USE OF AN INFORMATIONAL SYSTEM FOR MODELING AND SIMULATION CONCERNING THE PROGNOSIS OF ELECTRIC POWER

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Abstract:

The management of the electric power process in modern hydroelectric power plants implicate the intense use of the information technology, both for the activities performed in actual time and also for the ones performed outside the actual time.

Now, when discussing about the problem concerning the development of hydroelectric potential, in the same time with the optimization of production process, it is necessary to assist the manufacturer's decision in choosing those production capacities able to cover the electric power consume which has important variations in time.

Concerning the production of electric power, its defining particularity that it can not be deposited, also imposes that the prognosis of electric power to be as precise as possible. Using an advanced informational system instrument for parametric modeling and simulation concerning the electric power can also be made scenarios and prognosis having an error of 3% instead of 5%, in the present, being place at the upper limit of the admissible safety concerning the operation of the national energetic system.

Key words: production optimization, parametric modeling, production prognosis, web application

1. Introduction

Variation in time of the electric power consume outlines a series of technical problems concerning especially the coverage of the variable part from the load curve.

The main technical requirements which must observed by the plants participating to cover this area are:
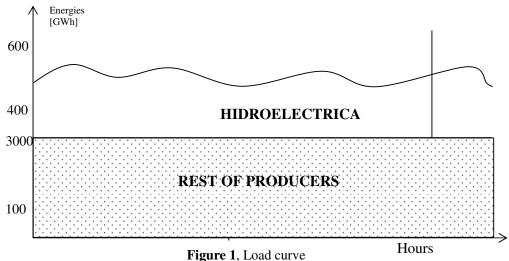
- *High loading speed,* in MW/min, in order to provide the slope for rapid development during the peak hours;
- *Actuation in a very short time,* in order to participate at the coverage of the variable part from the load curve;
- *Possibility to take over the sudden load variations;*
- *Full load when operating with alternating load;*
- *The possibility to operate at the minimum load as low as possible;*
- *Safety in operation at alternating loads and during the transitional processes connected to the groups starting.*

2. Application

The technical requests to be observed by a group for operation in alternating regime are concentrated in the handiness concept.

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The hydroelectric power plants observe all these technical requirements, fact that makes them more appropriate in covering the variable part of the load curve.

The establishment of the curve to be covered by the hydro units (hourly values) is illustrated in fig.1

Figure 1, Load curve

Considering:

C_i, i=1…24 as the hourly values from the prognosis of the internal consume made available by the OPCOM,

Mc – daily average of the values above,

Mh – daily average of all contractual obligations of S.C. Hidroelectrica S.A.

E_i, i=1…24 – hourly values of export obligations with the Mc average.

We obtain:

Mrest=Mc + Mc-Mh – the average remained to be produced by the rest of producers and which is considered equal with the hourly values, taking into account the fact that is about the nuclear and thermal plants which usually produce, banded energy (the darken area in fig. 1)

It results:

H_i=Ci+Ei-Mrest – these are the hourly values to be covered by the hydroelectric production (the white area in fig. 1).

The prognosis of annual production is an operation of great importance for planning the operation of the energetic system in the conditions of the Romanian market energy. Deviations higher than 5% in the evaluation of hydroelectric resources can have as consequence difficulties in providing the quantities of energy and the volume of system services, and also the disorder of market economic mechanism.

Lately, the importance of short time prognosis activity is determined by the amplitude of changes generated by the transformations in this sector and by the organization of the energy stock market.

Through its hourly performances, the production of electric power at national level is classified, from the statistic point of view, in the series of time category. The special literature generally presents two approaching methods:

- **parametric models** preferred for efficiency and for the fact that they can be developed both on the basis of a wide and small data register;

- **non-linear models** based on neuronal networks. This method is more advantageous because it allows the use of incomplete data sets, missing their continuity and it can use, just as parametric modeling, simultaneously information coming from multiple domains (energetic, meteorological, economic), but it needs a mighty modeling, prognosis and maintenance effort.

Using the method of neuronal networks does not guarantees the obtaining of any results better than the parametric models and that is why we have chosen an approach based on the parametric modeling.

Now, inside Hidroelectrica, the production planning is based on the establishment of "hydrological features" of hydrographic basins for the next period, taking into considerations the evolution of hydrological characteristic in the previous year, a method which does not provide sufficiently good accuracy.

The method we propose, for the prognosis of Hidroelectrica power production, is the static method for performing the short time prognosis based on a static model.

The wide spread static model has the following form:

$$P(t) = \sum a_i(t) \bullet f_i(t) \div \varepsilon(t), \qquad t \in \tau \tag{1}$$

where:

$P(t)$ is the electric charge at t moment;

$f_i(t)$ – time function, usually sinusoidal having a 6 or 24 hours period, depending on the forecasted time interval;

$a_i(t)$ – coefficients of loss, in general variable in their turn, but constant for particular situations;

$\varepsilon(t)$ – modeling error.

The advantage of this method results from the fact that they are simple, the model parameters can be easily updated using a linear regression or an exponential adjustment. The disadvantage concerning this method consists in the inflexibility offered by the same period to functions $f_i(t)$, the fact that they can take into consideration the changes in the electric power consume and the coverage of load peaks.

A model improved variant (l) is the one where the functions $f_i(t)$ correspond to the spectral decomposition of time series in the frequency domain. In these conditions a time variable is given by the following equation:

$$f(x) = a * \sin bx + c * \cos bx$$

Using the method of the smallest squares to determine the values occurring in the expression of the function taken into consideration, there must be solved the following system:

$$\sum (a * \sin bt_i + c * \cos bt_i - Y_i)^2$$

$$\sum 2 \sin bt_i (a * \sin bt_i + c * \cos bt_i - Y_i) = 0$$

$$\sum 2 \cos bt_i (a * \sin bt_i + c * \cos bt_i - Y_i) = 0$$

Equivalent with:

$$a \sum \sin^2 bt_i + c \sum \sin bt_i \cos bt_i - \sum Y_i \sin bt_i = 0$$

$$a \sum \sin bt_i \cos bt_i + c \sum \cos^2 bt_i - \sum Y_i \cos bt_i = 0$$

$$a^2 \sum t_i \sin bt_i \cos bt_i - a * c \sum t_i \cos 2bt_i - c^2 \sum t_i \sin bt_i \cos bt_i - a \sum t_i Y_i \cos bt_i + c \sum t_i Y_i \sin bt_i$$

$$= 0$$

```
m1:=a*(sin(b*1)^2+sin(b*7)^2)+c*(sin(b)*cos(b)+sin(b*7)*cos(b*7)
)-(1466*sin(b)+892*sin(b*7))=0;
    m2:=c*(cos(b*1)^2+cos(b*7)^2)+a*(sin(b)*cos(b)+sin(b*7)*cos(b*7
))-(1466*cos(b)+892*cos(b*7))=0;
   m3:=-a*c*(cos(2*b*1)+7*cos(2*b*7))+(a^2-
c^2)*(sin(b)*cos(b)+7*sin(b*7)*cos(b*7))-
a*(1466*cos(b)+892*7*cos(b*7))+c*(1466*sin(b)+892*7*sin(b*7))=0;
```

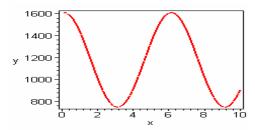We solve this system using the computer and we obtain several solutions:

$$m1 := a\,(\sin(b)^2 + \sin(7\,b)^2) + c\,(\sin(b)\cos(b) + \sin(7\,b)\cos(7\,b)) - 1466\sin(b)$$
$$- 892\sin(7\,b) = 0$$
$$m2 := c\,(\cos(b)^2 + \cos(7\,b)^2) + a\,(\sin(b)\cos(b) + \sin(7\,b)\cos(7\,b)) - 1466\cos(b)$$
$$- 892\cos(7\,b) = 0$$
$$m3 := -a\,c\,(\cos(2\,b) + 7\cos(14\,b)) + (a^2 - c^2)\,(\sin(b)\cos(b) + 7\sin(7\,b)\cos(7\,b))$$
$$- a\,(1466\cos(b) + 6244\cos(7\,b)) + c\,(1466\sin(b) + 6244\sin(7\,b)) = 0$$

```
s:={m1,m2,m3};
```
$$s := \{\,a\,(\sin(b)^2 + \sin(7\,b)^2) + c\,(\sin(b)\cos(b) + \sin(7\,b)\cos(7\,b)) - 1466\sin(b)$$
$$- 892\sin(7\,b) = 0,\ c\,(\cos(b)^2 + \cos(7\,b)^2) + a\,(\sin(b)\cos(b) + \sin(7\,b)\cos(7\,b))$$
$$- 1466\cos(b) - 892\cos(7\,b) = 0,\ -a\,c\,(\cos(2\,b) + 7\cos(14\,b))$$
$$+ (a^2 - c^2)\,(\sin(b)\cos(b) + 7\sin(7\,b)\cos(7\,b))$$
$$- a\,(1466\cos(b) + 6244\cos(7\,b)) + c\,(1466\sin(b) + 6244\sin(7\,b)) = 0\,\}$$

```
sol:=solve(s,{a,b,c});
```

```
> eq := x^2+1285*x-112791=0;
```
$$eq := x^2 + 1285\,x - 112791 = 0$$

```
> solve(eq,x);
```
$$-\frac{1285}{2} + \frac{1}{2}\sqrt{2102389},\ -\frac{1285}{2} - \frac{1}{2}\sqrt{2102389}$$

```
> sols := [solve(eq,x)];
```
$$sols := \left[\,-\frac{1285}{2} + \frac{1}{2}\sqrt{2102389},\ -\frac{1285}{2} - \frac{1}{2}\sqrt{2102389}\,\right]$$

```
> a=(1/2)*(-1285/2+1/2*2102389^(1/2));
```
$$a = -\frac{1285}{4} + \frac{1}{4}\sqrt{2102389}$$

```
> eq := x^2-7751925-5577*(-1285/2+1/2*2102389^(1/2))=0;
```
$$eq := x^2 - \frac{8337405}{2} - \frac{5577}{2}\sqrt{2102389} = 0$$

```
> solve(eq,x);
```
$$\frac{1859}{2}\sqrt{3} + \frac{1}{2}\sqrt{6307167},\ -\frac{1859}{2}\sqrt{3} - \frac{1}{2}\sqrt{6307167}$$

```
> sols := [solve(eq,x)];
```
$$sols := \left[\,\frac{1859}{2}\sqrt{3} + \frac{1}{2}\sqrt{6307167},\ -\frac{1859}{2}\sqrt{3} - \frac{1}{2}\sqrt{6307167}\,\right]$$

```
> c=(3/20)*(1859/2*3^(1/2)+1/2*6307167^(1/2));
```
$$c = \frac{5577}{40}\sqrt{3} + \frac{3}{40}\sqrt{6307167}$$

```
> b=arctg((1/338773)*(-1285/4+1/4*2102389^(1/2)-
1/1179)*(1859/2*3^(1/2)+1/2*6307167^(1/2))+3.14);
```

>
$$b = \text{arctg}\left(\frac{1}{338773}\left(-\frac{1515019}{4716}+\frac{1}{4}\sqrt{2102389}\right)\left(\frac{1859}{2}\sqrt{3}+\frac{1}{2}\sqrt{6307167}\right)+3.14\right)$$

```
> evalf(-1285/4+1/4*2102389^(1/2));
```
$$41.2404310$$

```
> evalf(5577/40*3^(1/2)+3/40*6307167^(1/2));
```
$$429.8467370$$

```
> evalf(arctg(1/338773*(-
1515019/4716+1/4*2102389^(1/2))*(1859/2*3^(1/2)+1/2*6307167^(1/2))+p
i));
```
$$\text{arctg}\left(\frac{1}{338773}\left(-\frac{1515019}{4716}+\frac{1}{4}\sqrt{2102389}\right)\left(\frac{1859}{2}\sqrt{3}+\frac{1}{2}\sqrt{6307167}\right)+\pi\right)$$

Using one of these solutions, we obtain the equation curve (a, b, c), having the below graphic representation:


```
>> evalf((-
1285/4+1/4*2102389^(1/2))*sin(1.04*x)+(5577/4*3^(1/2)+1/2*6307167^(1
/2))*cos(1.04*x)+1179);
```
$$41.2404310\sin(1.04\,x)+3670.615526\cos(1.04\,x)+1179.$$

According to these values, there will be obtained the following prognosis:

```
> evalf(41.24*sin(1.04*7)+429.84*cos(1.04*7)+1179);
```
$$1447.025594$$

```
> evalf(41.24*sin(1.04*10)+429.84*cos(1.04*10)+1179);
```
$$1449.587608$$

```
> evalf(41.24*sin(1.04*12)+429.84*cos(1.04*12)+1179);
```
$$1503.000879$$

```
> evalf(41.24*sin(1.04*14)+429.84*cos(1.04*14)+1179);
```
$$1404.54355$$

```
> evalf(41.24*sin(1.04*15)+429.84*cos(1.04*15)+1179);
```

```
> evalf(41.24*sin(1.04*20)+429.84*cos(1.04*20)+1179);
```
$$1058.007680$$

The percentage relative error (%) is calculated using the formulae:

$$\varepsilon = \frac{1}{N}\sum |y(t)-y_1(t)|*100\Big/y(t)$$

where: y(t) is the value of production performed;; y_1(t) is the value of estimated production.

As a test base have been chosen the hourly performances in February which does not contain red letter days, days which disturb both the analysis and the prognosis for the other days.

Based on the results presented, one can say that, from the quantitative point of view, to choose the scenario to predict the production of electric power is of a great importance. The results of the prognosis are very sensible in proportion to this criterion, especially in cases when is possible to occur a development contrary to the considered estimation. On the other hand, from the qualitative point of view, it is appreciated that the estimation based on the proposed model is a realistic approach, which provides the correct determination of hydroelectric power plants main parameters, so that they can cover the consume of electric power which have important alternations along time.

The elaboration of scenarios and prognosis is done using an advanced informational system for modeling and simulation, which also encloses a complex interconnected data base and a system of programs to provide the management of these data and their internet access system.

There had been used the newest platforms and software products for developing the data base accessible through the internet (SQL Server, OLAP).

The architecture of this application is modular, being possible to be extended with new functions, without disturbing the existent components and without the need to reorganize the existing data in the system.

3. Conclusions:

The web application based on data base, with advanced searching, displaying, calculation and presentation functions is an advanced modeling and simulation instrument referring to prognosis of electric power from all hydroelectric power plants belonging to Hidroelectrica company and to assist the producer decision in choosing those production capacities to cover those alternative part from the load curve.

Using an advanced informational system instrument of parametric modeling and simulation concerning the electric power prognosis there can also be made scenarios and prognosis with an error of 3% instead of 5% estimated in present time, located at the upper limit of admissible safety concerning the operation of national energetic system.

These application performances take into consideration the user-friendly interface, safety during exploitation and operation, data safety, short time response provided by Microsoft SQL Server 2000. The data safety shall be performed both by mechanisms specific to internet access control (proxy server) and by SGBD internal mechanisms related to Microsoft SQL Server 2000.

Taking into consideration the big territorial spread of plants belonging to Hidroelectrica, the application can also function locally, where there are no internet connections.

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