DATABASE TO SUPPORT ENERGY PLANNING APPLICATIONS

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Abstract. Currently, obtaining updated real data for analyzes related to the generation of hydroelectric and thermoelectric energy in Brazil is only accessible through the database provided by the National System Operator (ONS), by means of a file package used in the computational model NEWAVE (Long and Medium Term Interconnected Hydrothermal Systems Operation Planning Model). NEWAVE was developed to determine the optimal operation policy for the hydrothermal power system, but working with this information in a direct way is practically impossible, which makes it difficult to carry out new studies by industry and academia. Opposing this difficulty, researchers at the Laboratory of Technologies and Bioinspired Solutions of the Federal University of ABC (LabBITS) implemented an open platform for general access of the information of the Brazilian electric power generation system, where the main objective was to concatenate all the information to foment the studies with different operative scenarios referring to the energetic planning in Brazil. The data is constantly updated with files from the Electric Energy Trading Chamber (CCEE) database. The data was reorganized through JAVA programming language and was recorded in a new single database with MySQL as a template, to facilitate the reading and recording of study's input data and results. From this organization, a visual query platform is being developed to support the development of modules for the determination of optimal generation within a bioinspired computational platform called Energ.IA. [1]

Keywords: Database, Energy Planning, Hydrothermal Systems.

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[1] Energ.IA is an artificial intelligence and optimization tool platform developed by UFABC's LabBITS (Laboratory of Technology and Bioinspired Solutions) and applied to solve energy and system planning problems Electric Power

1 Introduction

Electricity generation in Brazil, comes mostly, from hydraulic sources. According to Alencar [1], hydropower projects have sustained the country's economic growth, since the military government, and have remained a great option even in the face of increasingly restrictive environmental barriers, given Brazil's large hydroelectric potential.

Difficulties in environmental licensing for new hydroelectric projects led to the expansion of more polluting thermoelectric generation due to the use of fossil-derived fuels, responsible for the emission of greenhouse gases. This situation is aggravated when inefficient planning of the operation of hydrothermal systems occurs.Therefore, it is important to make optimal use of the existing hydroeletric system and develop more sophisticated tools for hydrothermal power system operation planning, Asano Junior [2].

The National Interconnected System (SIN) is unique in the world characterized by the large availability of very low cost hydropower generation and more costly thermal generation. The optimal operation of this system comprehends the decision to using water for power generation now or to save water for future use and generate power through thermoelectric plants, Rabelo [3]. The lack of water in a dry period results in the risk of deficit, while the excess of thermalpower near a rainy period results in the risk of spoilage, wasting energy. Thus, an economical decision should balance the present benefit of using water for hydropower generation and the expected future benefit, due to it's storage, Cicogna [4].

Currently, obtaining data for analysis related to hydroelectric and thermoelectric power generation in Brazil is only accessible through the database provided by the the National System Operator (ONS) through the Electric Energy Trading Chamber (CCEE). A package of files used in the NEWAVE computational model CEPEL [5] is made available. According to Toscano [6], this is a long-term optimization model, which determines the hydroelectric and thermoelectric generation strategy each month with the objective of minimizing the expected cost of operation over the entire planning period, typically from 2 to 5 years.

NEWAVE was developed to determine the optimal operation policy for the hydrothermal power system, but working with this information in a straightforward manner is practically impossible, making it difficult for industry and academia to conduct further studies. Given this difficulty and the importance of the theme for the development of new methodologies that can help in planning the operation of the Brazilian electric system, researchers from the Laboratory of Bioinspired Technologies and Solutions of the Federal University of ABC (LabBITS) are implementing a platform, aiming at concatenating all the information to foster studies with distinct operating scenarios related to energy planning in Brazil. This new platform allows students and researchers from the laboratory to access the data and register progress in a knowledgeable manner and the platform can be developed hand in hand.

The paper is organized as follows. Initially we present a synthesis of the general scenario on energy production in Brazil and the database, followed by the mathematical formulations that are responsible for the optimization. This is followed by the methodology session, containing which data were used plus a brief explanation, and then an example of how the created database can be used for the elaboration of an energy planning. Finally, the article concludes by presenting the next steps to be consolidated as well as the benefits to be obtained.

1.1 Mathematical formulation

According to Asano et al. [7], the problem of Hydrothermal System Operation Planning can be optimized by an objective function (F.O.) that minimizes the total cost of operation planning, C_0, depending on the reservoir levels of each hydropower plant, i, for the whole period, t, within the planning horizon, $t \in [1, T]$, in months. The objective function also depends on the volume of artificially transferred water, $ya^t_{i,j}$, from plant i to plant j.

$$F.O. = \min_{x^t_i, ya^t_{i,j}} C_0 \tag{1}$$

The cost corresponds to the present value of the marginal costs of the operation of the thermoelectric system employed, C^t_{term}:

$$C_0 = \sum_{t=1}^{T} \frac{C^t_{term}}{(1+J)^{t/12}} \tag{2}$$

$$C^t_{term} = \Psi(E^t_{term}) \tag{3}$$

$$E^t_{term} = D^t - GH^t \tag{4}$$

$$GH^t = \sum_{i=1}^{N} P^t_i(x^t_i, u^t_i, q^t_i, ya^t_{i,j}), j \in \phi_i \tag{5}$$

where:
GH^t: is the total hydroelectric production in period t;
E^t_{term}: is the thermal complementation in period t;
D^t: is the consumption in period t;
Ψ: is the marginal cost function of thermoelectric system operation;
J: is the annual interest rate in the period;
u^t_i: is the flow effluent controlled by the i plant in the t period;
q^t_i: is the flow turbined by the i plant in the t period.
ϕ_i: is the set of power plants with resources to transfer water to power plant i.

The total hydroelectric production incorporates the production function P^t_i of each of the N hydroelectric plants i.

2 Methodology

In order to build a single database, with information to study different operating scenarios, the data is downloaded directly from the CCEE database into file packages called price decks [8]. They are composed by a group of files needed for NEWAVE processing, the price decks were analyzed and the data was reorganized in tables and a single MySQL database [9]. Through JAVA [10] programming language, the monthly price decks data were extracted, remodeled and automatically saved in the created database. The tables belonging to this bank are described below. A comprehensive description of the tables can be found in [5].

Table Dger

Table with general information about the considered price deck. Shows the planning horizon analyzed and all the considerations that were adopted for this planning. For the database, each row of this table presents all the important information for the analyzed deck; and the "numcaso" field is responsible for identifying to which deck each data in other tables it belongs.

Table Adterm

It presents information about anticipation of Liquefied Natural Gas (LNG) thermoelectric plants, related to the load level and the month, in chronological order.

Table Agrint

Displays the power exchange limit for the AgrintAgrup Table groups, according to the load threshold (light, medium and heavy) and specifying the start and end dates of the exchange.

Table Agrintagrup

It presents the energy exchange groupings between the submarkets, indicating the export and the receiving submarkets. This is a complementary table to the Agrint Table.

Table Carga_add

Provides monthly additional load values, in average MW, for each submarket throughout the planning horizon.

Table Cargapat

Presents monthly load values according to the submarket and the load level (light, medium and heavy).

Table Cvar

Contains data from the risk aversion mechanism. This data is used in planning of the operation, expansion and pricing of the electricity sector, as well as being part of the calculation of the physical guarantee of hydrothermal power plants.

Table Defpatmen

This table has information on the load levels (light, medium and heavy) of the month analyzed. The duration in hours of each load level varies according to the day of the week.

Table Desvio

Displays the amount of water in m^3/s diverted (if negative) or added (if positive) above the hydropower plant. Water diversion can be classified as consumptive use or remaining flow.

Table Durpatamar

Displays the monthly duration factor of each threshold for the entire planning horizon. This factor is a number between 0 and 1, and the sum of the duration factor of the thresholds in a given month should be equal to 1.

Table Empresas

Presents the number of brazilian thermal plants related to the number and name of the companies responsible for them.

Table Exph

Presents data of expansion of hydroelectric plants by pointing dates of new machines with their respective powers.

Table Exphvolmorto

This table is complementary to the Exph Table and presents information related to the dead volume of the hydroelectric plant.

Table Expt

Presents thermoelectric expansion or modification data, which can be of five types: minimum thermal generation (GTMIN), effective power (POTEF), maximum capacity factor (FCMAX), programmed unavailability (IPTER) and forced unavailability (TEIFT).

Table Ghmin

Displays the minimum hydraulic generation restrictions, informing the restriction start date.

Table Hidr

Presents data about the configuration of hydroelectric plants, such as downstream plant, historical flow data, existing or expanding plant.

Table Informacoes

Provides information about the initial year considered in the historical series for simulation purposes.

Table Intercambio

Displays the monthly exchange threshold value between submarkets for all planning years.

Table Intercpat

Presents the monthly values of the factors that should be applied to the average exchange between submarkets for each level and for all planning years.

Table Manut_term

Shows thermal plants that will undergo scheduled maintenance, specifying the date of maintenance, the duration of maintenance and the power in MW of the unit under maintenance.

Table Manut_combust

Displays changes in thermoelectric fuel cost value, indicating the beginning and end of the change.

Table Modif_hidr

Presents data regarding modifications to hydroelectric plants, indicating the date of modification and the new values to be considered. Modification can be in any of the following plant characteristics: minimum operating volume, maximum operating volume, machine sets, number of machines in a set, effective power, specific productivity, forced outage, scheduled outage, hydraulic loss, minimum flow, monthly evaporation coefficient, dimension-area or dimension-volume polynomials, leakage channel, maximum volume, minimum volume, number of base units, minimum volume with penalty adoption and minimum flow.

Table Penalidades

Presents the penalties applied for non-fulfillment regarding the requirements of other water uses, minimum mandatory flow or minimum exchange, according to the Equivalent Energy Reservoir (REE) number.

Table Restr_eletrica

Presents the moment when hydroelectric plants will have electrical restrictions and what are the values of these restrictions.

Table Selcor

It presents information about the simulation, parameters used in the selection of bender cuts.

Table Submercado

Displays data about submarkets indicating whether the submarket is fictitious or not.

Table Term

Presents the characteristics of thermoelectric plants: installed capacity, maximum capacity factor, forced outage, scheduled outage and minimum monthly thermal generation for all planning years.

Table Tipoexecucao

Presents the type of execution considered in the compilation of the NEWAVE program, being classified as complete execution or final simulation. This table is related to the “ typeExec ”field of the Dger table.

Table Tiposimfinal

Presents the type of final simulation considered in the NEWAVE program after convergence. Having one of the following classifications: not simulate, synthetic series simulation, historical series simulation, or data consistency. This table is related to the “ tiposimfinal ” field of the Dger table.

Table Combust

Displays fuel cost values according to thermal plant for each planning year.

Table Custo_deficit

Displays the deficit cost values per MWh for submarkets, according to deficit levels.

Table Dados_subm

Presents monthly information, such as average MW and small plant generation, about the submarket for all planning years.

Table Ree

Displays the Equivalent Energy Reservoirs related to the submarkets from which each o them belong.

Table Vazoes

Presents historical series of tributary flows of each hydroelectric plant, monthly, since 1931.

Table Vazpast

Presents monthly affluent flows for each hydroelectric plant, which will be used as initial condition in the generation of synthetic series.

Table Reservatorio

Provides information regarding hydroelectric plants, such as maximum and minimum volumes, maximum and minimum quotas,company responsible, among other informations contained in NEWAVE’s “HIDR.DAT” file.

Table Polinomios

Presents coefficient values of the dimension x volume, area x dimension and downstream polynomials. This information is in NEWAVE’s “HIDR.DAT” file.

Table Evaporacao

Shows the monthly water evaporation from reservoirs of hydroelectric plants.

Table Usina_caracteristicas

Contains several characteristics about hydroelectric plants, such as turbine type, maximum and minimum capacity factor, number of machine sets, among other information contained in NEWAVE's "HIDR.DAT" file.

Table Conjunto_maq

Presents information about machine sets of each hydroelectric power plant belonging to the brazilian hydrothermal system.

Fig. 1 shows tables that were created in MySQL Workbench [9], with their respect fields.

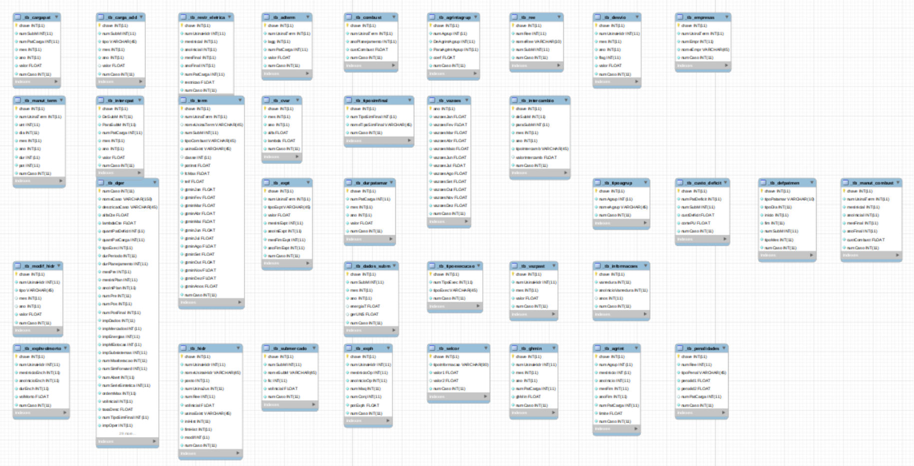
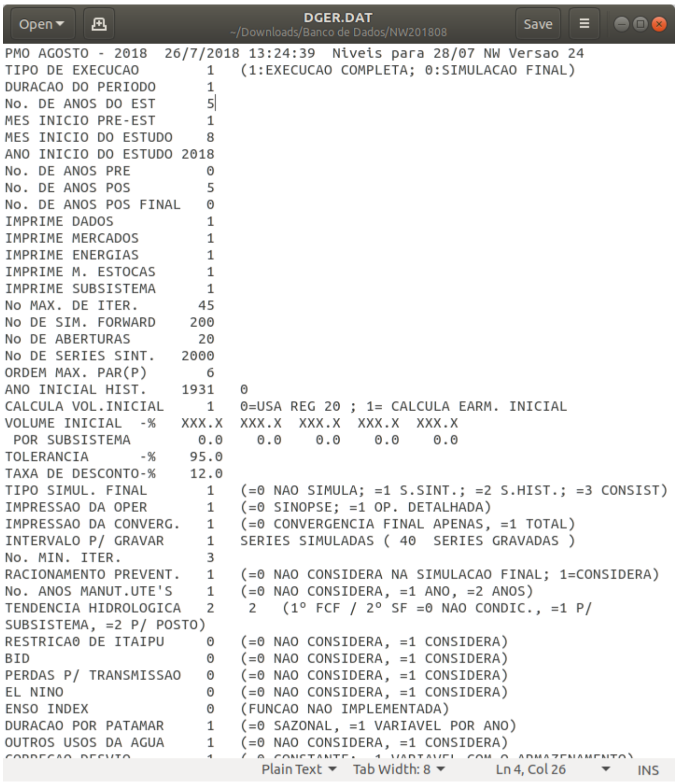


Figure 1. Visualization of the tables created in MySQL Workbench [9].

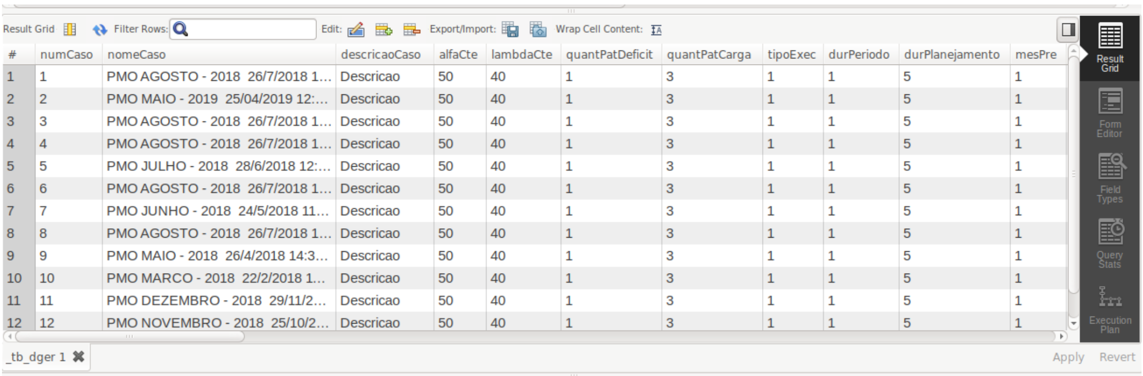
Files downloaded from the CCEE database are text files, such as the files shown in Fig. 2 and Fig. 4, or binary files, which require different and more complex manipulation to extract the information.



```
PMO AGOSTO - 2018  26/7/2018 13:24:39  Niveis para 28/07 NW Versao 24
TIPO DE EXECUCAO        1   (1:EXECUCAO COMPLETA; 0:SIMULACAO FINAL)
DURACAO DO PERIODO      1
No. DE ANOS DO EST      5
MES INICIO PRE-EST      1
MES INICIO DO ESTUDO    8
ANO INICIO DO ESTUDO 2018
No. DE ANOS PRE         0
No. DE ANOS POS         5
No. DE ANOS POS FINAL   0
IMPRIME DADOS           1
IMPRIME MERCADOS        1
IMPRIME ENERGIAS        1
IMPRIME M. ESTOCAS      1
IMPRIME SUBSISTEMA      1
No MAX. DE ITER.       45
No DE SIM. FORWARD    200
No DE ABERTURAS        20
No DE SERIES SINT.   2000
ORDEM MAX. PAR(P)       6
ANO INICIAL HIST.    1931   0
CALCULA VOL.INICIAL     1   0=USA REG 20 ; 1= CALCULA EARM. INICIAL
VOLUME INICIAL  -%   XXX.X  XXX.X  XXX.X  XXX.X  XXX.X
 POR SUBSISTEMA        0.0    0.0    0.0    0.0    0.0
TOLERANCIA      -%    95.0
TAXA DE DESCONTO-%    12.0
TIPO SIMUL. FINAL       1   (=0 NAO SIMULA; =1 S.SINT.; =2 S.HIST.; =3 CONSIST)
IMPRESSAO DA OPER       1   (=0 SINOPSE; =1 OP. DETALHADA)
IMPRESSAO DA CONVERG.   1   (=0 CONVERGENCIA FINAL APENAS, =1 TOTAL)
INTERVALO P/ GRAVAR     1   SERIES SIMULADAS ( 40  SERIES GRAVADAS )
No. MIN. ITER.          3
RACIONAMENTO PREVENT.   1   (=0 NAO CONSIDERA NA SIMULACAO FINAL; 1=CONSIDERA)
No. ANOS MANUT.UTE'S    1   (=0 NAO CONSIDERA, =1 ANO, =2 ANOS)
TENDENCIA HIDROLOGICA   2    2   (1° FCF / 2° SF =0 NAO CONDIC., =1 P/
SUBSISTEMA, =2 P/ POSTO)
RESTRICA0 DE ITAIPU     0   (=0 NAO CONSIDERA, =1 CONSIDERA)
BID                     0   (=0 NAO CONSIDERA, =1 CONSIDERA)
PERDAS P/ TRANSMISSAO   0   (=0 NAO CONSIDERA, =1 CONSIDERA)
EL NINO                 0   (=0 NAO CONSIDERA, =1 CONSIDERA)
ENSO INDEX              0   (FUNCAO NAO IMPLEMENTADA)
DURACAO POR PATAMAR     1   (=0 SAZONAL, =1 VARIAVEL POR ANO)
OUTROS USOS DA AGUA     1   (=0 NAO CONSIDERA, =1 CONSIDERA)
```

Figure 2. Dger table in text format [9].

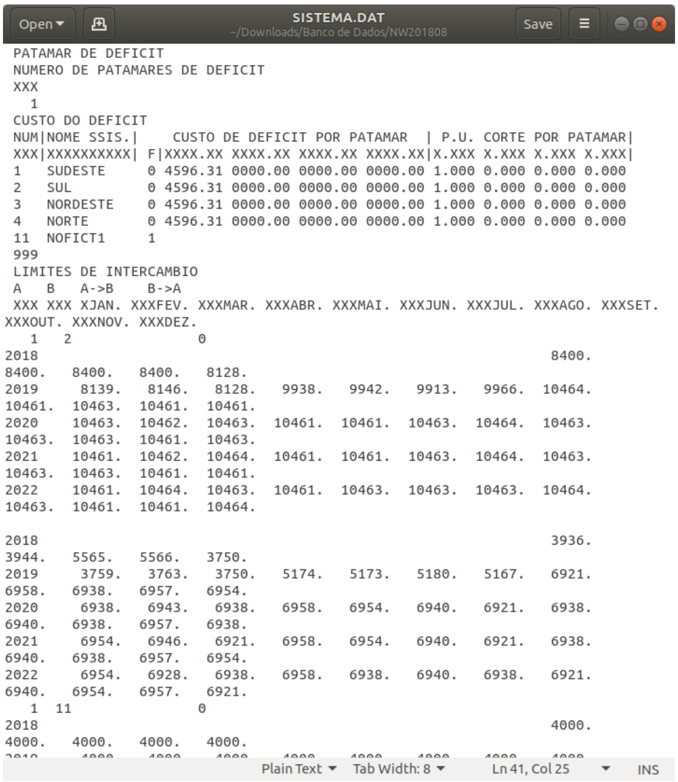
The Dger file, Fig. 2, is the first file to be written to the database, as it contains the necessary field to identify the price deck with the specification of the year and month in which NEWAVE program was simulated, and thus, identifying in the other database tables the respective input or output data of this simulation. An example of the filled Dger table in the database is shown in Fig. 3. It is possible to notice the year and month of simulation in the "nomeCaso" column.



#	numCaso	nomeCaso	descricaoCaso	alfaCte	lambdaCte	quantPatDeficit	quantPatCarga	tipoExec	durPeriodo	durPlanejamento	mesPre
1	1	PMO AGOSTO - 2018 26/7/2018 1...	Descricao	50	40	1	3	1	1	5	1
2	2	PMO MAIO - 2019 25/04/2019 12:...	Descricao	50	40	1	3	1	1	5	1
3	3	PMO AGOSTO - 2018 26/7/2018 1...	Descricao	50	40	1	3	1	1	5	1
4	4	PMO AGOSTO - 2018 26/7/2018 1...	Descricao	50	40	1	3	1	1	5	1
5	5	PMO JULHO - 2018 28/6/2018 12:...	Descricao	50	40	1	3	1	1	5	1
6	6	PMO AGOSTO - 2018 26/7/2018 1...	Descricao	50	40	1	3	1	1	5	1
7	7	PMO JUNHO - 2018 24/5/2018 11...	Descricao	50	40	1	3	1	1	5	1
8	8	PMO AGOSTO - 2018 26/7/2018 1...	Descricao	50	40	1	3	1	1	5	1
9	9	PMO MAIO - 2018 26/4/2018 14:3...	Descricao	50	40	1	3	1	1	5	1
10	10	PMO MARCO - 2018 22/2/2018 1...	Descricao	50	40	1	3	1	1	5	1
11	11	PMO DEZEMBRO - 2018 29/11/2...	Descricao	50	40	1	3	1	1	5	1
12	12	PMO NOVEMBRO - 2018 25/10/2...	Descricao	50	40	1	3	1	1	5	1

Figure 3. Equivalent Dger table in Energ.IA database.

The table Sistema, shown in Fig. 4, is an example of a file that has been divided into several tables for the purpose of facilitating future studies. This makes data analysis more specific and prevents the program from having to load too much data when the user wants to filter only a specific information.

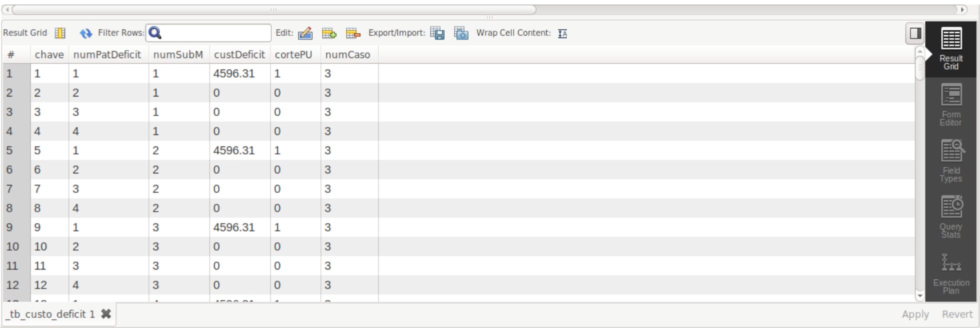


```
 PATAMAR DE DEFICIT
 NUMERO DE PATAMARES DE DEFICIT
 XXX
   1
 CUSTO DO DEFICIT
 NUM|NOME SSIS.|    CUSTO DE DEFICIT POR PATAMAR   | P.U. CORTE POR PATAMAR|
 XXX|XXXXXXXXXX| F|XXXX.XX XXXX.XX XXXX.XX XXXX.XX|X.XXX X.XXX X.XXX X.XXX|
 1   SUDESTE     0 4596.31 0000.00 0000.00 0000.00 1.000 0.000 0.000 0.000
 2   SUL         0 4596.31 0000.00 0000.00 0000.00 1.000 0.000 0.000 0.000
 3   NORDESTE    0 4596.31 0000.00 0000.00 0000.00 1.000 0.000 0.000 0.000
 4   NORTE       0 4596.31 0000.00 0000.00 0000.00 1.000 0.000 0.000 0.000
 11  NOFICT1     1
 999
 LIMITES DE INTERCAMBIO
 A   B   A->B    B->A
 XXX XXX XJAN. XXXFEV. XXXMAR. XXXABR. XXXMAI. XXXJUN. XXXJUL. XXXAGO. XXXSET.
XXXOUT. XXXNOV. XXXDEZ.
   1   2               0
2018                                                                    8400.
8400.   8400.   8400.   8128.
2019     8139.   8146.   8128.   9938.   9942.   9913.   9966.  10464.
10461.  10463.  10461.  10461.
2020    10463.  10462.  10463.  10461.  10461.  10463.  10464.  10463.
10463.  10463.  10461.  10463.
2021    10461.  10462.  10464.  10461.  10461.  10463.  10464.  10463.
10463.  10463.  10461.  10461.
2022    10461.  10464.  10463.  10461.  10463.  10463.  10463.  10464.
10463.  10461.  10461.  10464.

2018                                                                    3936.
3944.   5565.   5566.   3750.
2019     3759.   3763.   3750.   5174.   5173.   5180.   5167.   6921.
6958.   6938.   6957.   6954.
2020     6938.   6943.   6938.   6958.   6954.   6940.   6921.   6938.
6940.   6938.   6957.   6938.
2021     6954.   6946.   6921.   6958.   6954.   6940.   6921.   6938.
6940.   6938.   6957.   6954.
2022     6954.   6928.   6938.   6958.   6938.   6940.   6938.   6921.
6940.   6954.   6957.   6921.
   1  11               0
2018                                                                    4000.
4000.   4000.   4000.   4000.
```

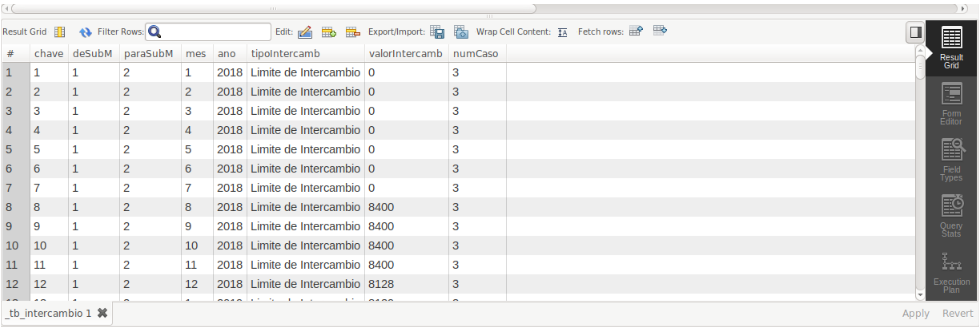
Figure 4. Sistema table in text format, [8].

As an example, the data viewed in the Table Sistema, Fig. 4, was divided into two tables: the Custo_deficit table e and the Intercambio table, as shown in Fig. 5 and Fig. 6, respectively.



#	chave	numPatDeficit	numSubM	custDeficit	cortePU	numCaso
1	1	1	1	4596.31	1	3
2	2	2	1	0	0	3
3	3	3	1	0	0	3
4	4	4	1	0	0	3
5	5	1	2	4596.31	1	3
6	6	2	2	0	0	3
7	7	3	2	0	0	3
8	8	4	2	0	0	3
9	9	1	3	4596.31	1	3
10	10	2	3	0	0	3
11	11	3	3	0	0	3
12	12	4	3	0	0	3

Figure 5. Equivalent Custo_deficit table in Energ.IA database.



#	chave	deSubM	paraSubM	mes	ano	tipoIntercamb	valorIntercamb	numCaso
1	1	1	2	1	2018	Limite de Intercambio	0	3
2	2	1	2	2	2018	Limite de Intercambio	0	3
3	3	1	2	3	2018	Limite de Intercambio	0	3
4	4	1	2	4	2018	Limite de Intercambio	0	3
5	5	1	2	5	2018	Limite de Intercambio	0	3
6	6	1	2	6	2018	Limite de Intercambio	0	3
7	7	1	2	7	2018	Limite de Intercambio	0	3
8	8	1	2	8	2018	Limite de Intercambio	8400	3
9	9	1	2	9	2018	Limite de Intercambio	8400	3
10	10	1	2	10	2018	Limite de Intercambio	8400	3
11	11	1	2	11	2018	Limite de Intercambio	8400	3
12	12	1	2	12	2018	Limite de Intercambio	8128	3

Figure 6. Equivalent Intercambio table in Energ.IA database.

3 Example of use

According to Asano et al. [7], changes in the Brazilian Electric System increasingly require tools to monitor its evolution, in order to minimize the cost of operation without impacting the availability of electricity generation. Thus, in order to illustrate the use of the platform to minimize operation costs, a subset of Brazilian hydroelectric system was taken. Fig. 7, presents the test case corresponding to the cascade of hydroeletric plants Grande and Pardo rivers. In this subset, 13 plants are considered, including plants with reservoirs: Camargos, Furnas, Mascarenhas de Morais, Caconde, Marimbondo and Água Vermelha; and run-of-the-river power plants: Itutinga, Luís Carlos Barreto, Jaguará, Volta Grande, Porto Colômbia, Euclides da Cunha and Armando de Sales Oliveira. With the ENERG.IA database different subsets of power plants of the Brazilian system and can be selected as part of a test setup.

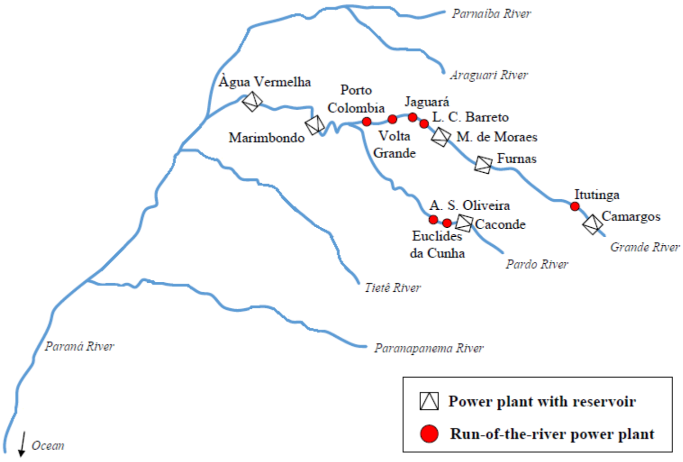


Figure 7. Cascade of plants represented in the test case.

In the case studied, the natural inflows for the coming 60 months in each river was projected based on the long term series of inflows with a neural network model proposed by Ferreira et al. [11]. Development of tools to forecast series of inflows is a topic of study at LabBITS where the database and computational platform Energ.IA is aimed to support. Historical data, series forecasts and tools developed are integrated in the platform which can be re-used, tested and compared with other techniques and new developments. Similar to the topic of optimization techniques, which are also part of the platform. In the studied presented below, a meta-heuristic proposed by Asano et al. [7] was used to minimize the cost of the power plants planned operation.

The volume variation of each reservoir of hydroelectric power plants presented in Fig. 8 represents the controlled operation of the system along the 60 month of the planning horizon, resulted from the optimization of the cost function described in Section 1.1. Water is stored and released from reservoirs, regulating seasonal effects of inflow and energy supply according to consumption.

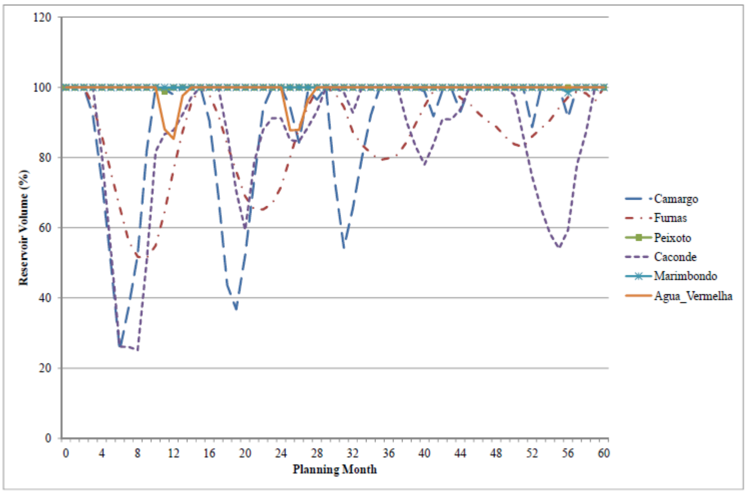


Figure 8. Monthly volume of reservoirs along the planning horizon.

The optimal operation is obtained by minimizing the present value of total cost from thermal electricity, which is illustrate in Fig. 9 as a difference between the expected consumption and the controlled hydro production.

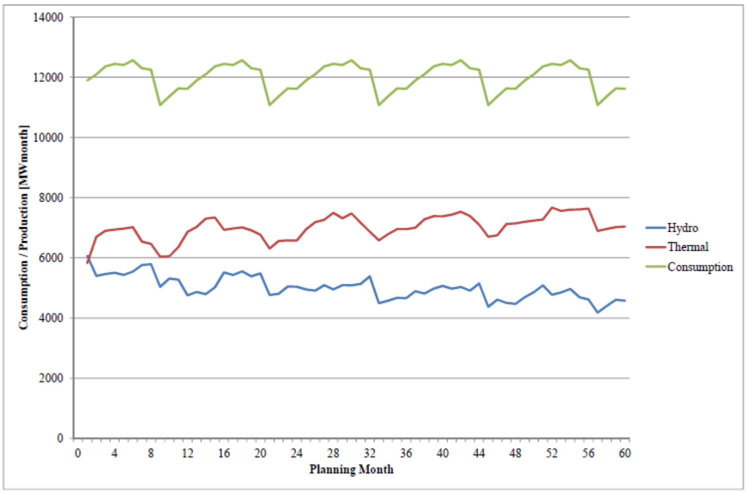


Figure 9. Representation of monthly hydroelectric and thermal generation, after application of the objective function.

Additionally, reservoirs constrains to allow public supply and other water uses are also parameters imported to the database and taken into consideration during the problem solving process.

4 Contributions

The sample presented in Section 3 is just a small example of the possibilities created by the new database created. Future use of data stored in the database will make possible:

- Reproduction of the test;
- Elimination of typo errors while inputing parameters automatically;
- Comparison of the test using different artificial intelligence techniques;
- Test considering any cascade of power plants or all plants of the Brazilian Hydroelectric System;
- Evaluation of different scenarios, being possible to compare with the planning done in the past and actual operation;
- Easily update the system parameters with data imported from ONS;
- Add information such as new machines in operation at the plants, parameters from other sources such as precipitation information or climatic influences;
- Expand with data for other energy sources such as wind speed, parameters of wind generators, solar irradiation, among others.

Thus, this database will gather important information for energy planning studies and contribute to the continuous development and future research activities at LabBITS.

5 Conclusion

The operation complexity of the Brazilian electricity system is remarkable, due to the large extension of the territory and size and characteristics of hydroelectric park, requiring efficient strategies in the pursuit of minimizing the costs of operation. Thus, this paper has presented the recent progress of the LabBITS team in the development of a database to integrate the Energ.IA platform, which is aimed to support energy planning and its decisions making process. The database was initially elaborated based on the parameters of Brazilian hydroelectric power system. These parameters are used as input data in national energy planning tools and updated data is added in the platform in a monthly basis. This updating process enables new research studies with current parameters and status of the real system.

The database demonstrates to be an interesting tool for energy planning studies. With this database, application and comparative tests of different artificial intelligence techniques will be possible and knowledge can be built without wasting of development time, rewriting previously tested codes or correcting typos in input parameters. Thus, with the database completed, more complex and realistic scenarios can be tested and new solutions proposed to improve the operation of Brazilian system.

Acknowledgements

Acknowledgments to the Laboratory of Technologies and Bioinspired Solutions (LabBITS), the UFABC Dean of Research and Undergraduate Studies, the Coordination for the Improvement of Higher Education Personnel (CAPES), and the National Council for Scientific and Technological Development (CNPq) , project number 432423 / 2016-8.

References

[1] Alencar, T. R., 2017. *Otimização da potência de bombeamento aplicado ao planejamento do sistema hidrotérmico de potência via colônia de formigas*. PhD thesis, Universidade Federal do ABC - Programa de Pós-Graduação em Energia, Santo André, Brasil.

[2] Asano Junior, R., 2018. *Energetic integration of new sources in Brazilian renewable electricity*. PhD thesis, Universidade Federal do ABC - Programa de Pós-Graduação em Energia, Santo André, Brasil.

[3] Rabelo, R. d. A. L., 2010. *Componentes de software no planejamento da operação energética de sistemas hidrotérmicos*. PhD thesis, Universidade de São Paulo - Escola de Engenharia de São Carlos, São Carlos, Brasil.

[4] Cicogna, M. A., 2004. *Sistema de suporte à decisão para o planejamento e a programação da operação de sistemas de energia elétrica*. PhD thesis, Universidade Estadual de Campinas - Faculdade de Engenharia Elétrica e Computação, Campinas, Brasil.

[5] CEPEL, jul.2019. Modelo estratégico de geração hidrotérmica a subsistemas equivalentes: Manual do usuário. `http://www2.aneel.gov.br/aplicacoes/audiencia/arquivo/2013/086/documento/manualusuario.pdf/`. Last accessed on July, 2019.

[6] Toscano, A. E., 2009. Comparação entre os modelos newave e odin no planejamento energético do sistema interligado nacional. Master's thesis, Universidade Estadual de Campinas - Faculdade de Engenharia Elétrica e de Computação, Campinas, Brasil.

[7] Asano, P. T. L., Gramulia, J. J., & Asano, R. J., 2018. Contribuição para a operação e o gerenciamento e controle de transferência não natural de água entre rios para geração de energia elétrica. *Congresso Brasileiro de Planejamento Energético - XI CBPE*, vol. 1.

[8] CCEE, 2019. Deck de preços do newave. `https://www.ccee.org.br/portal/faces/acesso_rapido_header_publico_nao_logado/biblioteca_virtual?palavrachave=Conjunto+de+arquivos+para+c%C3%A1lculo&_adf.ctrl-state=zcoxomrz6_1&_afrLoop=748356580864986#!%40%40%3F_afrLoop%3D748356580864986%26palavrachave%3DConjunto%2Bde%2Barquivos%2Bpara%2Bc%25C3%25A1lculo%26_adf.ctrl-state%3Dzcoxomrz6_5`. Last accessed on July, 2019.

[9] Oracle, 2019a. MySQL Workbench. `https://dev.mysql.com/downloads/workbench/`. Version : MySQL Workbench Community 8.0.17.

[10] Oracle, 2019b. Java SE Development Kit 11. `https://www.oracle.com/technetwork/java/javase/`. Version : Java SE Development Kit 11.0.4.

[11] Ferreira, F. G., Aragão, A. P., Asano, P. T. L., Santos, R. C., & Sacchi, R., 2017. Desenvolvimento de uma ferramenta computacional em plataforma aberta aplicada à previsão de vazões afluentes das usinas hidroelétricas. *Revista Interdisciplinas de Pesquisa em Engenharia*, vol. 2, n. 10, pp. 105–124.