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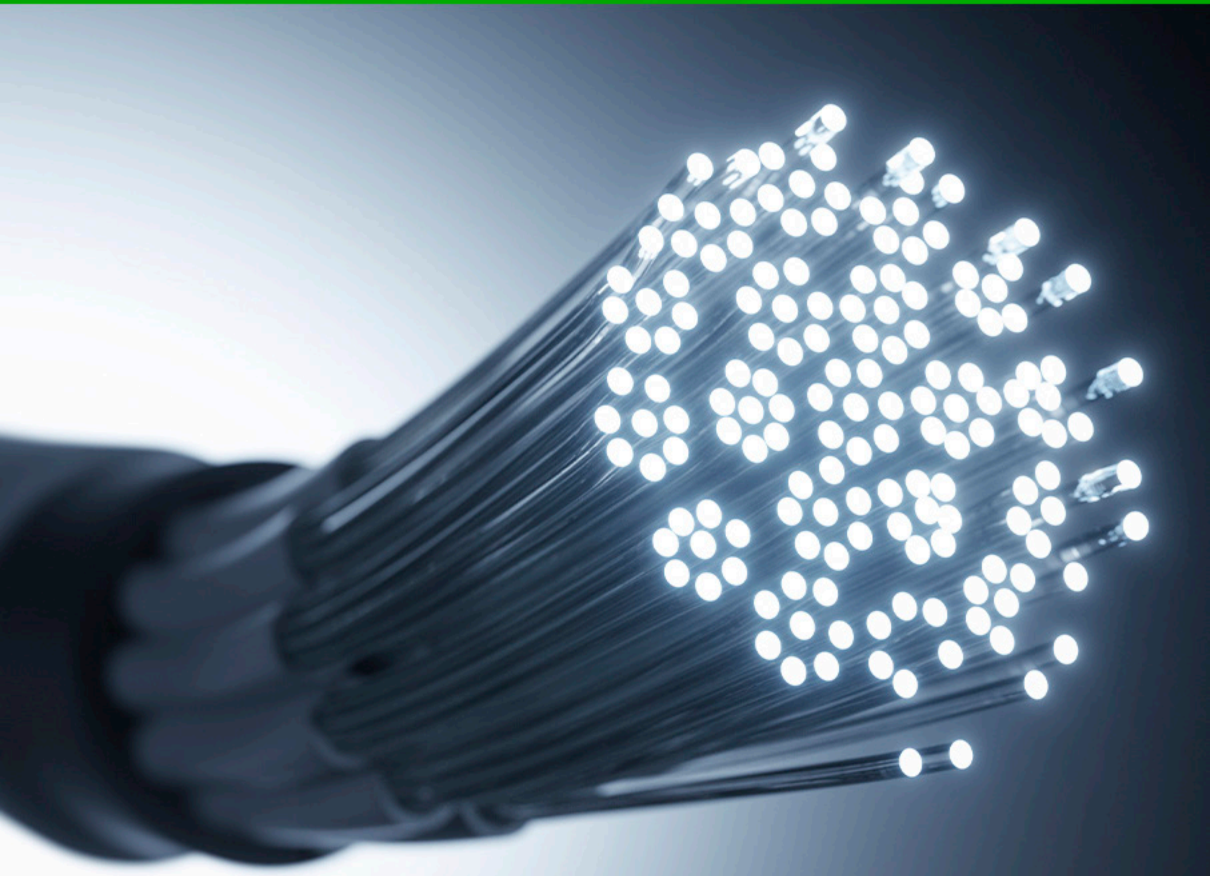
DESAFIOS DAS ENGENHARIAS:

ENGENHARIA ELÉTRICA 2



JOÃO DALLAMUTA
HENRIQUE AJUZ HOLZMANN
(ORGANIZADORES)

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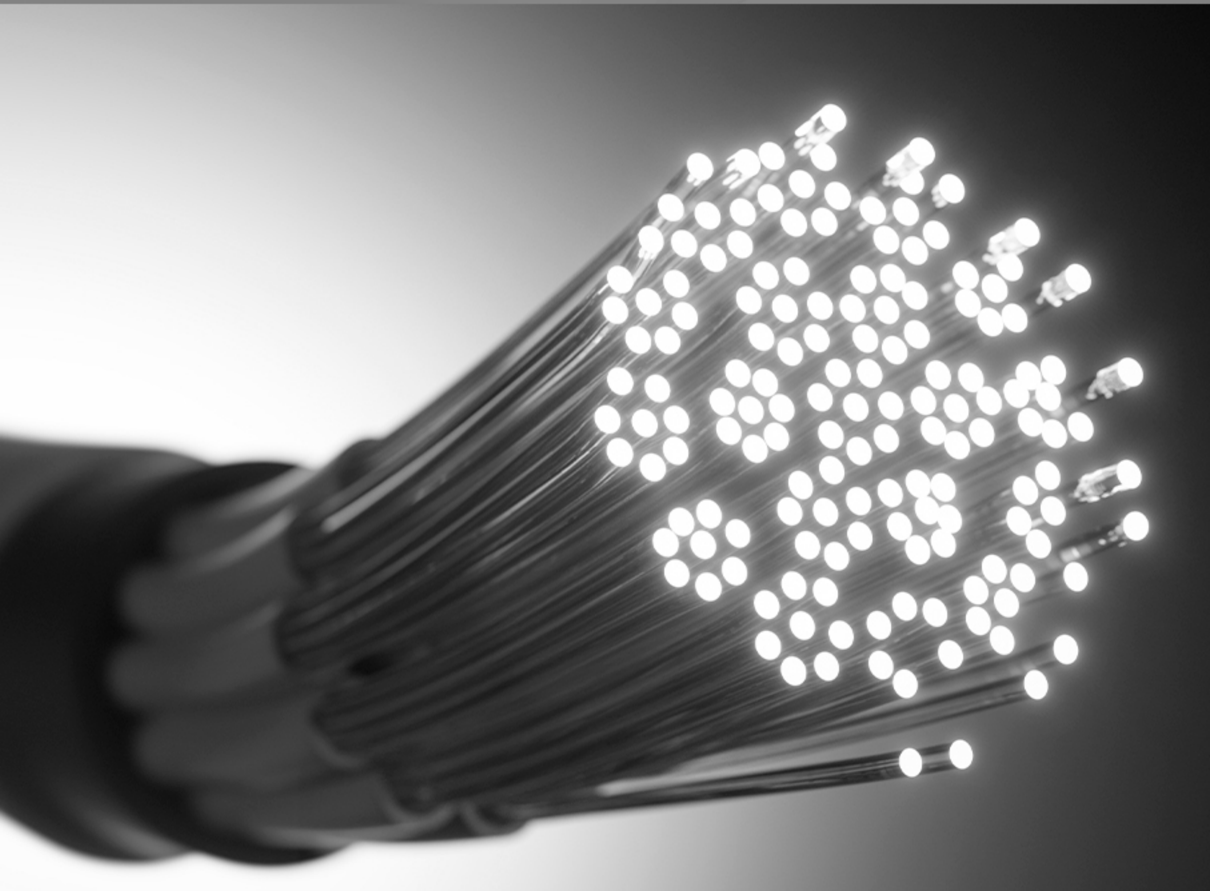

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Ciências Exatas e da Terra e Engenharias

Coleção desafios das engenharias: engenharia elétrica 2

Diagramação: Daphynny Pamplona
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Revisão: Os autores
Organizadores: João Dallamuta
Henrique Ajuz Holzmann

Dados Internacionais de Catalogação na Publicação (CIP)

C691 Coleção desafios das engenharias: engenharia elétrica 2 / Organizadores João Dallamuta, Henrique Ajuz Holzmann. – Ponta Grossa - PR: Atena, 2021.

Formato: PDF
Requisitos de sistema: Adobe Acrobat Reader
Modo de acesso: World Wide Web
Inclui bibliografia
ISBN 978-65-5983-556-0
DOI: https://doi.org/10.22533/at.ed.560211910

1. Engenharia elétrica. I. Dallamuta, João (Organizador). II. Holzmann, Henrique Ajuz (Organizador). III. Título.

CDD 621.3

Elaborado por Bibliotecária Janaina Ramos – CRB-8/9166

Atena Editora
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APRESENTAÇÃO

A engenharia elétrica tornou-se uma profissão há cerca de 130 anos, com o início da distribuição de eletricidade em caráter comercial e com a difusão acelerada do telégrafo em escala global no final do século XIX.

Na primeira metade do século XX a difusão da telefonia e da radiodifusão além do crescimento vigoroso dos sistemas elétricos de produção, transmissão e distribuição de eletricidade, deu os contornos definitivos para a carreira de engenheiro eletricista que na segunda metade do século, com a difusão dos semicondutores e da computação gerou variações de ênfase de formação como engenheiros eletrônicos, de telecomunicações, de controle e automação ou de computação.

Produzir conhecimento em engenharia elétrica é portando pesquisar em uma gama enorme de áreas, subáreas e abordagens de uma engenharia que é onipresente em praticamente todos os campos da ciência e tecnologia.

Neste livro temos uma diversidade de temas, níveis de profundidade e abordagens de pesquisa, envolvendo aspectos técnicos e científicos. Aos autores e editores, agradecemos pela confiança e espirito de parceria.

João Dallamuta

Henrique Ajuz Holzmann

SUMÁRIO

CAPÍTULO 5

STRATEGIES OF VOLTAGE CONTROL BASED IN FUZZY LOGIC ALGORITHMS WITH ALTERNATIVE, CLEAN AND RENEWABLE GENERATION OPERATING WITH ANOTHER CONVENTIONAL ELECTRIC GENERATION IN WITH RADIAL LOADS IN POWER SYSTEMS STABILITY

Data de aceite: 01/10/2021
Data de submissão: xx/08/2021

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ABSTRACT: The energy extracted from petroleum-derived fuels is becoming more expensive and of difficult availability. When these materials are transformed into electrical energy, they radiate heat energy and as a consequence of this combustion, pollutes the environment. On the other hand, having water resources is not easy when they are not available and cannot be processed in their natural form. It should be noted that the Electricity Generation from the Nuclear reaction of radioactive elements is very expensive. It is true that with a small percentage of atomic fuel, heat energy can be generated more than 1000 times than the usual fuels. Consequently, the use of this kind of energy requires greater care in handling it. The radioactive waste generated by this atomic reaction cannot be destroyed, it can only be stored away from natural life. There are many methods of creating Clean Electric Energy, from Renewable Resources such as water, wind, biomass, Solar Light, static energy stores, etc. These methods make the production of clean electrical energy moderately expensive. Unless there is a specific and mandatory regulation of a Central Government for the use of this type of Generation and interconnected to the National Electricity Network. This Electrical Interconnection should be done in an interesting way in terms of economics and the Stability of the Electrical Power System. In this research, a portion of an Electric Power Transmission Subsystem is used for the study; electrically located towards the North-West of the main “Electric Center” of the National Electricity Network. A photovoltaic plant of 50MWp of capacity in alternating current, and a Battery Energy Storage System of 15MW in direct current were introduced, where there are very long Transmission Lines, Electrical Substations with very radial loads. In this part of the electrical network, the Diesel Generation is usually a necessity, both to supply feeder loads as well as to control Voltage at times of maximum demand. This power system is normally connected to the National Electricity Network.

KEYWORDS: Fuzzy logic, voltage control, artificial intelligence.

ESTRATÉGIAS DE CONTROLE DE TENSÃO BASEADAS EM ALGORITMOS DE LÓGICA FUZZY COM GERAÇÃO ALTERNATIVA, LIMPA E RENOVÁVEL OPERANDO COM OUTRA GERAÇÃO ELÉTRICA CONVENCIONAL COM CARGAS RADIAIS NA ESTABILIDADE DE SISTEMAS DE ENERGIA

RESUMO: A energia extraída dos combustíveis derivados do petróleo estão-se tornando mais cara e de difícil disponibilidade. Quando esses materiais são transformados em energia elétrica, eles irradiam energia térmica e, como consequência dessa combustão, poluem o meio ambiente. Por outro lado, ter recursos hídricos não é fácil quando eles não estão disponíveis e não possam ser processados em sua forma natural. Deve-se notar que a Geração da Eletricidade a partir da reação nuclear de elementos radioativos é muito custosa. É verdade que com uma pequena porcentagem de combustível atômico, a energia térmica pode ser gerada mais de 1000 vezes do que os combustíveis usuais. Consequentemente, o uso desse tipo de energia requer maior cuidado em sua manobra. O lixo radioativo gerado por esta reação atômica não pode ser destruído, só pode ser armazenado longe da vida natural. Existem muitos métodos de geração de energia elétrica limpa, a partir de recursos renováveis, como água, vento, biomassa, luz solar, armazenamento de energia estática, etc. Esses métodos tornam a produção da energia elétrica limpa moderadamente custosa. Exceto regulamentação específica e obrigatória de Governo Central para a utilização desta modalidade de Geração e interligada à Rede Elétrica Nacional. Esta Interligação Elétrica deve ser feita de forma interessante em termos de Economia e Estabilidade do Sistema Elétrico de Potência. Nesta pesquisa, uma parte do Subsistema de Transmissão de Energia Elétrica é usada para o estudo; localizado eletricamente a Noroeste do principal "Centro Elétrico" da Rede Elétrica Nacional. Foi introduzida uma central fotovoltaica de 50MWp de capacidade em corrente alternada e um Sistema de Armazenamento de Energia a Baterias de 15MW em corrente contínua, onde existem Linhas de Transmissão muito longas, Subestações Elétricas com cargas muito radiais. Nesta parte da rede elétrica, a Geração Diesel costuma ser uma necessidade, tanto para suprir cargas dos alimentadores quanto para controlar a Tensão nos momentos de máxima demanda. Este sistema de energia é normalmente conectado à Rede Nacional de Eletricidade.

PALAVRAS-CHAVE: Fuzzy Logic, controle da Tensão, Inteligência Artificial.

1 | GENERAL INTRODUCTION

In this part of the research, based on the previous studies, we will include the Bidirectionality of the equipment, the flywheels of inertia and we will analyze the results to advance towards the investigations of renewable energy (specifically Solar Light) with PVP. The main objective of this study is to determine the best management of the reactive power for optimal voltage control at strategic points where the stresses are being felt. The secondary objective is to use the resources available in the power system under study. All the signals that will go to the control sensors (primary and secondary voltage controls, generation prices) through a powerful and versatile artificial intelligence (AI) tool; such as complex fuzzy logic (FL) decision algorithms.

Electromechanical Characteristics

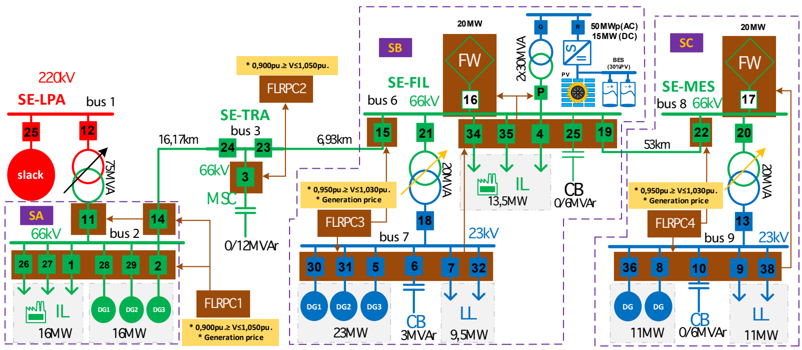

Figure 1. PES in studies with injection NES, DG, PVP and BESS.

ELECTRICAL SUBSTATION

It remains practically the same, except for the 50MWp (AC) and 15MW (DC) PVP and BES [23] System respectively, connected directly to the SE-FIL 66kV bus load center.

TRANSMISSION LINES

In general terms, the Transmission Lines did not suffer great variations.

GENERATION

As for the Generation, it was fully adapted with GD. Electric Substation has its own DG, requesting to operate without interconnection with the NEN, to operate in Islands or to operate in fully autonomous and independent Sub-Islands. The Electric Generators (Diesel) and (Gas) are distributed in 66kV and 23kV, very close to the Load. One PVP and BES [23] System will be connected directly to the bus of SE-FIL 66kV.

POWER TRANSFORMERS

In general terms, the Power Transformers of system in study did not suffer great variations. In the SE-FIL, the PT that will serve as the source for PVP and BESS [23] [24] will be two (2) of 66 / 23kV of 30MVA each.

COMPENSATION

A flywheel is added to the SE-FIL and SE-MES to accelerate or brake under-frequency or over-frequency respectively and of an electrodynamic nature.

LOADS

In general terms, the Loads of system in study did not suffer great variations [22]. *The loads and DG were divided into parts equal or proportional to the loads of each SE in order to facilitate the practicality, performance and academic analysis of the systems under study.*

COMMERCIAL FEATURES

In this part it was not investigated in depth contractual, but obviously the regulation of buying and / or selling the energy of the NEN, Diesel, Gas or Solar must be studied. This research focuses directly on the Voltage Stability of the SEP under study.

CURRENT CONTROL ACTIONS FOR THE OPERATION OF THE ELECTRICITY NETWORK

Currently the control actions are carried out by varying the voltages of the neighboring SE. Load shedding according to need or making a connection in parallel with a Generator Distributed (DG) and PVP/BES system during convenience operative or temporarily during times of high demand or bad weather. All this information would be processed thanks to the programming and intervention of the MATLAB® FUZZY DESIGN [21] to carry out similar decisions.

The actions of control of Voltage and Operation of the electromechanical equipment would be left to the decision of the FLPRC strategically located throughout the study PES.

PHOTOVOLTAIC POWER PLANT AND BATTERY [24] ENERGY STORAGE SYSTEM (PREVISION)

To the SEP studied, a PVP and BES [23] systems are added in the Electric Power Transmission Levels format, directly connected to the 66kV bus of the SE-FIL, as shown in figure 29.

THE FOLLOWING DATA WERE EXTRACTED FROM SOLARGIS®

Dates in [15]

Global tilted irradiation Yearly average: 5,418 kwh/m^2 per day.

Air temperature Yearly average: 25°C.

Specific photovoltaic power output Yearly average: 4,284 kwh/m^2 per day.

Performance ratio Yearly average: 79,1%.

Address: Filadelfia, Boquerón, Paraguay.

Geographical coordinates: -22,380451°,-060,03574°

Time zone: UTC-04, America/Asuncion [PYT].

Elevation: 139m.

Land cover: Mosaic cropland (>50%) / natural vegetation.

Population density: 1inh./km^2.

Terrain azimuth: flat.

Terrain slope: 0°.

Below are pictures of project horizon and sun path. Also, they are detailed in the image of day length and solar zenith angle.

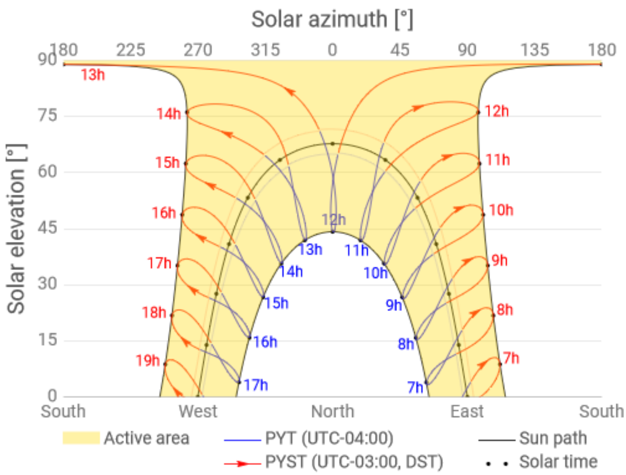

Figure 2. Project horizon and sun path. Adapted from [15].

In the same way, were obtained, the data of the Solar Energy Potential and Meteorology.

Global horizontal irradiation (GHI): 5,139 kWh/m^2 per day.

Direct normal irradiation (DNI): 4,707 kWh/m^2 per day.

Diffuse horizontal irradiation (DIF): 2,010 kWh/m^2 per day.

Ratio of diffuse to global irradiation (D2G): 0,391.

Air temperature: 24,7°C.

Cooling degree days (CDD): 2.527 degree days.

Heating degree days (HDD): 70 degree days.

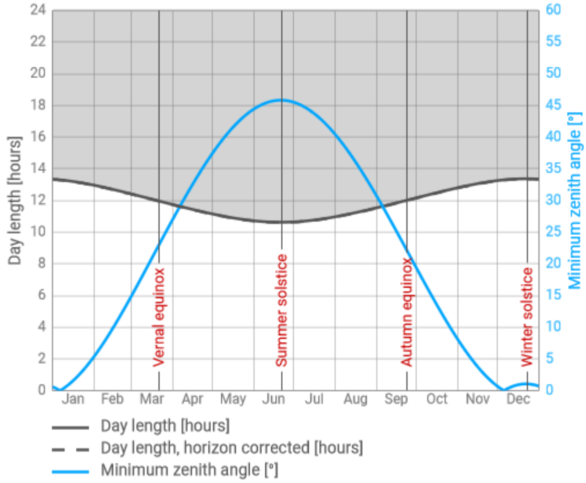

Figure 3. Day length and solar zenith angle. Adapted from [15].

On the other hand are shown, but from the same information source [15], the Photovoltaic Electricity data and its performance.

Specific photovoltaic power output (PVOUT specific): 4,284 kWh/kWp per day.

Total photovoltaic power output (PVOUT total): 78.189.816,6 kWh

Global tilted irradiation (GTI theoretical): 5,418 kWh/m2 per day.

Long-Term PV Power Potential Data (25-Year Average) from the same information source [15].

Specific photovoltaic power output: 4,005 kWh/kWp per day.

Total photovoltaic power output: 73.084.033,5 kWh.

Performance ratio: 73,9 %

Capacity factor: 16,7 %

GLOSSARY

- ***Cooling degree days:*** Quantifies energy demand needed to cool a building. "Cooling degree days" are a measure of how much (in degrees), and for how long (in days), outside air temperature was higher than a specific base daily average temperature (18°C). Yearly and monthly values are aggregated from daily values
- ***Capacity factor:*** The ratio of an actual electrical energy output over a year to the maximum possible electrical energy output over a year expressed in %. The maximum possible power production is the AC installed capacity times the number of hours in a year, while the actual production is the amount of electricity delivered annually from the project.
- ***Ratio of diffuse to global irradiation:*** Ratio of diffuse horizontal irradiation and

global horizontal irradiation (DIF/GHI).

- ***Diffuse horizontal irradiation:*** Average yearly, monthly or daily sum of diffuse horizontal irradiation.
- ***Direct normal irradiation:*** Average yearly, monthly or daily sum of direct normal irradiation.
- ***Global horizontal irradiation:*** Average annual, monthly or daily sum of global horizontal irradiation.
- ***Global tilted irradiation**:* Average annual, monthly or daily sum of global tilted irradiation.
- ***Global tilted irradiation (theoretical):*** Average annual, monthly or daily sum of global tilted irradiation without consideration of terrain shading.
- ***Heating degree days:*** Quantifies energy demand needed to heat a building. "Heating degree days" are a measure of how much (in degrees), and for how long (in days), outside air temperature was lower than a specific base daily average temperature (18°C). Yearly and monthly values are aggregated from daily values.
- ***Performance ratio:*** Ratio between specific AC electricity output of a PV system and global tilted irradiation received by the surface of a PV array (PVOUTspecific/GTI).
- ***Specific photovoltaic power output:*** Yearly and monthly average values of photovoltaic electricity (AC) delivered by a PV system and normalized to 1 kWp of installed capacity.
- ***Total photovoltaic power output:*** Yearly and monthly average values of photovoltaic electricity (AC) delivered by the total installed capacity of a PV system.
- ***Air temperature:*** Average yearly, monthly and daily air temperature at 2 m above ground.

THEORETICAL DATA OF PHOTOVOLTAIC PANELS DISCLOSED BY THE SAME SOURCE OF INFORMATION [15]

System size: Installed capacity: 50MWp

PV module type: c-Si - crystalline silicon (mono or polycrystalline).

Geometry of PV modules: Azimuth: 0° • Tilt: 21°.

Relative row spacing: 2,5

Inverter type: Centralized high-efficiency inverter [97.8% Euro efficiency].

Transformer type: High efficiency transformer [0.9% loss].

Snow and soiling losses at PV modules: Monthly soiling losses up to 3.5 % • Monthly snow losses up to 0.0 %.

Cabling losses: DC cabling 2 % • DC mismatch 0.3 % • AC cabling 0.5 %.

System availability: 99.5 %.BES System.

BESS [24] equivalent to 30% of the total installed capacity of the PVP, or 15MW. (tentative and theoretical values). [23] Local ESS is a local provider of storage capacity for storing and delivering energy. This equipment is very necessary when sunlight is not present. This storage equipment must be capable of delivering a certain amount of energy to the Electric Grid (EG).

[23] The parameters of the Li-ion battery are defined via look-up tables based on experimental data.

[24] The lifetime of each type of PV array is 20 years. It is assumed that the replacement time of the BESS is four years. The minimum and maximum rated power values of each PV array are 200kW and 20MW, respectively. For the BESS, the minimum and maximum rated capacity values of each battery are 20kWh and 1MWh, and the minimum and maximum rated power values of each battery are 20kW and 1MW.

Parameters of Batteries (Bullich-Massagué et al; 2020; Mariaud et al., 2017).

	Battery 1	Battery 2	Battery 3
Description	**Lead-acid**	**Li-ion**	**NaS**
Charging/discharging efficiency (%)	91,0	94,0	88,0
Cycle number (cycle)	600,0	5000,0	2500,0
SOC^{min}	0,4	0,1	0,2
SOC^{max}	0,9	1,0	0,8
Unit power capacity cost ($\$\cdot kW^{-1}$)	400,0	700,0	500,0
Unit energy capacity cost ($\$\cdot kWh^{-1}$)	600,0	900,0	1200,0
O &M coefficient (%)	1,0	1,0	1,0

Table 1. Parameter of Batteries [adapted from 24].

PHOTOVOLTAIC POWER PLANT AND BATTERY ENERGY STORAGE SYSTEM (IN OPERATION)

Data of Operation [16].

Address: Del Salto Department, Uruguay.

Geographical coordinates: -31.262800°, -57.863060°

Name: PVP “EL NARANJAL”.

Start-up by “INGENER GROUP” and managed by “COLIDIM S.A”.

Installed Capacity (MW): 50MWp

Solar panels and respective trackers: 200.000 panels.

Area destined for PV Generation: 145Ha. Or 1.449.000m^2.

Photovoltaic Power Plant and Battery Energy Storage System For a proposed case study.

[23] [24] For this case, a PVP/BESS Complex is of **50MWp (AC**) and **15MW (DC)** are proposed, **with double solar panels** (**200.000**), with solar flow followers or **trackers** [17], connected directly to the 66kV Buss of SE-FIL, as shown in the figure for an area of 150Ha.

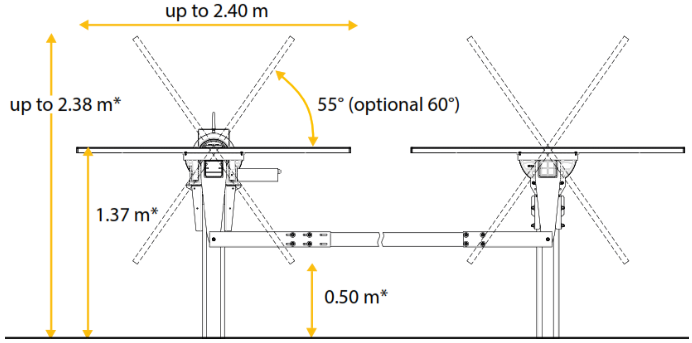

Figure 4. Tracker-Duetto: all in one. Adapted from [17].

Appearance of the PVP and BES System to be used in the SE under study.

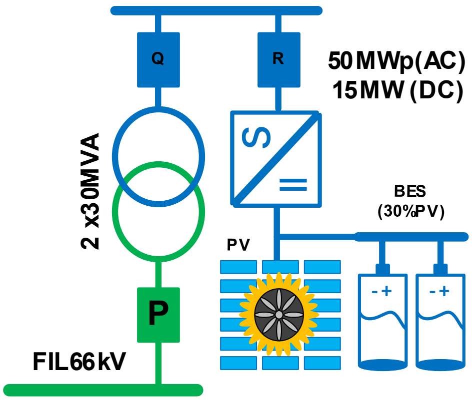

Figure 5. PVP and BES System (own creation).

Historical maximum demand (MW) in the SEP under study hour by hour. The different voltages of the buses involved are also displayed: 220, 66 and 23kV respectively. Simulation results are compared in RP (Power flows) vs. Values registered on February 23, 2021, the day that the historical maximum demand of 3,777MW was registered. The **Load registered** correspond to **SE-LPA**

schedule (2021/02/23)	
Real	NEN(MW)
00:00	49,0
01:00	43,0
02:00	43,0
03:00	43,0
04:00	43,0
05:00	43,0
06:00	43,0
07:00	41,0
08:00	45,0
09:00	47,0
10:00	50,0
11:00	58,0
12:00	62,0
13:00	65,0
14:00	67,0
15:00	67,0
16:00	65,0
17:00	65,0
18:00	61,0
19:00	57,0
20:00	59,0
21:00	61,0
22:00	59,0
23:00	56,0
24:00	53,0

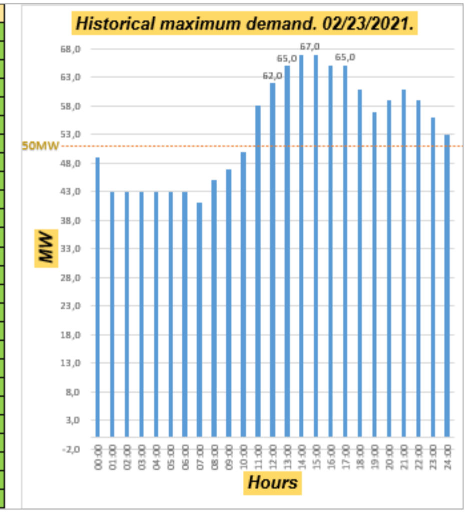

Table 2 and Figure 6. Historical Maximum demand (MW), 02/03/2021. (own creation).

RESULTS AND DISCUSSIONS. GENERAL EQUATION OF TRANSMISSION LOSSES

$$\text{Loss} = 100\% - \left(\frac{L_1+L_2+\cdots L_n}{G_t}\right) \quad 6$$

(6) Where **L_n** are the Loads and **G_t** are the total Generation.

$$\text{Loss} = 100\% - \left(\frac{L_1+L_2+\cdots L_n}{DG_1+DG_2+\cdots DG_n+NEN}\right) \quad 7$$

(7) Where **L_n** are the Loads, **DG_n** are Distributed Generation and **NEN** is the National Electricity Network.

$$\text{Loss} = 100\% - \left(\frac{L_1+L_2+\cdots L_n}{DG_1+DG_2+\cdots DG_n+NEN+PVP+BESS}\right) \quad 8$$

(1) Where **L_n** are the Loads, **DG_n** are Distributed Generation, **NEN** is the National Electricity Network, **PVP** is Photovoltaic Power Plant and **BESS** is Battery Energy Storage System.

The losses are calculated below for each notable case presented.

Chapter	Load	Generation	Loss	
2	59,6	69,4	14,1	%
3	59,3	59,7	0,7	%
4	56,3	56,3	0,0	%

Table 3. Calculation of Transmission Losses for each case.

RECORD OF HISTORICAL VALUES VS PROPOSALS OF PVP AND BESS

The following shows the registered values of Voltage Values, after the Intervention of PVP [15] [16], GD [12], NEN and BESS [23] [24] for generation in the record of maximum demand, Values in MW.

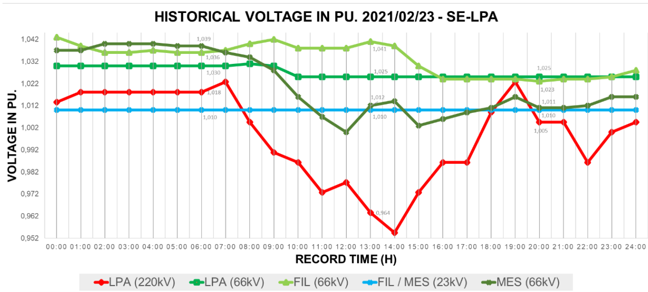

Figure 7. Voltage in different Buses of SEP in studied.

It is observed that the Voltage values in 66 as 23kV respectively remain constant, thus maintaining a fine control of them. TAP positions are gained and Transmission losses decrease drastically.

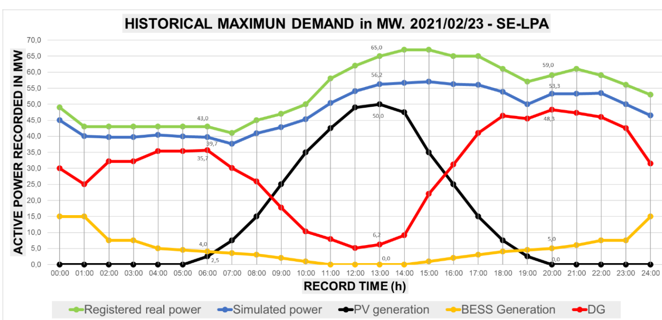

Figure 8. Generation NEN, DG, PV and BESS as a result of joint operation.

The historical Demand versus the generations NEN, DG [12] , PV [16] , BES [23] in terms of Active Power (MW) are plotted below. The great intervention of the additional generations is observed, maintaining the system with a lot of reliability, performance, sturdiness and with a wide Voltage control. Losses for Transaction decrease dramatically. The partial or total feeding of the feeders becomes very easier.

The **green curve** corresponds to the Active Power registered in 220kV buses of the SE-LPA. The **blue curve** corresponds to the (simulated) Active Power in 220kV buses of the SE-LPA after the intervention of the other Electric Generations. The **black curve** corresponds to the generation (simulated) of the PV in 66kV buses of the SE-FIL. The **yellow curve** corresponds to the Generation (simulated) of the BESS in 66kV buses also of the SE-FIL.

And the **red curve** corresponds to (simulated) the entire DG in each Electrical Substation in the vicinity of the load (LPA, FIL and MES).

PROGRAMMING IN MATLAB® [21] THE NEW PROPOSAL OF PV AND BESS

Programming for the new proposal of PV Injection and BES [23] system related to other generation sources to control Voltage and supply feeder service using MATLAB® Fuzzy Logic Design [21] Tool.

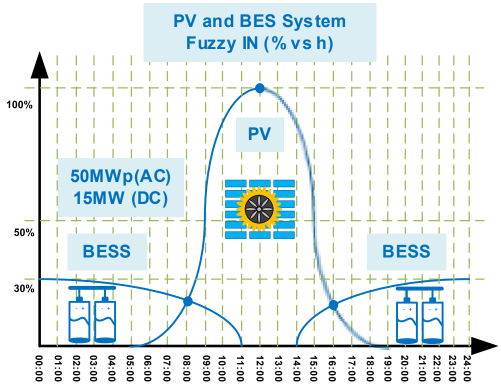

Figure 9. Behavior during the day regarding the injection of Active Power from

PVP/BESS COMPLEX TO SEP AND THE SAME FOR THE NIGHT (THEORETICAL FORM AND OWN CREATION)

Behavior during the day regarding the injection of Active Power from PVP to SEP and the same for the night (Theoretical form). These signals would be an input value for the Fuzzy Brain Together with another Voltage Signal, since this Power Electronics equipment does not have physical inertia, so it is impossible for it to control transients of an electrodynamic nature and it must have other equipment capable of facing such situations. For protection in this case was considered a Normal Voltage of Operation between 0,950 and 1,030 pu.

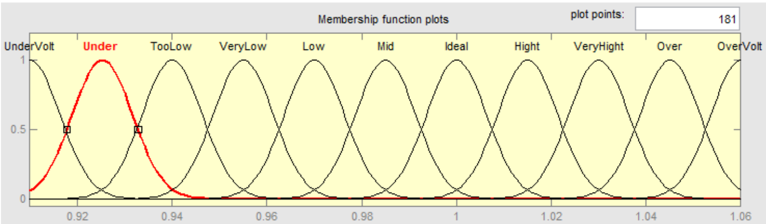

Figure 10. Voltage input in 66kV Buses for PVP/BESS Complex.

Figure 38 shows another of the FB input signals to associate with the triangular decision output.

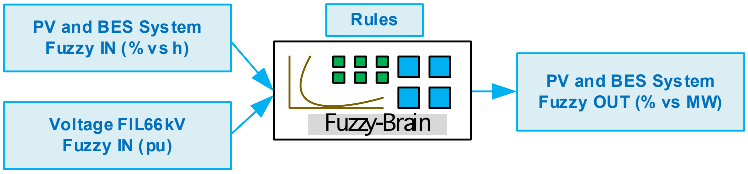

Figure 11. Inputs, processing and decision making.

Process by which the inputs are processed by the fuzzy brain based on established rules to associate them with the triangular decision output.

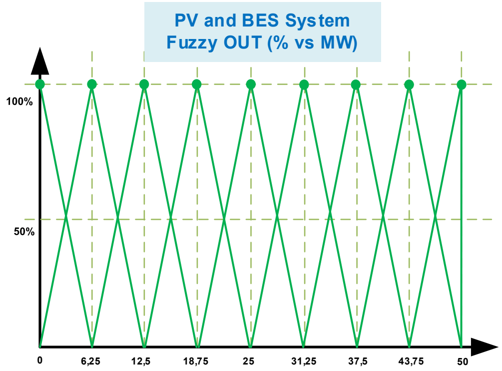

Figure 12. Output with triangular decision after going through Fuzzy processing

The next step would be to carry out the programming including the PVP and the BESS [24], for later conclusions.

FIRST PROGRAMMING PROPOSALS IN MATLAB®

First programming proposals in MATLAB, taking into account the operational limits of Voltage and availability in the PV / BESS generation as input, and the Generation relation in MW for the establishment of the rules.

After carrying out some programming in MATLAB®, satisfactory results were obtained regarding the Participation of the PV Generation and BESS from 00:00 to 24:00 on a hot summer day and in full sun. The PVP / BESS Complex operating range has also been related in terms of Voltage limits from 0,950 to 1,030 pu; that is, from 62,7kV to 68kV.

Topology of the construction and relationship of input, processor and output data, through the CF to the different FLRPC installed throughout the PES.

PRELIMINARY RESULTS AFTER PROGRAMMING IN MATLAB®

MATLAB® graphics defines a surface by the *z*-coordinates of points above a rectangular grid in the *x-y* plane. The plot is formed by joining adjacent points with straight lines. Surface plots are useful for visualizing matrices that are too large to display in numerical form and for graphing functions of two variables [21].

The following graph (Surface Graphics) shows the axes in three dimensions:

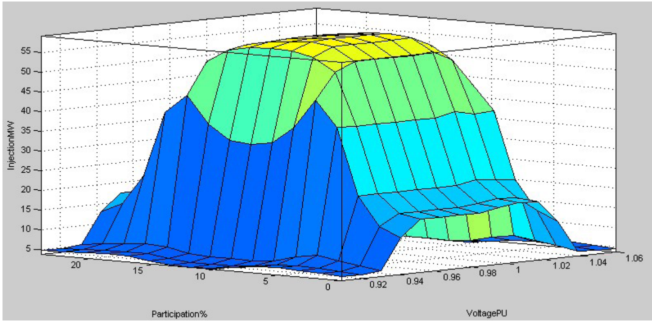

Figure 13. Surface Graphics. Results of the programming of the PVP / BESS complex.

In figure 13, **Axis "X",** which indicates the Active Power Injection from the PVP / BESS complex (5 to 50MW) and that its operation is subject to the value of the 66kV bus voltage where the Installation is interconnected, participation of Solar Generation and storage (00:00 to 23:00 of the day).

As indicated above, the **"Y" axis** corresponds to the participation of Solar Generation and storage in percentage terms (see figure 37), reported hour by hour (00:00 to 24:00 a day). This corresponds directly to one of the inputs to the FB and it is strongly related to the FLRPC3 on the 66kV bus.

As for the **"Z" axis**, it is also a voltage information in pu. input to the FB directly linked to the FLRPC3 of the 66kV bus where the equipment is connected. To limit the operability of the PVP / BESS complex, values of 0,950 < V <1,030 pu were established. These voltage values are established between approximately 62,7 / 68kV, since this equipment lacks physical inertia, so for electrodynamic events, it is convenient to disconnect it below or above these values. FL Programming is found in **Appendix 2**.

CONCLUSION OF THIS CHARTER

With the DG installing directly on the load bus, a significant reduction in transmission losses has been achieved. Voltage control has become more efficient and practical. The possibility of autonomy in the form of islands is clearly observed when the loads are not fed from the NEN.

The PVP with the BESS fully integrated to the 66kV bus of the SE-FIL makes the performance of the operation optimal, since it increases the reliability of the very radial power system in the area.

The autonomy of the loads becomes a practicality, given the ease of operation between their own networks when the sources of the National Electricity Network are interacting, Distributed Generation (Diesel and Gas with lower Carbon emissions), Photovoltaic Generation (Generation clean and renewable) and the storage of Electric Energy through Battery Banks (BESS).

For futures works, it would be interesting to investigate the dynamic behavior of all these sources interacting all at the same time, always looking for the operational and economic convenience of the Company.

THE SATISFACTORY RESULTS, IN SUMMARY, ARE AS FOLLOWS:

The programming in the Fuzzy Logic interface is **very flexible** in terms of the information to be processed, since different units of measurement can be handled and they are finally independent of the result to be obtained.

The use of the AIFL is **very powerful** in terms of the complex decisions that the FB must make when the information conditions are minimal.

A **clear performance** of the AI method used was demonstrated thanks to its practicality and flexibility, as long as the input and desired output information are correctly processed.

Finally, the use of this AIFL demonstrates a **strong versatility** for any type of programming and complex decisions.

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