# The extrapolative methods principle for the forecast of the electrical energy consumption

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***Abstract.*** As part of this paper, the main purpose is to present the elaboration methodology of some forecasts in the energy consumptions area, using few mathematical models.
It is self-understood that are processes which are developed in time, in conditions of aleatory perturbation. The adaptation process must be continuous, showed in forecasts and rehearses castigations which will mentain the evolution on the target. More, once we are close to the specific targets, in the future are new targets, who presumes new forecast horizons and new decisions.

## I.Introduction

The forecast for the electrical energy consumption and power also, is the scientific activity with the main purpose: the forecast for the energy consumption and power based on calculations analysis and based on the interpretation of different dates, so we will obtain a more precise concordance between the estimated consumptions and the one effectively realised.[1]
We can see that a batch of parameters (reasons) with aleathory character leads to the energy consumtion: climatical factors, demographical factors, economical factors and another factors.
The methodology of elaboration for a forecast study, for the energy consumption has few main steps:
- collecting, selection and analyse the initial dates;
- establishing the mathematical model for the consumption;
- the analyse for the variance which has been obtained for the forecast and establishing the final decision.[2]

## II.Components of the mathematical model for the energy consumption

Consumption curve, represints the energy fluctuation in time (or taking into consideration another parameter) and it can be split in more components. The forecast experience of the energy consumption shows four main components which determines the consumption curve *(W)* (See example Figure 1):

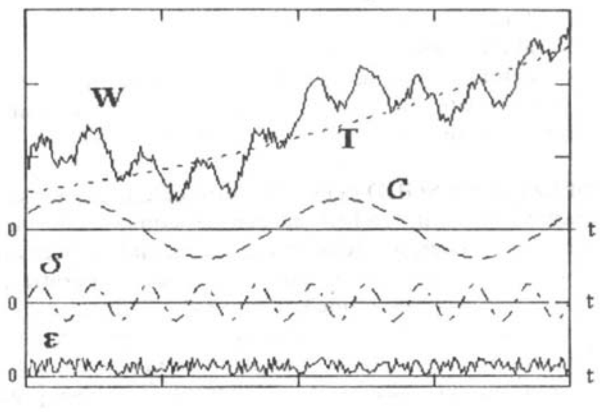


Figure 1.The components for the mathematical model of the energy consumption curve

1. the trend (T) represents the consumptions main compound, establishing the modification of the essential form for the energy consumption.

2. the cyclic component (C) it's caused by the existence to some fluctuant causes with slowly effect, like the request-supply correlation with a period over a year.
3. the seasonal component (S) it is caused by certain parameters which presents seasonal fluctuations (especially climatic elements). This component has a few months variation period and a similar shape for all years.[3]
4. the aleatory component (ε) it dues to perchance causes, that has been previously specified.

As a conclusion, the energy consumption results, totaling the elements that have been specified above:

$$W(t)= T(t)+C(t)+S(t)+\varepsilon(t) \qquad (1)$$

## III. The extrapolative methods principle

The direct forecast methods are supposing the following assumption: the causes, the factors and the trends (which established the energy consumption in the past) are also present in the future, without appearing any dramatic and sudden changes during the forecast (which are meant to affect the consumption evolution).
This assumption justifies the energy consumptions evolution trend from the past to the future period and brings the forecast problem to the analysis of the energy consumption variation law.
The mooted forecast methods are supposing the establishment of a mathematical model likeness a one or more variables function (generally a single variable, time), who fairly estimates the trend on the last period. The estimation of the functions coefficients is made by solving an equations system where the coefficients are calculating means for the energy consumptions (for the last period).

**3.1 The estimation for the model components**

It is considered a value set $y_t$ observed, for a chronological time serie.
Mathematical shaping can be made using an additive model:

$$y_t= T_t +C_t +S_t +R_t \qquad (2)$$

We consider the additive model: $y_t= T_t *C_t *S_t *R_t$ where: $T_t$ represints the trend (continuous component), $C_t$ represints cyclical component, $S_t$ represints seasonal components,$R_t$ represints the component due to aleatory variations.
The additive model is merged in additiv model by logarithmical way.

**a)The trend $T_t$** is determined by using a liniar model:

$y_t=b_0+b_1*t+\varepsilon_t$ ,where finding the parameters $b_0$, $b_1$ is made with matrix method.

Are noted the following matrixes :

$$X=\begin{pmatrix}1 & x_1\\ 1 & x_2\\ \dots & \dots\\ 1 & x_n\end{pmatrix},\ Y=\begin{pmatrix}y_1\\ y_2\\ \dots\\ y_n\end{pmatrix},\ B=\begin{pmatrix}\hat{b}_0\\ \hat{b}_1\end{pmatrix} \Rightarrow B=(X'X)^{-1}(X'Y) \qquad (3)$$

=> $\hat{b}_0$ and $\hat{b}_1$ parameters which will determine the regressive right line:

$$y_t=\hat{b}_0+\hat{b}_1\cdot x_t . \qquad (4)$$

The advantages for this method is that it can be applied successfully in case of multiple regressive and non right line regressive.

**b) The cyclical component $C_t$** is acquired using the additive model

$$y_t= T_t*C_t*S_t*R_t$$

***Graphical method***

1. is established the trend (regressive right line )
2. for each period of time is evaluated, by calculations, the trend value $\hat{y}_t$

the percent of the trend is $\frac{y_t}{\hat{y}_t}*100$ . Are graphically represented, the points $\left(t,\frac{y_t}{\hat{y}_t}*100\right)$, t=1,..,n and the line 100%. If we see a cyclic phenomenon, we can consider the cycle with the length T.

***The methods for development in Fourier serie***

We have the following steps: In the simple cases, $y_t$ can be represented using the mathematical formula:

$$y_t=\alpha+\beta\cdot\sin\frac{2\pi t}{T}+\gamma\cdot\cos\frac{2\pi t}{T}+\varepsilon_t$$ ,T=cycle period, $(\varepsilon_t)_t$ is the aleathory component.

If T is known and n (number of observations) is a T multiple: n = m*T, than m is the complete cycle number involved in our analysis. The unknown parameters $\alpha, \beta, \gamma$ are calculated using the method of the smallest squares. So we can obtain the calculations[4]:

$$\hat{\alpha} = \frac{1}{n}\sum_{i=1}^{n} y_t = \frac{1}{T}\sum_{u=1}^{T} \overline{z}_u \tag{5}$$

$$\hat{\beta} = \frac{1}{T}\sum_{u=1}^{T} \overline{z}_u \cdot \sin\left(\frac{2\pi u}{T}\right), \tag{6}$$

$$\hat{\gamma} = \frac{1}{T}\sum_{u=1}^{T} \overline{z}_u \cdot \cos\left(\frac{2\pi u}{T}\right) \tag{7}$$

where $\overline{z}_u = \frac{1}{m}\sum_{v=0}^{m-1} y_{u+vT}, u = 1,2,\dots,T$ .[5], [6] (8)

With T estimated in this way, are graphically represented the points (t, $\hat{y}_t$ ),t=1,2,..,n,

$$\hat{y}_t = \hat{\alpha} + \hat{\beta} \cdot \sin\frac{2\pi t}{T} + \hat{\gamma} \cdot \cos\frac{2\pi t}{T}. \text{ [7]} \tag{9}$$

**c) The seasonal component $S_t$**

The seasonal parameter is used to compare the periodical fluctuations on short term between seasons (in our paper: months). The method showed below is applied for the additive model: $y_t = T_t * C_t * S_t * R_t$ and is assumed that doesn't exists a cyclic effect.[8]

First, we calculate MA(T) ; is determined the parameter of the time series y/MA ; we calculate the means on each month ; we calculate the sum of this means and we will obtain in this way the seasonal parameters.[9]

**d) The forecast**

The forecast can be obtained by smoothing. We will consider the exponential smoothing using the formula:

$$s_1 = y_1;$$

$s_t = \alpha \cdot y_t + (1-\alpha) \cdot s_{t-1}, t \ge 2, \alpha \in (0,1)$ $\alpha$ is picked up like we want it. $s_2 = \alpha \cdot y_2 + (1-\alpha) \cdot y_1$

$$s_3 = \alpha \cdot y_3 + (1-\alpha) \cdot y_2 = \alpha \cdot y_3 + \alpha(1-\alpha) \cdot y_2 + (1-\alpha)^2 \cdot y_1 = \alpha\left(y_3 + (1-\alpha) \cdot y_2 + (1-\alpha)^2 y_1\right)$$

$$s_t = \alpha\left(y_t + (1-\alpha) \cdot y_{t-1} + (1-\alpha)^2 y_{t-2} + \dots\right), t \ge 2. \tag{10}$$

## IV.Case study

It is considered a data base (1096 dates) which represints the electrical energy consumption from SDFEE of Braila, during 2006. The registrations from the data base represints a real data base concerning the energy consumptions which allows to locate, with a certain trust level, the consumptions on intervals obtained by proportional division principle.[10] The safety of the forecasts is directly proportional with the number of the available registrations and with their precision, and the dates are renewed daily.[11]

The dates estimation and the forecast in a time series is made using the modeling methods which have been discussed earlier. We have elaborate, using Matlab, the mathematical model for the forecast of the electrical energy consumption.

The forecast for the energy consumption, on short term, with Matlab, we've tried to reach the following steps:

a).It is realised a data base;

b).We will make the calculations for the geometrical trend and we will see if is concordant with the graphical method;

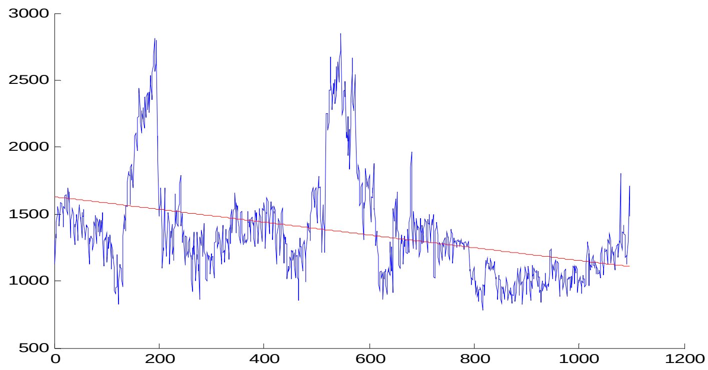


Figure 2. The evolution in time of the energy consumption

c). We've made the calculations for determine the cyclical component and this is shown like below;

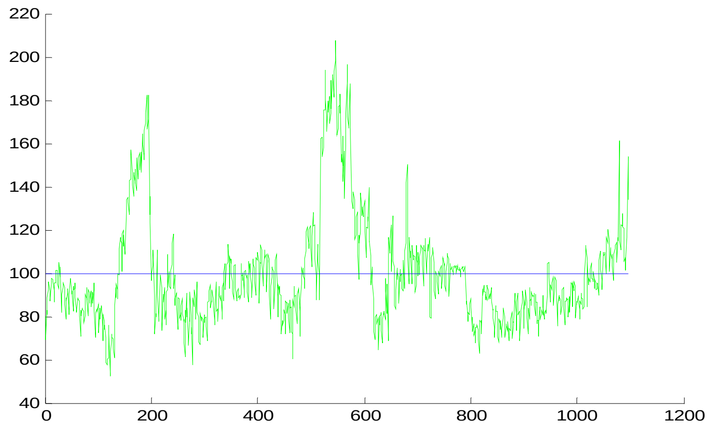


Figure 3 The estimative result 100 * y/y for determine the cyclical effect.

d).We've made the calculations for the seasonal effect and we have obtained the graphic:

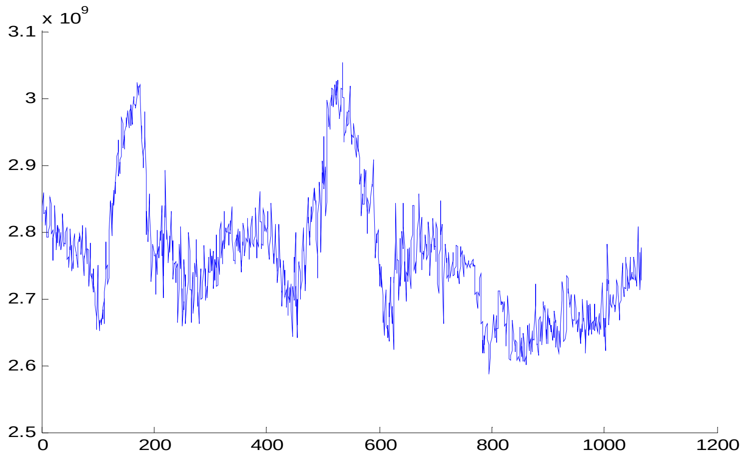


Figure 4 The produced energy evolution in time, after the dismission of the seasonal effect

e).It is realised the forecast for the next year using the exponential straightening and we will obtain the following graphic.

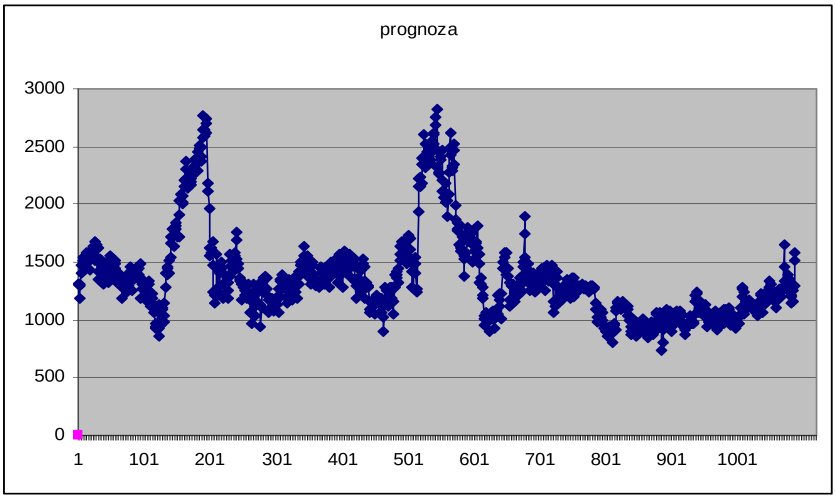


Fig.5 Estimative forecast of the energy comsuption for the next year

## V.Conclusions

The forecasts for consumption represents the main elements for analysis in the elaboration/ modification of some decisions in different stages of the supply electric energy service management. In this case, is needed to make some consume forecasts on short and medium term, very precise, and in this way we want to obtain the contract on the competitive market of a eighth quantities and implicit the cost reduction connected to the electrical energy acquisition.

Using a procedure of recursive approximation, we have some good results, and so in the conditions of large variations, we can develop a model which takes into considerations the previous dates in reduced number. In conformity with the graphics, the forecast shows that the energy consumption in 2007, at SDFEE of Braila is almost the same with the one realized in 2006.

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