REDUCING THE INTERMITTENCE OF RENEWABLE ENERGY SOURCES WITH SEASONAL-PUMPED-STORAGE PLANTS

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Abstract. *This paper presents a computational method to model and evaluate if Pumped Storage Plants (PSP) have the potential to reduce the intermittency of wind generation from different sites in Brazil and to improve the operation efficiency of hydroelectric plants in cascade. Since the problem to be solved does not have a defined analytic solution, a Stochastic Optimization Algorithm was implemented to reach an optimal solution to the set of equations, inputs and proposed scenarios. A case study was developed based on the Paraná River Basin and the results shows that the model can operate in a variety of different operational patterns, making feasible the evaluation of different hydrological and wind scenarios and to assume different PSP storage and generation capacities and allowing the comparison between the efficiency improvement of a conventional Pumped-Storage and a Seasonal-Pumped-Storage in the same scenario. The study concludes that a PSP can effectivity reduce the intermittency of wind and solar sources and contribute to the optimization of the Brazilian electricity sector.*

Keywords: Pumped-storage, Hydroelectricity, Electricity Supply Modelling, Genetic Algorithms, Evolutionary Algorithm.

Resumo. *Este artigo apresenta um método computacional para modelar e avaliar o potencial de Usinas Hidrelétricas Reversíveis (UHR) para reduzir os efeitos da intermitência da geração eólica de diferentes locais no Brasil e aumentar a eficiência da operação de Usinas Hidrelétricas em Cascata. Uma vez que o problema em tela não tem uma solução analítica definida, foi implementado um Algoritmo de Otimização Estocástico para obter uma solução ótima para um conjunto de equações, parâmetros de entrada e cenários propostos. Foi desenvolvido um estudo de caso na Bacia do Rio Paraná cujos resultados mostram que o modelo pode operar em diversos cenários de operação, permitindo avaliar diferentes cenários hidrológicos e eólicos com diferentes capacidades de armazenamento e geração da UHR permitindo comparar a melhoria de eficiência de uma UHR Sazonal (UHRS) e convencional no mesmo cenário. Este estudo conclui que a implementação de UHR pode ser uma alternativa efetiva e tecnicamente viável para redução da intermitência de fontes como Eólica e Solar, além de contribuir para a otimização e aumento da eficiência na operação do Sistema Elétrico Brasileiro.*

Keywords: Usina-Hidrelétrica-Reversível, Hidroeletricidade, Modelagem Computacional, Algoritmos Genéticos, Algoritmos Evolutivos.

1   INTRODUCTION

The Brazilian power grid had, in June 2016, a total of 144.129 MW of installed capacity in the interconnected system with its base being mainly composed by hydroelectricity, that answers for 64,5% (ANEEL, 2016) of all installed power connected to the national interconnected grid. However, new environmental laws are only permitting the construction of run-of-the-river dams, with the intention to reduce the flooded area and avoid environmental impact. This reduces the amount of water the system can store, which makes the dams vulnerable to the water regime in the river.

This results in serious problems to the efficiency of the national grid operation. Firstly, most of the electricity will be generated during the wet season. Secondly, run-of-the-river plants do not have the same regulation potential as the conventional hydroelectric facilities to manage the introduction of intermittent sources of energy such as wind and solar power. Furthermore, it makes the Brazilian electricity sector even more dependent on rain patterns.

Considering the predicted expansion of the wind farms in the next decade, it is essential to implement regulations to allow the continuing expansion of the technology. A possible approach is to increase energy storage and transmission lines.

Another issue with the Brazilian interconnected system is that its storage potential is largely concentrated in the Southeast/Center-West subsystem, as shown in Table 1, making the electricity system vulnerable. Due to this, in cases of long dry periods occurrences in this region, such as happened in the last couple of years, electricity generation capacity may be seriously reduced.

Table 1. Storage capacity in each Brazilian subsystem.

Region	Maximum Storage Capacity [MW.month]
Southeast / Center-West	205.002
South	19.873
Northeast	51.859
North	14.812

Furthermore, the new hydropower facilities are run-of-the-river plants in the Amazon region with no energy storage and a small capacity factor: full generation in the wet season, very reduced generation, otherwise.

The northeast subsystem, for example, has had a considerable increase in electricity demand in the last decade without increasing the regulation capacity in the subsystem. Its main generation increase has been wind and solar power plants, both from intermittent and non-dispatchable sources, decreasing the system's efficiency and controllability.

Given that most of the energy storage capacity is located far from the intermittent generating sources, it is important to decentralize the energy potential of Brazil. Storage plants closer to the wind and solar potential would regulate the intermittency introduced in the northeast region. This would secure power supply and allow a more reliable energy management in the National Interconnected Systems (SIN).

Apart from traditional dams in a regular Hydroelectric, there are few energy storage technologies available and fewer that suits to an application in a large-scale system, due to either low cycle efficiency or high implementation costs. The preferable way to store energy in a matrix transition with high insertion of Solar and Wind power plants should be through pumped storage plants (PSP), as proposed by (Krüger et al, 2014). PSP have the advantage of being, in essence, a Hydroelectric Power Plant, enhancing its flexibilities in operation and grid benefits as providing ancillary services as Black-start capacity and voltage regulation. As a well-developed and mature technology, this application benefits from lower costs, experienced manufacturers and many implemented references, such as in Europe, North-America, China and Japan mainly to regulate nuclear and coal generation.

The fundament of PSP is to use the unconsumed energy during reduced load periods in order to pump the water from a lower reservoir to a higher reservoir, and turbine it when needed at the same plant power house. It consists on transforming electrical energy into hydraulic energy, in large scale and an efficiency of approximately 75%.

As Brazil reached the limit in available conventional hydropower reservoirs, this research analyzes the implementation of Pumped-Storage with seasonal (SPS) and daily cycles (PSP). SPS is a pumped storage plant that operates combined with a series of dams in cascade downstream defined by (HUNT, 2014). Given their short response time, SPS could be used to regulate the power generation from wind farms, as well as, store energy seasonally.

A PSP operation with a seasonal cycle would increase the Brazilian energy storage capacity, and if allocated in a different region, considerably diminish the influence of climate vulnerability in the country's generation profile.

In order to evaluate this technology in the Brazilian scenario, a part of the Brazilian hydroelectric system was modeled considering the interaction of dams in cascade and how the outflow of an upstream dam can influence the inflow of a downstream dam. Through a routine developed in the software Matlab (MACHADO, 2015), once an electrical demand is established, it is possible to obtain a power generation function of the hydro system based in the natural inflow of the rivers as input to the model.

To introduce non-existent PSP in the system operating in an optimized form, it was implemented an Evolutionary Algorithm called Genetic Algorithm (GA), in order to maximize the system's efficiency at the end of the analyzed period. In this computational method, it is necessary to establish the optimizable variable of the study. Considering that pumped inflows or outflows of the SPS do not have an analytic solution; it was decided to make it a target variable to be optimized in the study, being it the individuals of the population of the GA.

This model allows an evaluation of a series of different scenarios, it is flexible to the point that allows the user to choose the desired inflow data, the amount of demand that the system must attend, the size of the SPS reservoirs, making possible a comparison between a conventional daily cycle PSP and a PSP with seasonal reservoir. Also the amount of wind generation is configurable by choosing the wind power installed. As desired, it is also possible to choose every input parameter required by the GA.

2   METHODOLOGY

A partial model of the Brazilian interconnected national grid was developed composed by the Paranaíba Basin, Grande Basin and Paraná Basin, using a routine in Matlab to simulate it.

Then it was introduced two virtual pumping facilities, the first called Canastra and connected to the Furnas Dam in the Grande River, and the second called Catalão connected to the Serra do Facão Dam in the São Marcos River as proposed by (HUNT, 2014).

The scheme of the Paraná Basin is shown in Figure 1. The data used for each PSP is shown in Table 2 as proposed by (HUNT, 2014).

Table 2. Technical aspects of each reservoir.

Reservoir	Canastra	Catalão
Minimum Altitude (m)	1050	900
Maximum Altitude (m)	1250	950
Lower Reservoir Altitude (m)	768	756
Maximum Fall (m)	482	194
Useful volume (km^3)	17,22	5,22
Installed Power (MW)	5.500	400
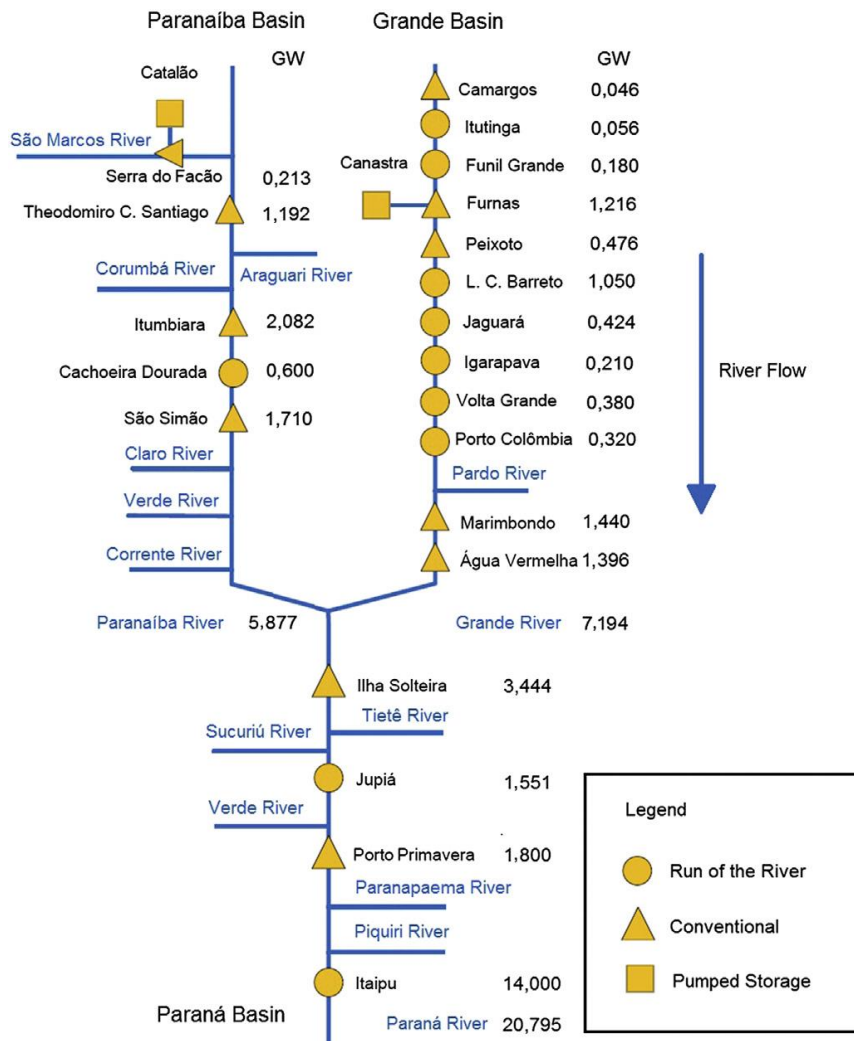
Figure 1. Diagram of dams in the Paraná, Paranaíba and Grande Watersheds with two proposed Seasonal-Pumped-Storage schemes (HUNT, 2014).

2.1　Model Premises: Hydropower

The first step in order to simulate the behavior of the system described in Figure 1 is to establish the power function of a conventional dam as developed by (SILVA FILHO, 2003). The power generated by a hydroelectric plant is given by Eq. (1).

$$p(t) = \eta \cdot \rho \cdot g \cdot h \cdot q(t)$$

(1)

Where:

- η: efficiency of the hydroelectric plant;

- ρ: water density [kg/m^3];

- g: acceleration due to gravity [m/s^2];

- h: water head [m];

- $q(t)$: water flow through the plant's turbines [m^3/s];

Taking as premise that the efficiency of the turbine does not vary with the water head, there are two mutual dependent variables in the generation function described by Eq. (1): the water flow and the water head. This way, the only feasible alternative to calculate the power generated by the plant is through an iterative process.

Besides, the turbines or the generators capacity, depending on the water head, may limit the plant's generation. If the head is too low, turbines could operate in a partial load, however it could lead to a forbidden region of cavitation and, in this case, the generator cannot produce its effective power because the turbine cannot supply it with enough power. In this case, the turbine is limiting the set's operation. On the other hand, the bigger the net head, the closer the turbine can be to its nominal capacity and in this case, if the turbine produces all the possible power, the generator can be overloaded.

This way, it is possible to define two acting regions to characterize the plant behavior:

- If the head is too low, the generator cannot generate its effective power because the turbine can't supply it with enough power. In this case, the turbine is limiting the set's operation.

- If the head is too big, its vanes cannot be open 100% in order to protect the generator. In this case, the generator limits the set's operation.

These two acting areas of the generators and turbines are important because according to the reservoir level of a hydroelectric plant, it may deeply influence its generation. So, the impacts that an upstream dam causes in a downstream dam given the water flow going through the upstream dam and the characteristics of the lower plant need to be considered. However, given that there are a series of dams in cascade, and the interaction between them impact the generation function, since *q(t)* is limited by q_{max}, it was necessary to establish an iterative process to arrive to the maximum swallowing the plant allows.

Once the maximum power and flow of each plant based on its reservoir initial conditions have been established, the next step would be calculating the inflow of each dam given its upstream conditions and its natural inflow.

2.2 Water inflow with dams in cascade

Given that the natural inflow in the dams connected to the SIN have their natural inflow available in (ONS, 2016), it is possible to calculate the incremental inflow (y_{inc}) and their total inflow (y_i) given the downstream flow of the dams upstream (u_j) according to Eq. (2) and Eq. (3) as proposed by (SILVA FILHO, 2003) .

$$y_{inc,i} = y_{nat,i} - \sum_{j \in \Omega} y_{nat,j}$$

(2)

$$y_i = y_{inc,i} + \sum_{j \in \Omega} u_j$$

(3)

Where Ω is the set of dams upstream to dam *i* and *u* is its downstream flow.

Considering the monthly average inflow, it is reasonable to apply this equation to the system. However, in the case of an hourly study as it is required in this paper, this is not appropriate given that the dams may be hundreds of kilometers away and there is a transit time for the outflow of an upstream dam to arrive to a downstream dam. This constraint, however, was not considered in the study. Thus, the behavior of an upstream plant will affect the downstream plant in the following hour of study.

2.3 Simulation modeling for the hydroelectric plants in cascade

Considering the inflow of every plant in the system in Figure 1, its own characteristics and the interactions between the dams, it is possible to calculate the downstream flow of each plant in the system given a demand to be supplied at each discretization period. Taking into account the hourly wind generation, it is possible to incorporate it directly into the energy production of the system, since it is a non-dispatchable source of power. In Figure 2 it is possible to visualize the parameters considered in the study, those that are entries and the ones that are calculated and optimizable.
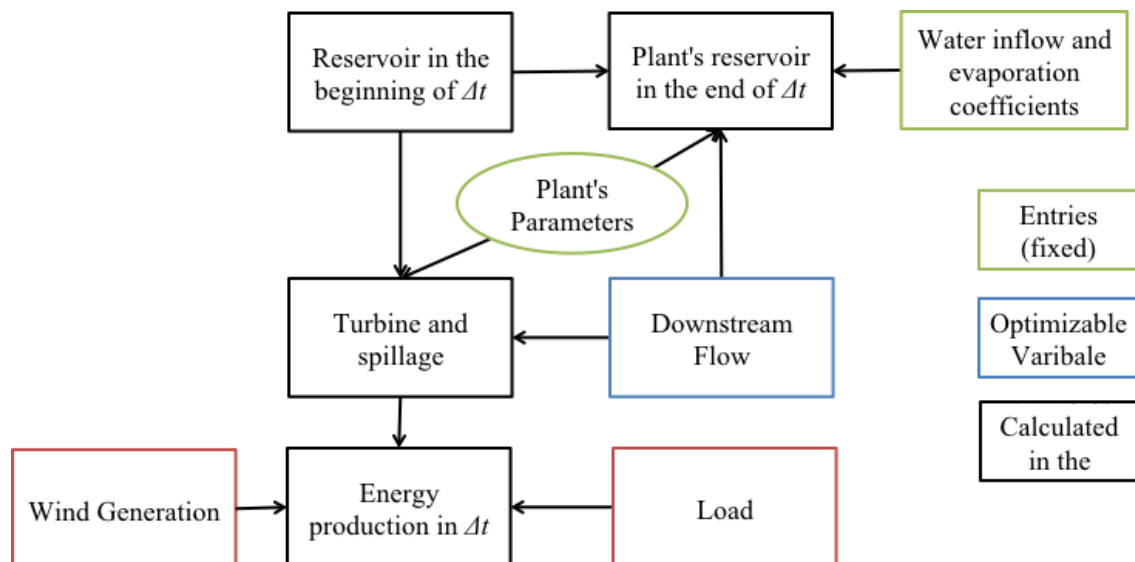

Figure 2. Block diagram of the simulation considering an hourly discretization and wind generation.

In this study, it was considered that the reservoirs operated using a parallel operation politic. All of them emptied or filled in the same proportion according to a linkage factor denominated λ, greater than 0 and lower than 1. Then, the volume of the reservoir, x, may be determined in function of λ according to Eq. (4).

$$x(\lambda) = x_{min} + \lambda \cdot (x_{max} - x_{min})$$

(4)

Where:

- x_{min} is the minimum operative volume of the reservoir;

- x_{max} is the maximum operative volume of the reservoir;

Through the variable λ is possible to arrive to the stored volume at the end of the discretization period. Through the variation of volume of the conventional reservoirs, it is calculated its total downstream flow, meaning the sum of the spilled flow and the turbine flow. To adjust λ so that it secures the required generation, it was used an iterative process given by Figure 3. In the block "Restrictions, conflicts and generation" the turbine flow was limited according to the plants restrictions (both generation and turbine) and an algorithm to avoid spillage was used when there is available volume in the reservoir and the downstream flow calculated in the "Water Balance" block is greater than supported by the turbine or generator, q_{max}.
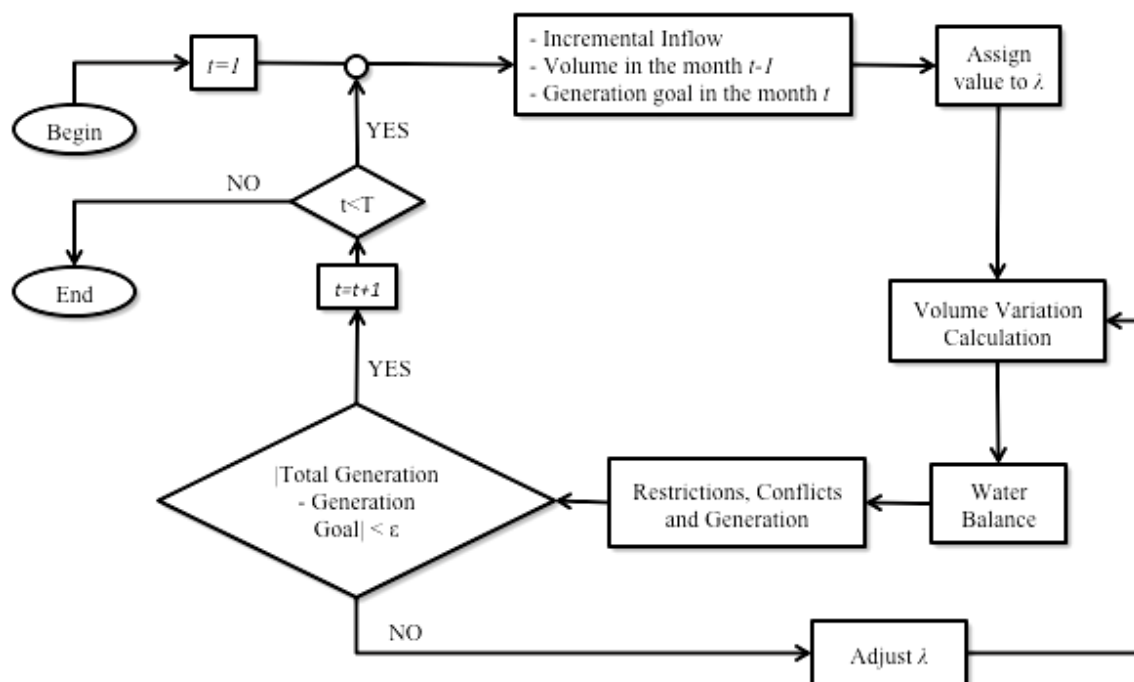

Figure 3. Algorithm used for the iteration process to calculate the total generation. (SILVA FILHO, 2003)

Through the algorithm implemented, it is possible to determine the outflow of each dam of the system considering the effects caused by the dams upstream in the previous period and their own restrictions.

When adjusting λ, it must always be between 0 and 1, in case it is adjusted to a value outside of this limit, it means that either there is an excess of water and there must be spillage ($\lambda>1$) or there is lack of reservoir and there will be a shortage of energy ($\lambda<0$).

2.4   Genetic Algorithm

To consider the effect of the PSP in the system, the water flow going through their turbines or pumps was optimized using the Genetic Algorithm where the population of the algorithm was composed by the inflow (if $q>0$) or outflow (if $q<0$) of the PSP. Then, after simulating the system for each individual of the population, it was established an objective function to maximize the energy generated and stored in the end of the period under analysis as well as minimize the spillage of water. The objective function is given by Eq. (5).

$$E_{balance}(t) = \sum_{t=1}^{T} E_{generated}(t) + E_{stored}(t+1) - \sum_{t=1}^{T} E_{spilled}(t)$$

(5)

Where:

$$E_{generated}(t) = E_{gen}(t) - E_{load}(t)$$

(6)

$$E_{stored}(t+1) = \sum_{j\in\Theta}^{N} \left\{ Vol_j(t+1) \cdot 9{,}81 \times 10^3 \cdot h_{j_{up}}(t+1) - E_{j_{dead-volume}} \right\}$$

(7)

$$E_{gen}(t) = W(t) + H(t) + E_{gen_{pump}}(t) - E_{cons_{pump}}(t)$$

(8)

- W(t): generation from wind source

- H(t): generation from hydroelectric plants.

- Θ represents the set with all the hydroelectric plants with conventional reservoirs and the PSP.

Considering there is the possibility, through the algorithm from Figure 3, that the load isn't completely supplied, it was established a penalization to the objective function when that happens. On Eq. (9) it is possible to see the penalization established when $E_{generated}$ is outside of the tolerance factor ε.

$$\begin{cases} if \left| E_{generated}(t) \right| < \varepsilon \rightarrow E_{generated}(t) = 0 \\ if \, E_{generated}(t) < -\varepsilon \rightarrow E_{generated}(t) = E_{generated}(t) \times 1 \times 10^{20} \\ if \, E_{generated}(t) > \varepsilon \ \rightarrow E_{generated}(t) = E_{generated}(t) \times 0{,}25 \end{cases}$$

(9)

Also, in case the energy generated is greater than the load, it was applied a multiplier factor that lowered its influence in the fitness function, since it would be uncertain that another system could absorb a generation excess. In this case, this energy would need to be spilled.

In order to visualize the GA applied in the system, it is represented in Figure 4 the process used. Inside the block "System's model" it is incorporated the hydroelectric plant generation function, and the maximum water flow the turbine and generator allows according to the water head.
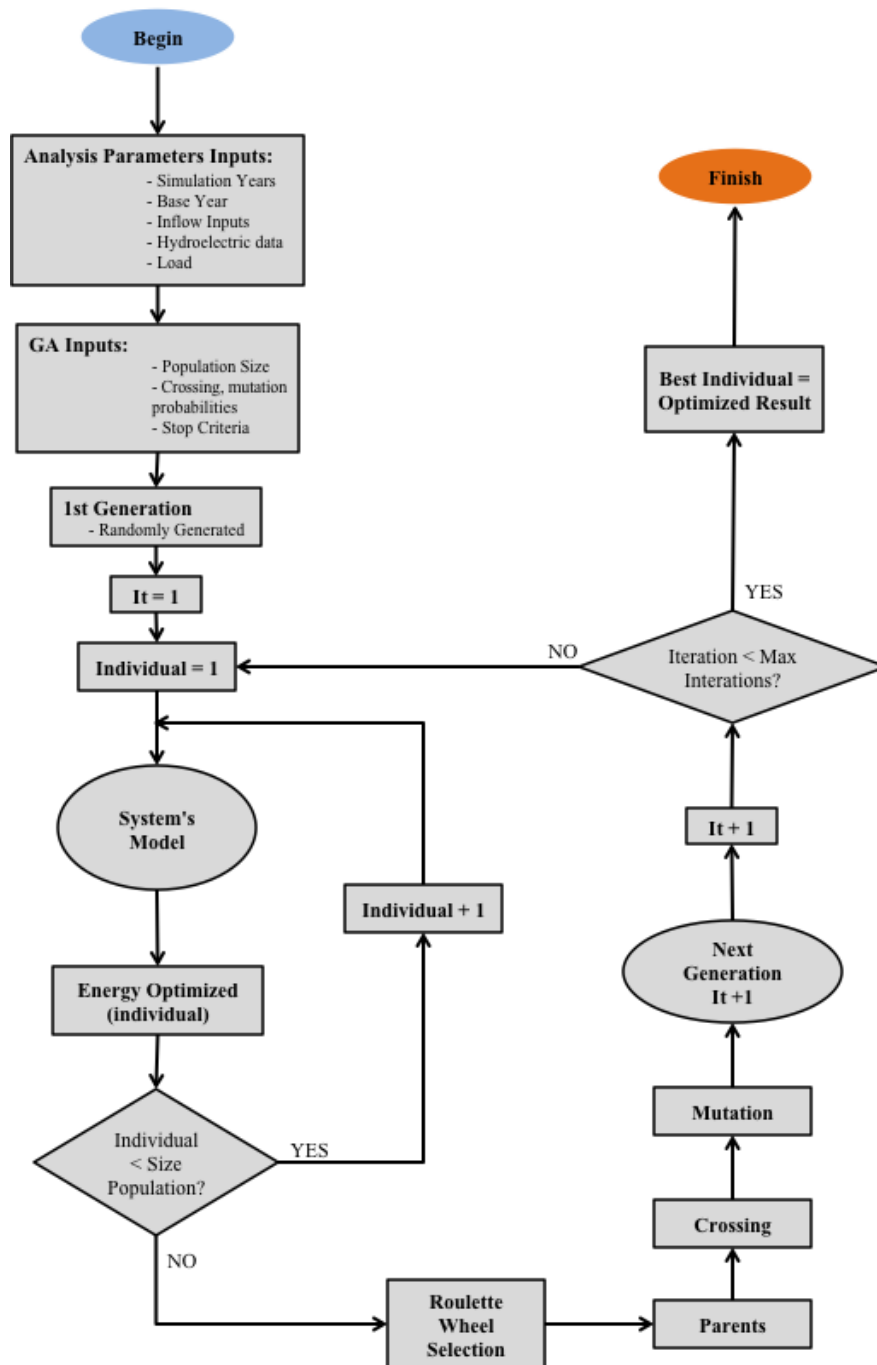
Figure 4. Block diagram with the GA applied in the simulation.

2.5   Wind generation profile

In order to obtain the wind generation data, using the wind data for each field in a certain period it is possible to trace the generation profile of each field given the power curve of a wind turbine. Since the total wind power installed is a variable, it was decided to use the generation profile in p.u. based in the plant's physical guarantee as supplied by (WITZLER, 2015).

Using an hourly discretization, totalizing 8760 points, the wind profile was traced for the same year as the natural inflows that were used in each study.

The wind profile of four different fields was used, each in a different state with an installed capacity proportional to 2014 capacity. On Table 3, it is shown each field with its location, installed power and capacity factor used to trace each wind power generation pattern.

Table 3 Wind fields considered in the study.

Field	State	Power (MW)	Capacity Factor	Physical Guarantee (MW)
1	CE	1.229	0,51	632,16
2	RN	807	0,40	324,85
3	BA	715	0,54	388,21
4	RS	628	0,43	269,56

Since the intention is to use the total wind generation profile, the four profiles were added altogether to trace the final wind generation profile in the period under analysis. Then it was incorporated into the system's total generation.

2.6   Energy Market

Considering the horizon of a year, it was considered a peak demand between November and March that totalized 52,8% of the installed capacity, and a lower demand in the rest of the year (48,9% of the installed power). In addition, since the simulation is in a daily basis, there was a daily peak between 12 to 18 o'clock according to Figure 5. 1 p.u. in the image corresponds to the current month's demand
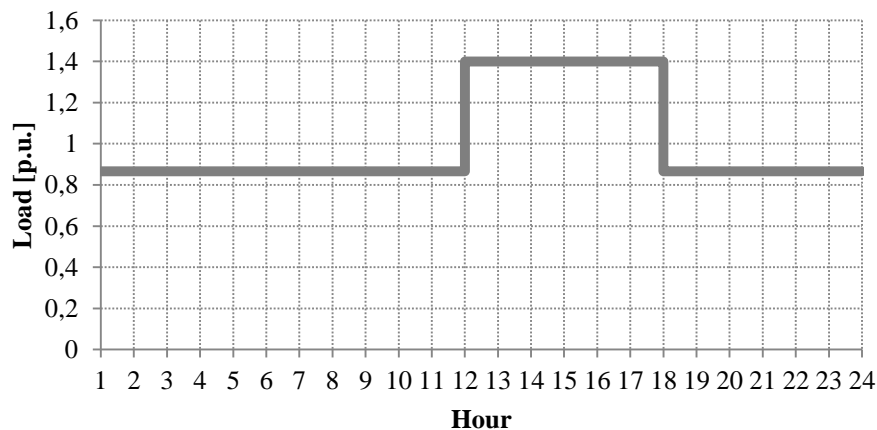

Figure 5. Daily market of energy.

3   RESULTS

3.1   Case 1 – SPS with seasonal storage cycle

In this case, it was used the wind and water flow data from 1990. The SPS reservoirs were dimensioned to a seasonal storage size according to each one's power. Both conventional and pumped reservoirs were with 50% of its volume in the beginning of the simulation.

After the simulation, it is possible to analyze the results hourly. In Figure 6 it is possible to look into the system's behavior after February 10th.
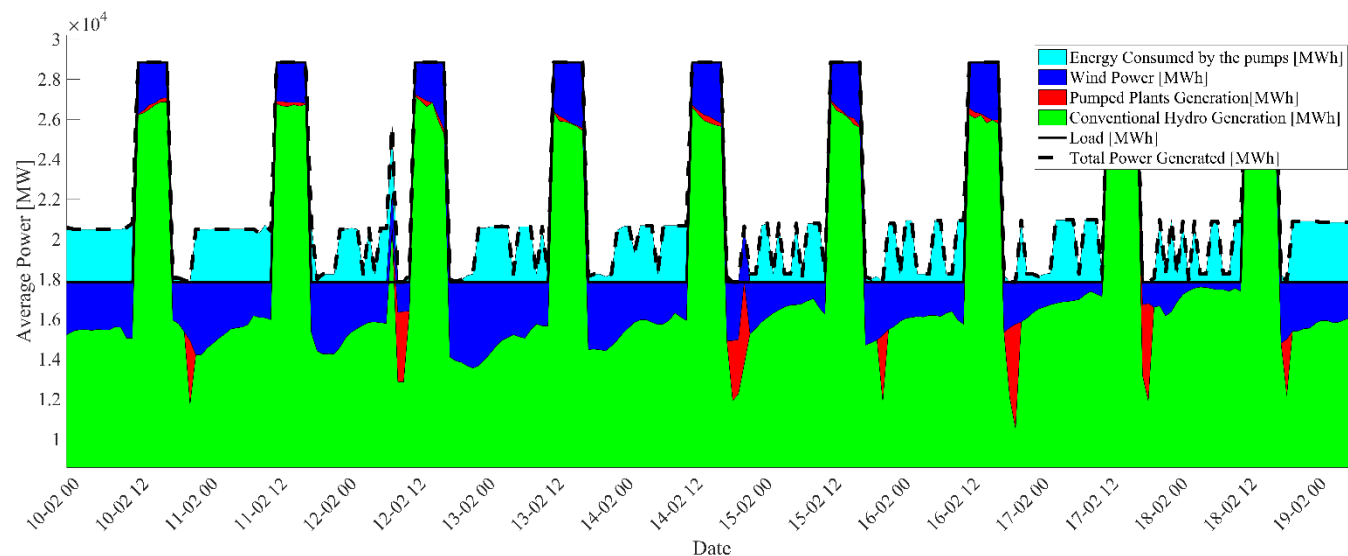

Figure 6. Generation profile in a week of February 2012.

In this graph, the energy generated by the SPS plant is represented in red. The energy from wind farms in dark blue, the energy consumed by the SPS in light blue, and the energy generated from conventional hydroelectric plants in green. A dashed line represents the total power generated.

The main functionalities of a SPS is represented in Figure 6. Along the night, when wind speeds are more intense and the demand is smaller, the SPS is consuming energy, and the conventional hydroelectric plant added to the wind sources supply this demand together with the pumping consumption. This way, in the following day, during the peak hour when the wind generation is much smaller, as it can be seen by the dark blue area, the SPS is able to change its operational sense and supply the system in way to attend all the required demand. Also, in this period it was possible to identify that the wind generation along the night was greater than along during day time. So that at night the SPS operate in pumping mode while at the peak in the day, operate generating energy.

At the same period, the pumping sense at Catalão and Canastra work in way to compensate the generation from the wind sources, creating the generation/consume profile established in Figure 6 and Figure 8. It is interesting as well that both PPS keep a flux of water when pumping more stable and much below the nominal capacity of the plant, meanwhile when generating energy it has peaks of generation with a flow very close to its nominal capacity.

This happens because of the availability of energy in which the pumps depend and is mostly variable according to the wind profile. For example, it is noticeable that on February 18th, near to midnight, there is big drop in the wind generation, getting close to zero.
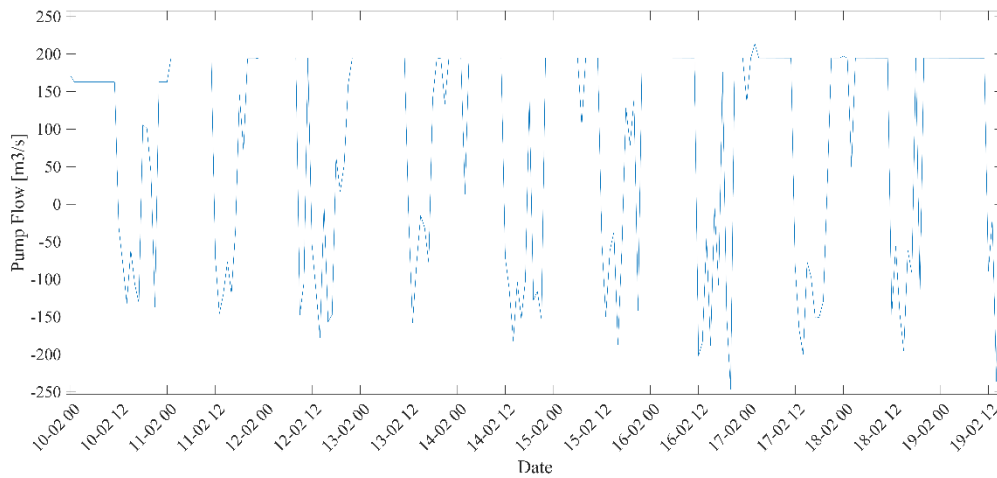

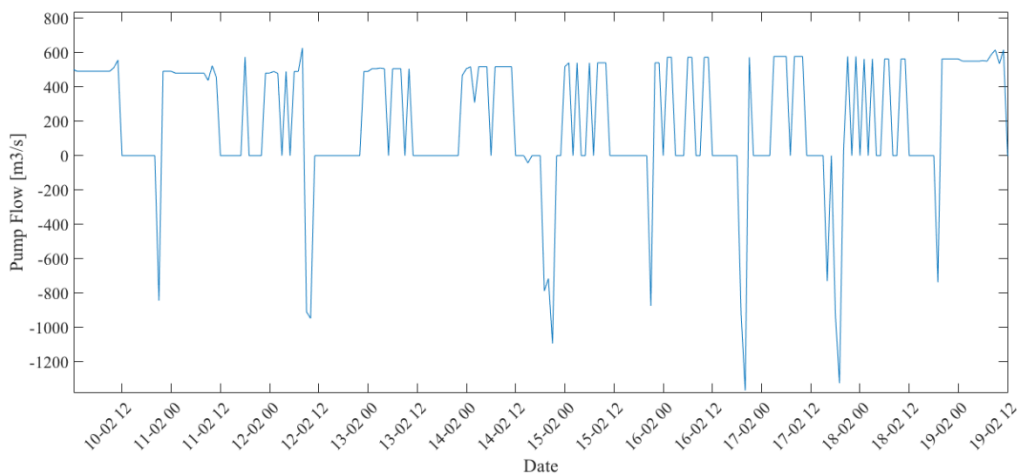**Figure 7. Pumped water flow at Catalão in February.**

Figure 8. Pumped water flow at Canastra in February.

When that happens, both SPS, including Canastra, which was turned off in the previous hour, inverted their working sense with a high flux going through the turbines to generate the amount of energy required to compensate a decrease in the wind generation. Observe that this happened not only in the peak-hours, but since the wind generation was bellowing average also at night it is observed a generation by both SPS.

The same effect can be observed along the year for a few times given the high variability of the wind generation and the volatility of the SPS to adjust to a variable generation profile.

Looking into the one-year horizon of the SPS operation, it is possible to see at Canastra that most of the time it is operating in way to fill the reservoir, always storing more energy than consuming, which happens mostly in the peak hours of the day. This is due to the size of the reservoir that was dimensioned by (HUNT, 2014) to be a yearly cycle reservoir.
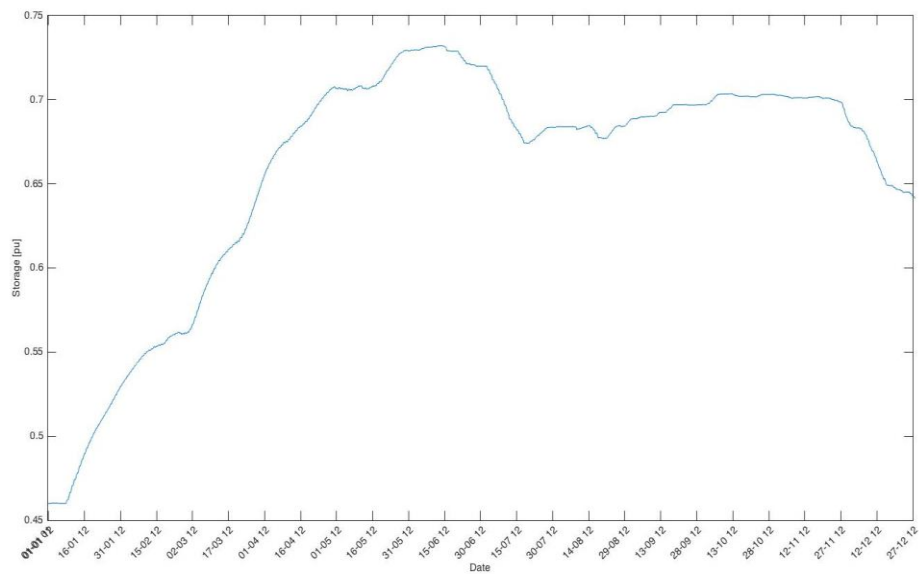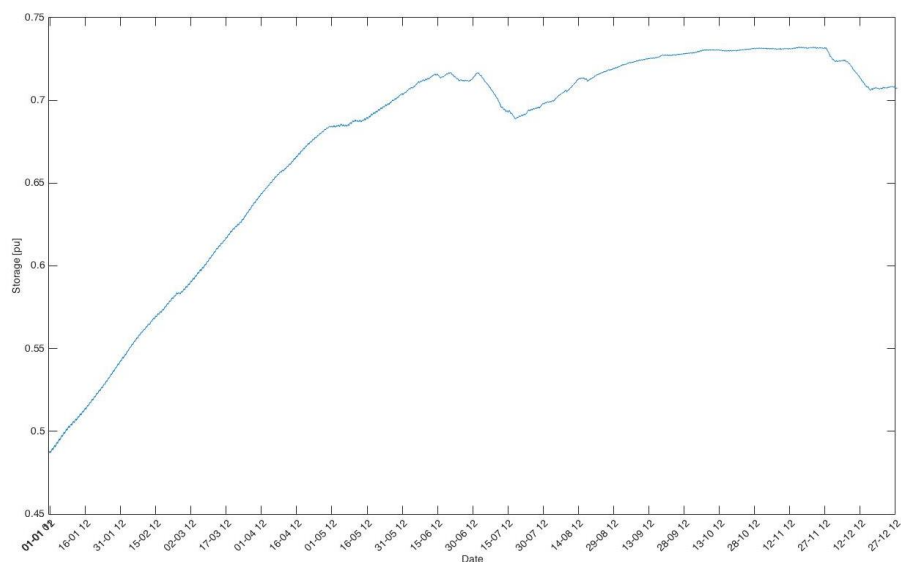
Figure 9. Reservoir Level at Canastra PSP

Figure 10. Reservoir Level at Catalão PSP

However, from May on, it is possible to notice an increase in the turbine mode of the SPS while the pumping operation mode is reduced given it is in a dry season of the year and it becomes important as a backup reservoir for the whole system.

A similar effect happens at Catalão, that when the dry season begins, it reduces its pumping mode keeping oscillating between both modes, but always emptying its reservoir more than filling.

This can be verified seeing both the tendency of the pump flow in the facilities as well as its reservoir level in that period represented in Figure 9 and Figure 10, how they decrease in the dry period allowing the conventional reservoirs to remain stabilized in this season.
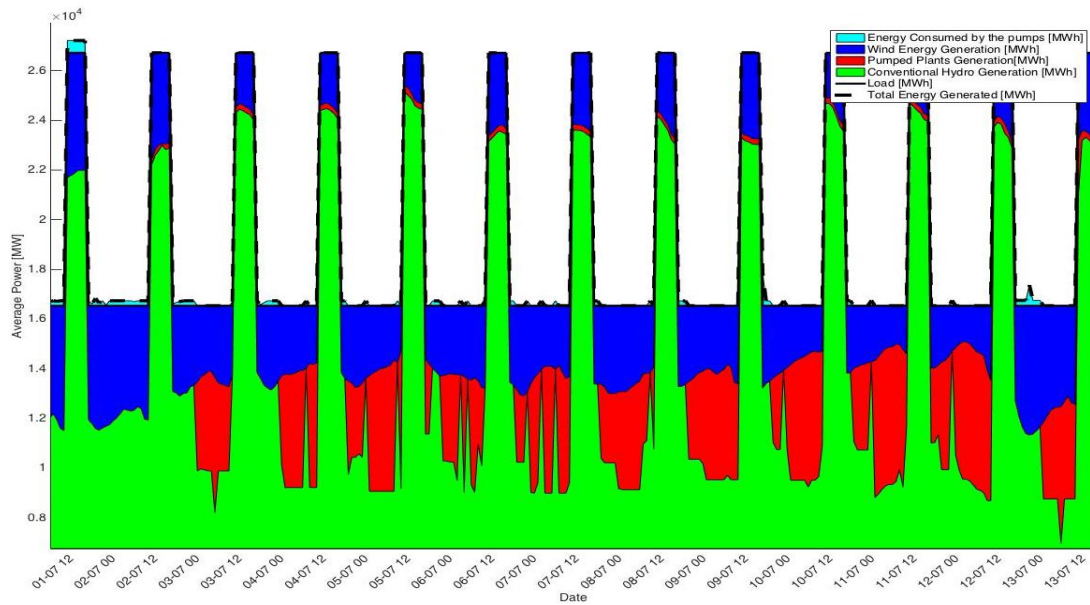
Figure 11. Power x Demand in July.

Taking another example along the year, now in July, in the middle of the dry season, it is possible to observe a diverse behavior of the pumps. Due to the dry period, the pumps start to work constantly to regulate the generation and sparing at most the conventional hydroelectric plants. Since the inflow is smaller in this period, the operation politics adopted in this case allowed the SPS to empty themselves, increasing its generation along all the dry period.

3.2   Case 2 – PSP with daily storage cycle

In this case it will be considered a smaller reservoir dimensioned according to Table 4, an increased wind power, and a higher minimum outflow in the dams. This was made to stress the dams and verify the functionality of an SPS in a daily cycle.

Table 4 Inputs for each PSP with daily storage cycle.

	Max Energy [GWh]	Max Volume [hm3]
Canastra	132	38,75
Catalão	9,6	3,71

It was considered a greater demand, with a longer peak period. Therefore, the demand considered was 5% greater in peak hours, which lasted from 1pm to 8pm. Using this data as input, it was possible to analyze how an SPS helps regulating peak and off-peak demand.

As in the previous case it works together with the wind profile, looking into February 2nd and 3rd, it is possible to see, through the dark and light blue area, that the wind generation was smaller than on February 19th, for example. Due to this, the pumps do not pump as much water since there was not a large exceeding amount of energy in the system. And it only turbine water during the peak hours, emptying the reservoir.
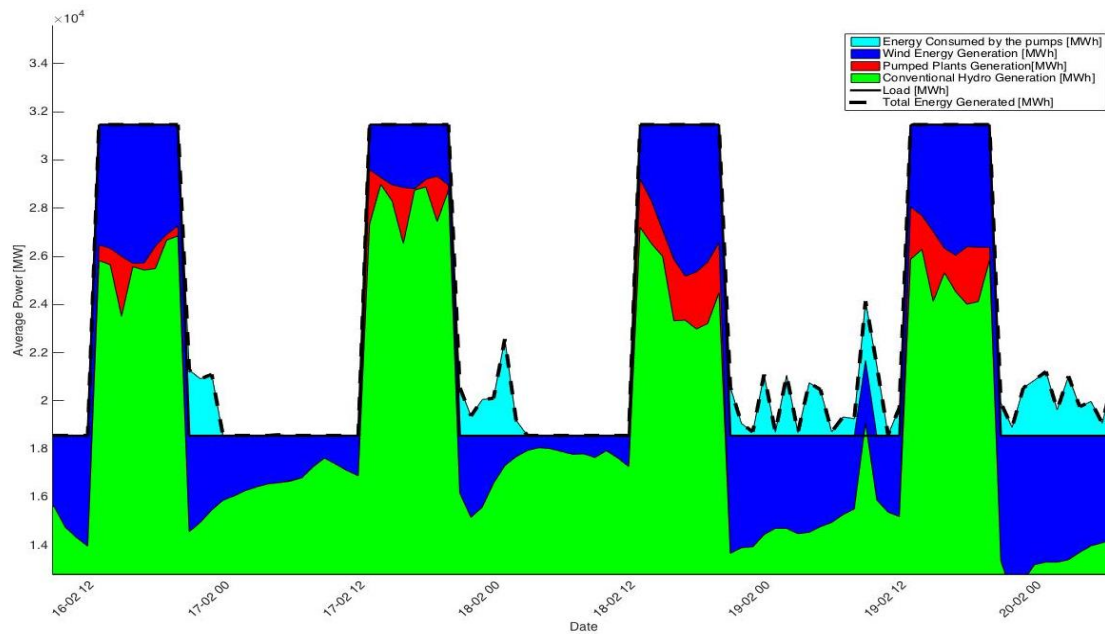
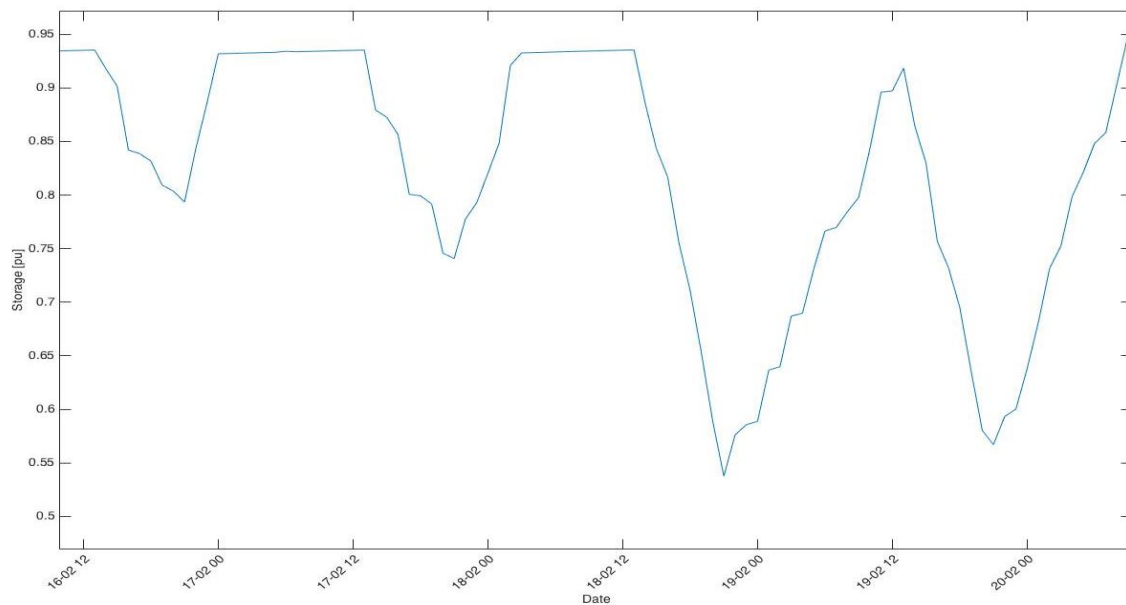**Figure 12. Power x Demand in February.**

Figure 13. Pumped Reservoir level in February.

Now, looking into a regular winter day, when less water is inflowing to the dams and there is a larger wind generation, the both SPS work more often being established a more defined daily cycle, however there is also much less available energy since the hydroelectric power plants have a much lower generation profile.
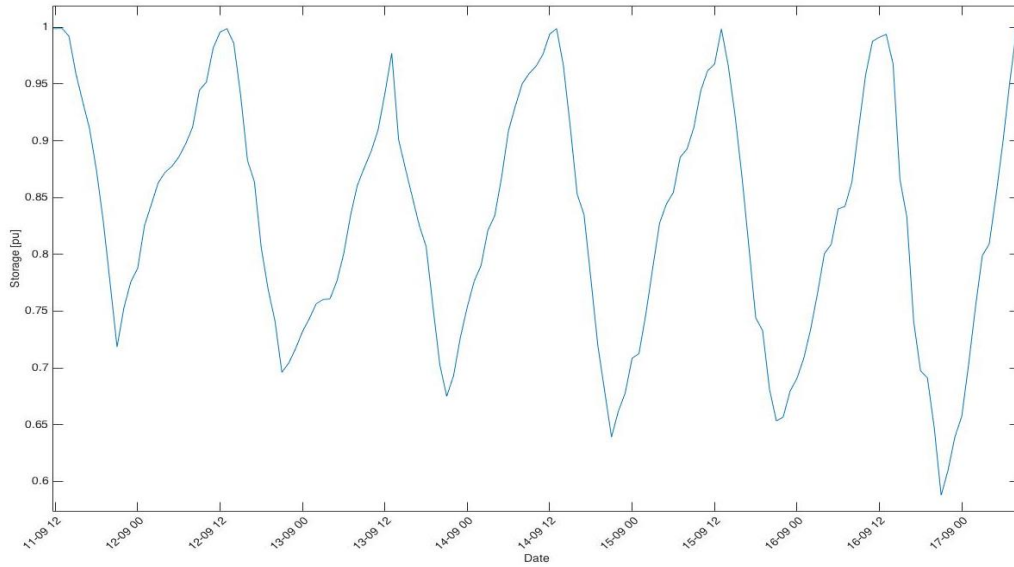
Figure 14. Pumped Reservoir level in September.

At this point, it is possible to observe that the PSP filled completely at some points, causing energy to be spilled since the conventional hydroelectric plants with reservoir have a minimum water flow required at all times.
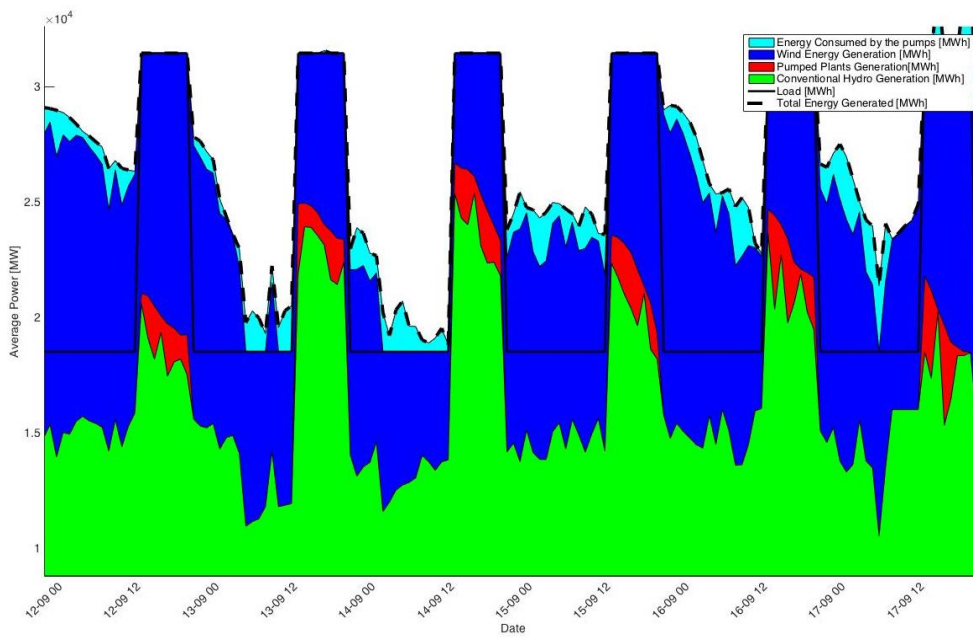

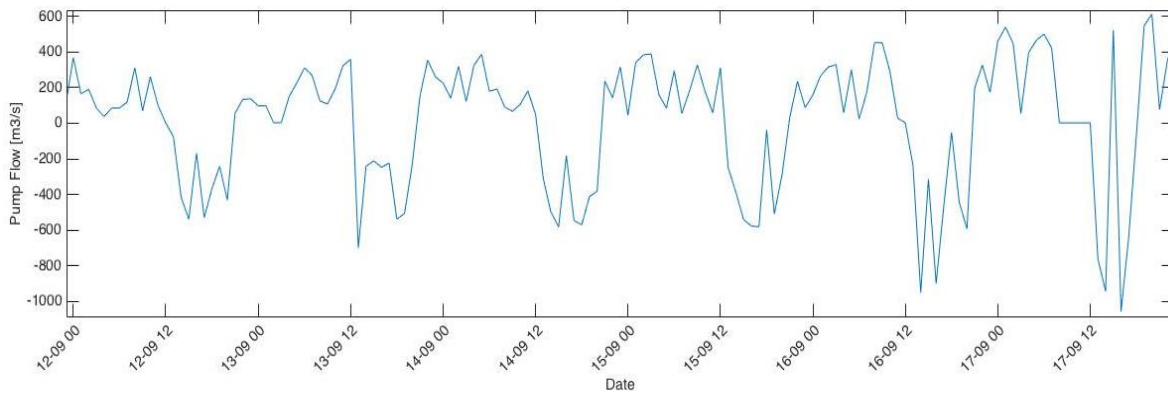**Figure 15. Power x Demand Profile in September.**

Figure 16. Pump flow at Canastra in September.

Observing the daily cycle, it was possible to see how it could be implemented, in a much smaller scale, a pumped storage facility to counterbalance the wind generation profile and store an exceeding energy from off-peak periods to use it during the peak demand of the day.

4   CONCLUSION

After simulating these two scenarios, it was possible to compare them to a case where the SPS was not present.

Table 5. Final Results.

	Energy Generated [TWh]	Energy Consumed [TWh]	Energy Wasted [TWh]	Energy Wasted / Energy Generated	Final Energy Stored [TWh]
No PSP	217	193,43	23,57	10,86%	104,0
Case 1	185	182,19	2,81	1,52%	144,6
Case 2	222	200,25	21,75	9,80%	104,5

Looking into Table 5 it is possible to compare the improvements on the amount of energy wasted for each case. As it was predicted, the larger the SPS reservoir, the better results it would supply. Then, in case 1 where it was considered two SPS that together summed 22,34 TWh of storage capacity, managed to spill only 1,52% of all energy generated in the period, a great improvement from the 10,86% of wasted energy from the case without an EPS.

Meanwhile, in the Case 2 that included a small scale SPS in the system, it already showed an improvement of 1% in the wasted energy.

Considering that the Energy Consumed column includes both the electrical load and the pumping energy consumed, it was expected for Case 2 to have the highest amount of energy consumed due to the higher load used as input for this case, as well as the amount used for pumping. The result can only be compared among the three cases when looking into the third column since its load levels are different.

Besides, comparing stress case with the case without the SPS plant, the amount of energy stored in the end is also superior with the SPS, since less water was spilled, being stored in the system's reservoirs.

Through the incorporation of wind farms, it showed an efficient way to manage and operate the reservoirs allowing it to store peak wind generation, which occurs in the middle of the night, using it along the next day to regulate the peak load in the afternoon. Considering the overall efficiency of a PSP that is between 70% and 80%, it is according to the literature review one of the most efficient storage methods and the only method that allows a large storage in the form of potential energy as well.

Besides, its presence along the year, managed to regulate the water flows in the system along the dry season, so that most conventional reservoirs remained at a constant level when normally it would empty.

In general, the case analysis allowed observing the influence and effects of an SPS in a portfolio of hydro and wind generation and how its inclusion would be beneficial for the system, allowing a peak regulation through storage of wind power. Considering the future scenario in Brazil where wind generation is constantly growing and latest auctions started to introduce photovoltaic power plants, mainly in the Northeast subsystem, the intermittency from these renewable sources will need a regulation. Given this fact, since hydroelectric power is the main component in the Brazilian energy matrix, a pumped storage plant becomes a good alternative to play this role.

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