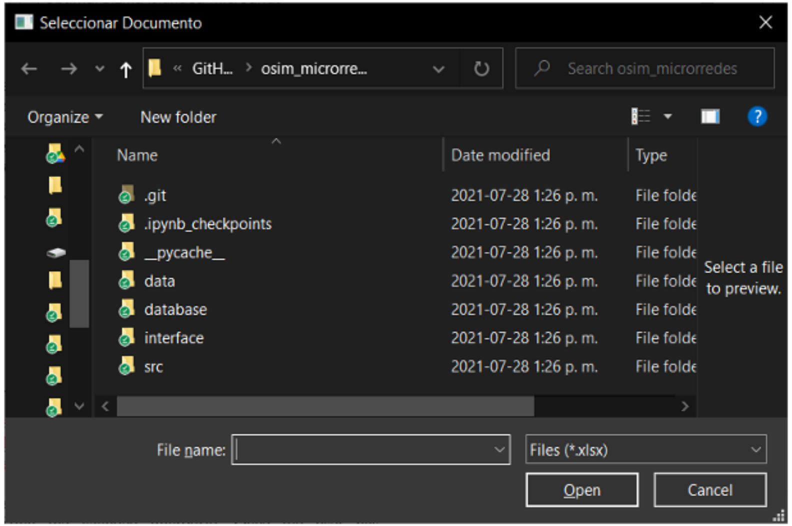
Battery

Parameters Battery			
Positive battery constant	0.0100	Battery Voltage (V)	2.0000
Self-Discharge rate	0.2000	Inverter efficiency(%)	0.9500
Capacity Rate(h)	5.0000	O&Mfactor initial investment(%)	0.0200
Maximum depth of discharge(%)	0.5000	actor initial capital cost invested(%)	0.7000
Maximum number of cycles	3000.0000	Lifecycle(years)	10.0000
rice per kWh generated(USD/kWh)	0.1200	Price per kWh installed(USD/kW)	61.4000
Battery cell capacity(kW)	0.8400	Discharge efficiency(%)	1.0000
DC system voltage (V)	48.0000	Charge efficiency(%)	0.9000

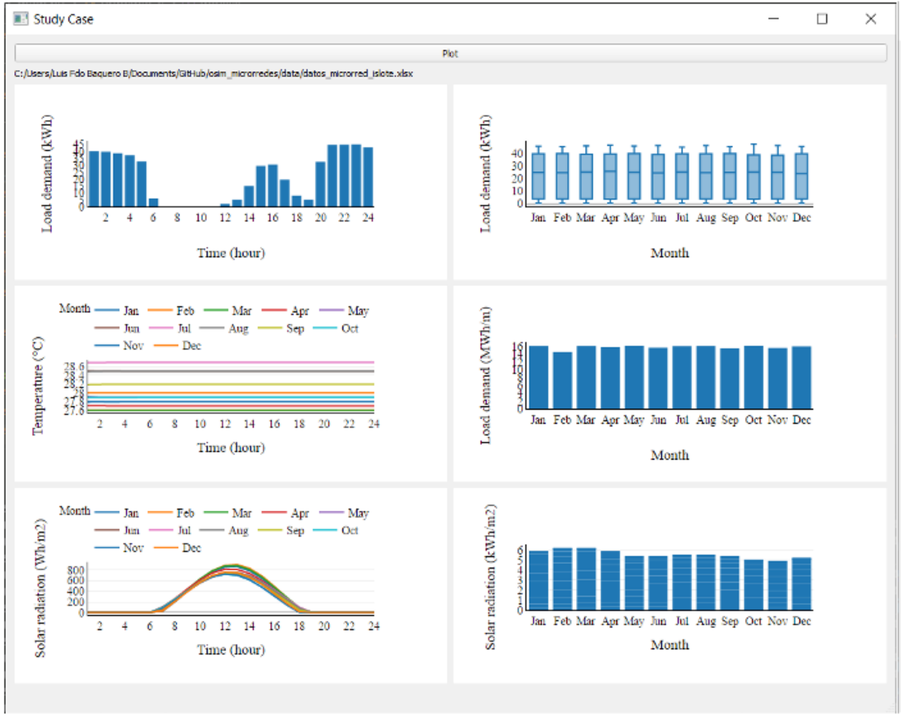
Save

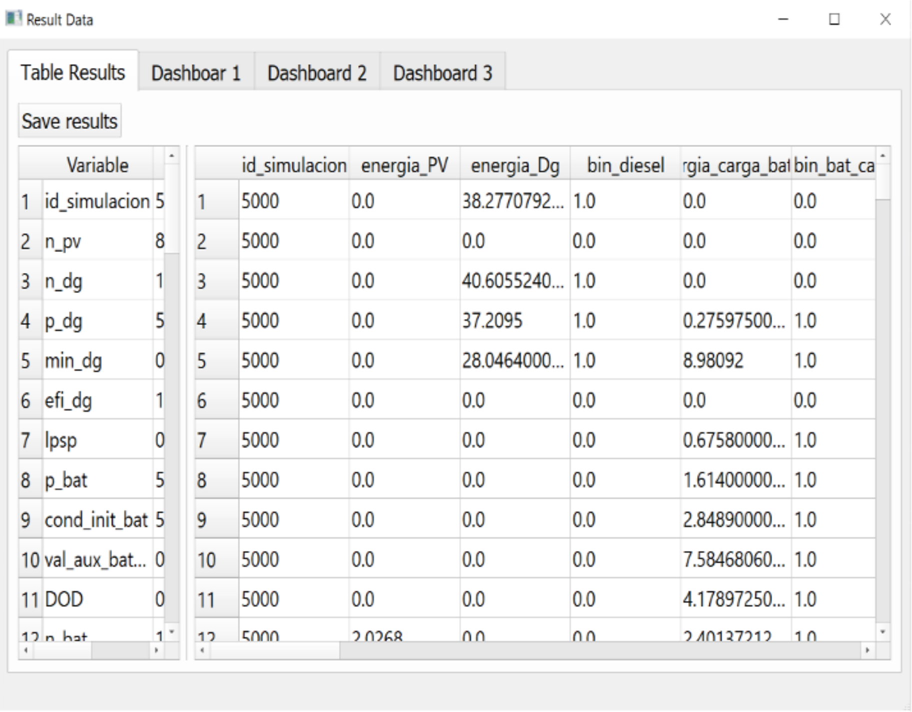
IV. Results


Optimizer
Optimizer Gurobi
Time Limit
0.0000
MIP GAP
0.05000000
Save

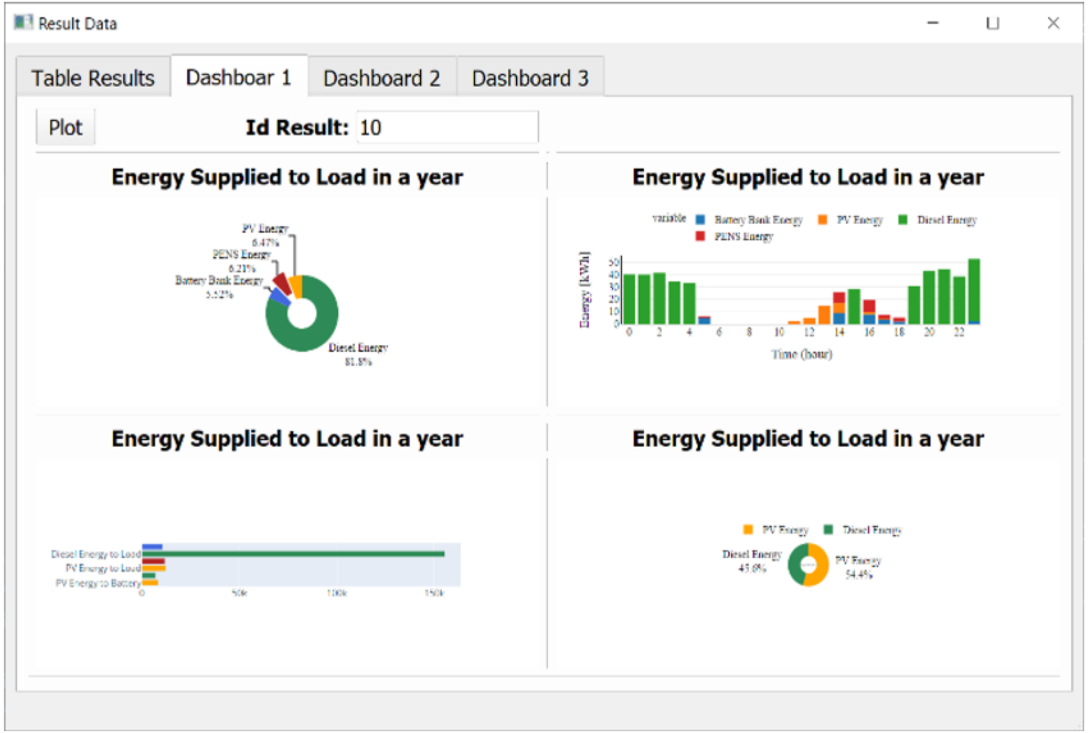

Seleccionar Documento
GitH...
osim_microrre...
Search osim_microrredes
Organize
New folder
Name
Date modified
Type
.git
.ipynb_checkpoints
__pycache__
data
database
interface
src
2021-07-28 1:26 p. m.
File folde
Select a file to preview.
File name:
Files (*.xlsx)
Open
Cancel

IV. Results

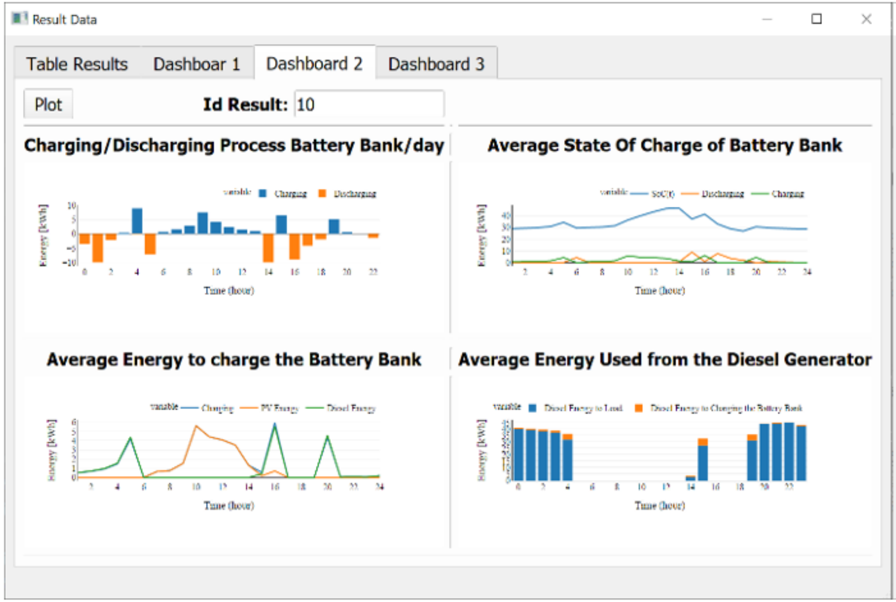

Study Case
Plot
C:/Users/Luis Fdo Baquero B/Documents/GitHub/osim_microrredes/data/datos_microrred_islote.xlsx
Load demand (kWh)
Time (hour)
Load demand (kWh)
Month
Month
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Temperature (°C)
Time (hour)
Load demand (MWh/m)
Month
Solar radiation (Wh/m2)
Time (hour)
Solar radiation (kWh/m2)
Month


Result Data
Table Results
Dashboar 1
Dashboard 2
Dashboard 3
Save results
Variable
1 id_simulacion 5
2 n_pv 8
3 n_dg 1
4 p_dg 5
5 min_dg 0
6 efi_dg 1
7 lpsp 0
8 p_bat 5
9 cond_init_bat 5
10 val_aux_bat... 0
11 DOD 0
12 n_bat 1
id_simulacion energia_PV energia_Dg bin_diesel rgia_carga_bat bin_bat_ca
1 5000 0.0 38.2770792... 1.0 0.0 0.0
2 5000 0.0 0.0 0.0 0.0 0.0
3 5000 0.0 40.6055240... 1.0 0.0 0.0
4 5000 0.0 37.2095 1.0 0.27597500... 1.0
5 5000 0.0 28.0464000... 1.0 8.98092 1.0
6 5000 0.0 0.0 0.0 0.0 0.0
7 5000 0.0 0.0 0.0 0.67580000... 1.0
8 5000 0.0 0.0 0.0 1.61400000... 1.0
9 5000 0.0 0.0 0.0 2.84890000... 1.0
10 5000 0.0 0.0 0.0 7.58468060... 1.0
11 5000 0.0 0.0 0.0 4.17897250... 1.0
12 5000 2.0268 0.0 0.0 2.40137212 1.0

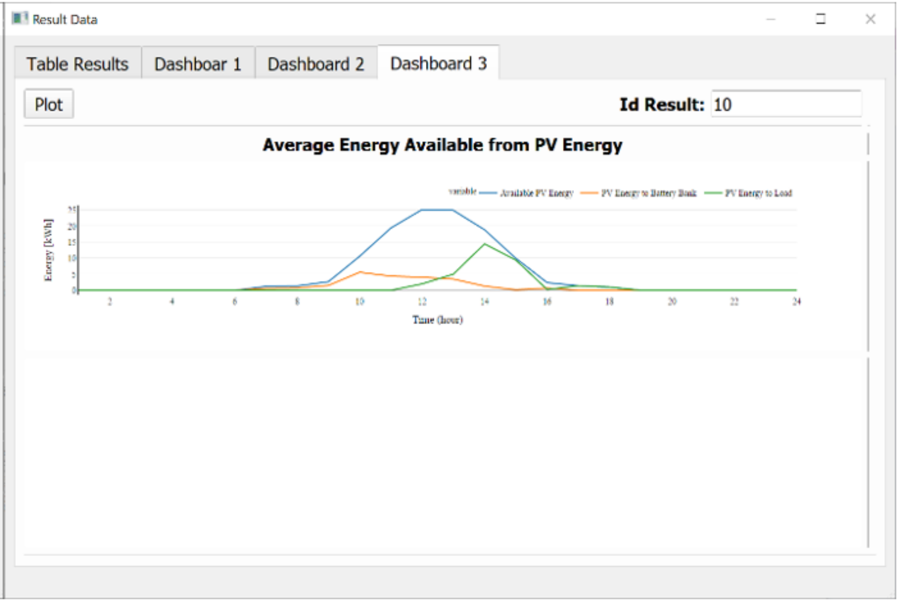
IV. Results


Result Data
Table Results
Dashboard 1
Dashboard 2
Dashboard 3
Plot
Id Result: 10
Energy Supplied to Load in a year
Energy Supplied to Load in a year
Energy Supplied to Load in a year
Energy Supplied to Load in a year
Time (hour)
Energy [kWh]

IV. Results



Result Data
Table Results
Dashboar 1
Dashboard 2
Dashboard 3
Plot
Id Result: 10
Charging/Discharging Process Battery Bank/day
Average State Of Charge of Battery Bank
Average Energy to charge the Battery Bank
Average Energy Used from the Diesel Generator
Time (hour)



Result Data
Table Results
Dashboard 1
Dashboard 2
Dashboard 3
Plot
Id Result: 10
Average Energy Available from PV Energy
Time (hour)

IV. Results

In table it is shown the result to supply the energy demand of the community of “Santa Cruz del Islote” located in Bolivar, Colombia. This community has a high demand of energy at night and has a median of consumption of 24 kWh and a maximum of 47 kWh in October. The solar radiation is over 800 Wh/m^2 in March.

Main Results		
Variable	**Unit**	**Value**
Number of PV cell	Units	80
Battery Bank	kW	50.4
Diesel Genset Capacity	kW	50
Loss of Power Supply Probability	%	6.21

V. Conclusions

- In this paper was developed a open-source tool for sizing islanded MGs which includes solar and diesel generator, and batteries.
- This tool considers a deterministic optimization model.
- The optimization model considers the technical constraint of battery like maximum cycles allowed of charging and discharging.
- The reliability of the system was included as a constraint on the optimization model and the energy no supplied to the load was treated as a variable with a high cost in the objective function.
- It is possible to visualize the results in a friendly dashboard that can help to the users in the decision making by the easy configuration and visualization of results.

VI. Questions