Title: Modeling of the Energy Consumption within the Framework of the Energy Efficiency Management

Authors: Pavlova, Y., Rondeel, W., & Kotsar, O.

Article citation: Pavlova, Y., Rondeel, W., & Kotsar, O. (2015). Modeling of the Energy Consumption within the Framework of the Energy Efficiency Management. *Linköping Electronic Conference Proceedings*(119), 229-236.
doi:http://dx.doi.org/10.3384/ecp15119229

Modeling of the Energy Consumption within the Framework of the Energy Efficiency Management

Yuliia Pavlova[1] Wilhelm Rondeel[1] Oleg Kotsar[2]

[1]Faculty of Technology, Telemark University College, Norway, pavlova.yuliia.kpi@gmail.com, wilhelm.rondeel@hit.no

[2]Institute for Energy Saving and Energy Management, NTUU "Kyiv Polytechnic Institute", Ukraine, kovpers@ukr.net

Abstract

Insufficient level of energy efficiency in Ukraine requires a reformation of power sector in order to develop the mechanisms that could stimulate market players for efficient resource usage. For this purpose, it is advisable to use the experience of other energy markets, which is based on the offering of saved electrical energy or reduced capacity as a resource in the market. Thus, it is important to determine accurately the expected and actual demand reduction and amount of saved energy. This study contains the comparative analysis of the existing approaches for determination and measurement of the data necessary for solving the mentioned tasks. Therefore, the paper investigates methods for modeling of energy consumption of the Ukrainian objects where energy efficient projects are implemented. The main contribution of this paper is in the usage of forecasting methods for the development of the expected energy use models of such objects. In the case of the certain type of objects the accuracy of the research results exceeds the accuracy of the results, obtained through usage of the existing approaches in a pure form.

Keywords: energy efficiency, electricity market, modeling of energy use, energy saving.

Abbreviations

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BCM&BM	Bilateral Contract Market and Balancing Market
EE	Energy efficient
IPMVP	International Performance Measurement and Verification Protocol
M&V	Measurement and Verification
MAD	Mean Absolute Derivation
MAPE	Mean Absolute Percentage Error
MSE	Mean Squared Error
PJM	Pennsylvania-New Jersey-Maryland
SSE	Sum Squared Error

1 Introduction

Providing of reliable power supply according to demand in compliance with acceptable consequences for the environment, needs more efficient usage of electricity (Denysiuk, 2013). Insufficient level of energy efficiency in Ukraine, in its turn, requires an immediate reformation of the Ukrainian power sector in order to stimulate final consumers to decreasing of fossil fuel unit costs and reduction of harmful emissions. One of the most efficient ways of power sector development is the liberalization of the energy markets that was realized in the vast majority of countries. Taking into account current introduction of the liberalized electricity market in Ukraine it is advisable to use the experience of the best energy efficiency managing practices of the other markets for determining and developing the instruments and mechanisms that could stimulate Ukrainian market players for the efficient resource usage.

2 Management of the Energy Efficiency in the World Electricity Markets

Nowadays large attention in energy markets is devoted to stimulation of energy saving and energy efficiency. Creation of the incentives is carried out directly through competition and by means of implementation of different mechanisms for energy saving management. Particularly, in some competitive energy markets of the USA a consumer's ability to reduce its demand for electricity is equivalent to the ability of a generator to increase its electricity output. Therefore the rules of such markets allow final consumers to sell demand resources, creating in this way a competition for the generation companies.

In the American electricity markets Pennsylvania-New Jersey-Maryland (PJM) and New England participation of demand resources is being carried out through selling of energy efficient (EE) resources in the capacity markets. In other words final consumers offer permanent continuous reduction of their demand and electricity consumption during the defined period that have to be achieved due to the EE projects (Bastian, 2010). In such a manner final consumers can not only save costs as a result of changing their load, but also obtain additional compensation. Such mechanisms has led to decreasing of non-productive power costs, fossil fuel savings, harmful emissions reduction and avoiding of expenses on building new power stations (SPEER, 2013). Some European energy markets in the framework of energy saving activity implement the programs of imposing obligations, which are related to achieving of the determined goals (in harmful emissions reduction and decreasing of fossil fuel usage) due to EE measures. In distinction of the American markets, such European scheme can function in several forms together with various tradable mechanisms and attracting different market participants and entities (Bertoldi, Rezessy, 2009).

Taking into account positive experience of the world markets, it is advisable to develop in the Bilateral Contract Market and Balancing Market (BCM&BM), which is being implemented in Ukraine, the mechanisms of EE resources trading in order to stimulate consumers for the implementation of EE technologies. In that way the quantity of saved electrical energy (or capacity) can be paid for market participants according to certain rules in order to return some compensation for their expenses on energy saving measures. Similar to American energy markets, the value of saved electrical energy can be accounted in the BCM&BM for the estimation of the obtained energy efficiency level. For this purpose it's necessary to analyze and compare the existing methods and approaches for determining the amount of savings and to develop methodology of their application in the BCM&BM.

3 The Analysis of the Approaches for Determining Energy Efficient Resources Value

The section presents the comparative analysis of the existing approaches and methods for determination and measurement of the data which are necessary for quantifying the demand reduction and amount of saved electrical energy. Consequently, the possibilities of their usage in different forms for the Ukrainian energy consumption objects are investigated.

3.1 The Fundamental Principles of the Existing Approaches

Participation of the EE resources in energy markets requires the determination and verification of the value of EE resource, usually expected demand reduction in MW during the defined hours. Requirements and rules of the EE resources participation in energy markets are mostly determined by guidelines developed by relevant authorities. However, the majority of these documents are based on the materials of International Performance Measurement and Verification Protocol (IPMVP), which is a methodological document of Efficiency Valuation Organization (EVO, 2014). IPMVP proposes the approaches for determination and calculation of the achieved energy savings (i.e. value of EE resources) due to the EE projects. IPMVP describes general requirements and principles of Measurement and Verification (M&V) activity of the achieved results, offers four possible M&V options and determines the requirements for the results reporting. Another basic document is guideline of American Society of Heating, Refrigerating and Air-Conditioning Engineers «ASHRAE Guideline 14-2002. Measurement of Energy and Demand Savings» (ASHRAE, 2002). It is based on the same requirements and M&V options as IPMVP, but it contains more detailed instructions. It is worthwhile to say that above mentioned documents do not offer the precise algorithms of actions for each type of EE project. But they contain general requirements that should be followed by all EE resource suppliers.

Let us analyze the main approaches for determination of the achieved energy savings and M&V options that are offered in IPMVP and ASHRAE Guideline. This will allow to estimate further possibility of their usage by BCM&BM participants. So far as energy savings represent the absence of energy use, they cannot be directly measured. Above mentioned documents offer approaches that involve determination of the EE resource value by comparison of the expected energy use that would have occurred in the reporting period without EE project realization, and actual energy use during the reporting period after EE project realization. The Figure 1 presents the fundamentals of the determination of the achieved savings. During the baseline period (before the EE project realization) and reporting period consumer, who provides EE resource, carries out measurements of the energy use and the independent variables that can influence it. The object's main operating conditions are also determined. After the end of the baseline period, a mathematical model of the baseline energy use is developed on the ground of actual data. This model determines the dependence between energy use and key operating parameters and independent variables.

For the purpose of determination of the expected baseline energy use, the measured independent variables of the reporting period are inserted into the mathematical model of the baseline energy use. In such a manner the baseline energy use is adjusted for the set of reporting conditions. In order to take into account and to reflect the influence of the other factors on energy consumption, various adjustments should be used. For example, such adjustments can be used in the cases of production level increase, changes in object size or equipment etc. The selection of the most appropriate M&V option, which will be used within the chosen approach, is significant for the determination of the achieved savings. In the case when the existed options are not appropriate for the precise projects, EE resource supplier can offer alternative methodology (Bastian, 2010).

DOI 10.3384/ecp15119229

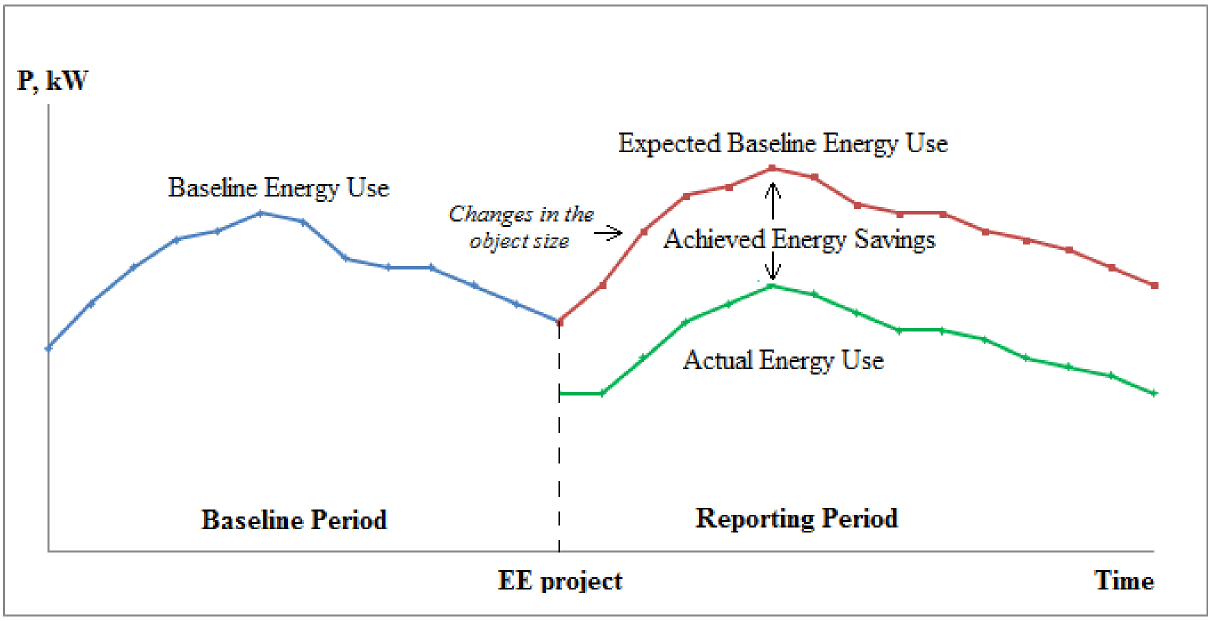

Figure 1. The determination of the achieved energy savings after EE project realization.

3.2 The Analysis of the Conditions and Tasks that Can Occur during Modeling of Energy Consumption of the Object

The analysis of IPMVP and ASHRAE Guideline allows to establish, that the existing approaches and M&V options mostly require measurements of energy use and independent variables that influence it. These values are necessary for the development of the models of energy use and for the next calculation of the EE resource value. In particularly, option A of IPMVP, which is based on the simplified calculations, foresees measurement of the main independent variables, because within this option energy consumption is calculated on the basis of the measured data of the chosen variables and other estimated parameters. Option B foresees straightforward measurement of the energy use of the precise equipment or part of the object during the baseline and reporting periods and their following comparison. But for increasing of the results certainty and their adjustment for the reporting conditions, in the majority of cases relevant adjustments are added. They are mainly determined on the ground of the measured independent variables that influence energy use. Option C is similar to option B, but it is used when the measurement of energy use of the precise object part is not possible. Therefore, in this case it is necessary to use the appropriate adjustments for updating of the obtained results. Calculation of the adjustments and estimation of the independent variables are carried out by mathematical modeling, predominantly regression analysis. For this purpose, measurement of the independent variables is also necessary. Option D is the most costly and complicated, because it includes modeling of the energy use in software with following simulation. It is used quite seldom, mostly in the cases of absence of the baseline data.

Therefore, the described analysis affirms that within the approaches and M&V options, which are provided by IPMVP, it is necessary to conduct measurement of the independent variables that influence energy use, particularly operating hours, weather conditions, production output etc. However, if to review appliance of the existing approaches in the Ukrainian electricity market, it should be mentioned, that in a majority of the energy consuming objects, such measurements are not carried out. But their capacity is being measured mainly with 30-minutes averaging. Therefore, application of the offered options in their current form can require some expenses for the realization of additional measurements of other variables. Furthermore, for the development of the mathematical models of energy use usually it is necessary to possess a set of data for a long past period (for example, months, year). But as far as participants of the Ukrainian electricity market already conduct measurements of the capacity, it is advisable to use such data for determination of the EE resource value. Among options that are provided by IMPVP, for the existing data it is possible to use only option B, because it foresees measurement of the energy use of the whole object and in some cases affords an opportunity to determine EE resource value without independent variables measurements. Particularly, in the cases, when energy use can be considered as sustainable and can be taken as equal to actual baseline energy use without making any adjustments. Let’s get a view of the usage of the option B in the case of commercial object.

4 Development of the Forecasting Model of the Object's Energy Use

In the framework of this research the electrical consumption of tradable object is examined. The object under consideration is a supermarket that contains several departments and different types of electrical appliances. Figure 2 presents the load curve of the supermarket for one month with 30-minutes measurement interval. This load curve is a time series that contains 1440 data values.

After analyzing of the object's consumption pattern, investigation of its operating conditions and factors that influence it, this load curve can be characterized as the time series which contains periodical changes in data that tend to be repeated every week. Furthermore, the load curve during the day contains peak periods that are similar from day to day. Therefore, according to IPMVP, due to changes in the character of the object's energy use and dependence on different factors, it is necessary to add adjustments into the model of the baseline energy use. But measurements of the independent variables for these adjustments were not carried. Thus, in the authors' opinion for this and similar objects it can be advisable to use option B in adapted form. Particularly, it is being offered to determine the expected baseline energy use through forecasting. Subsequently it is necessary to check the adequacy of forecasting model and compare the forecasting results with the results, which could be obtained in the case of the usage of the option B for this object in the existing simplified form. It should be mentioned that for the load forecasting for different types of objects it is necessary to choose the most appropriate forecasting method according to particular features of the object, such as type of object, specifics of work, changes in energy use, type of load curve, dependence on different factors etc.

For the forecasting of the load of this supermarket one of the most extended forecasting methods has been chosen – exponential smoothing. Exponential smoothing is a procedure for continually revising a forecast in the light of more recent experience. It assigns exponentially decreasing weights as the observation is getting older. In other words, recent observations are given relatively more weight in forecasting than the older observations (Kalekar, 2004). For the determination of the energy use model, autocorrelation analysis has been done for this time series. With the purpose of separation seasonal and trend components, autocorrelation analysis has been conducted for the different periods of pre-history and with delays for different periods. Autocorrelation coefficient was calculated according to the equation:

$$r_k = \frac{\sum_{t=k+1}^{n} (Y_t - \bar{Y})(Y_{t-k} - \bar{Y})}{\sum_{t=1}^{n} (Y_t - \bar{Y})^2} \qquad (1)$$

where:

r_k - coefficient of autocorrelation of the delay for k periods;

$\bar{Y}$ - average value of time series;

Y_t - actual value at the time moment t;

Y_{t-k} - value for k periods earlier then at the time moment t-k (Hanke *et al*, 2001).

From the Figure 2 it is possible to determine, that the load curve is similar from day to day, i.e. every 48 values, therefore autocorrelation analysis has been conducted for 48 (1 day), 96 (2 days) and 144 (3 days) values of time series with the delaying for the periods r=1..48 and r=49..96. From the Table 1 it is visible, that for the first several delay periods r_1, r_2, r_3, autocorrelation coefficients are significantly different from 0, and with the increasing of delay period they are decreasing gradually. Therefore, according to (Hanke *et al*, 2001), this proclaims presence of the trend component. The results of the analysis also indicate that the value of the autocorrelation coefficients is increasing the nearer the delay period is getting to 48th or 48-fold. This affirms the presence of the seasonal component in the time series which is repeated every 48 values, i.e. daily.

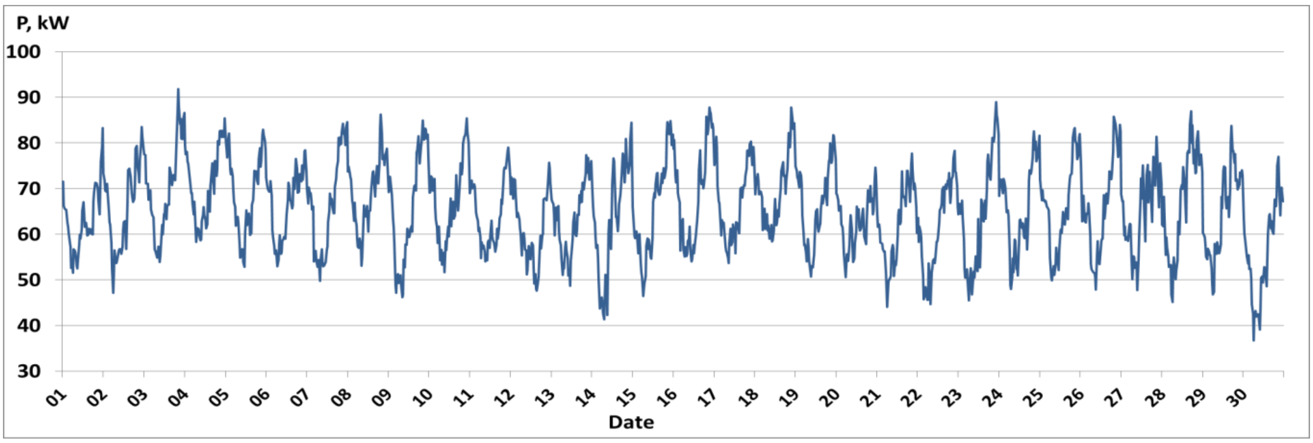

Figure 2. Energy demand of the supermarket for the one month period.

DOI
10.3384/ecp15119229

Table 1. The Autocorrelation Coefficients for the Time-series with 144 Values.

	Time-series =48	*Time-series =96*	*Time-series =144*
r_1	**0,817**	**0,905**	**0,921**
r_2	0,642	0,767	0,821
r_3	0,488	0,644	0,741
r_4	0,408	0,618	0,676
…	…	…	…
r_{23}	-0,034	-0,357	-0,396
r_{24}	-0,061	-0,339	-0,386
r_{25}	-0,092	-0,330	-0,386
…	…	…	…
r_{44}	0,086	0,292	0,427
r_{45}	0,097	0,326	0,457
r_{46}	0,09	0,365	0,493
r_{47}	0,076	0,385	0,514
r_{48}		**0,365**	**0,518**
r_{49}		0,316	0,510
r_{50}		0,265	0,476
r_{51}		0,224	0,417
…		...	…
r_{94}		0,022	0,164
r_{95}		0,015	0,169
r_{96}		0	**0,175**

According to specific of this object functioning, its consumption has similar behavioral model from week to week. Thus, in the framework of this research, the same additional autocorrelation analysis has been conducted for the identification of the seasonal component that is repeated weekly. The analysis has been done for the time-series of the load data for 3 weeks with the delay for the periods r=1..336. Time-series correspondingly had the next amount of data: 336 (1 week), 672 (2 weeks) and 1008 (3 weeks). As it is shown in the Table 2, the nearer the delay period is getting to 336th or 336-fold, the value of the autocorrelation coefficients are increasing. Therefore, it can be asserted, that time-series contains week season cycle.

Table 2. The Autocorrelation Coefficients for the Time-series with 1008 Values.

	Time-series =336	*Time-series =672*	*Time-series =1008*
r_1	**0,935**	**0,936**	**0,935**
r_2	0,856	0,861	0,859
r_3	0,798	0,805	0,801
r_4	0,740	0,750	0,744
…	…	…	…
r_{333}	0	0,322	0,448
r_{334}	0,002	0,342	0,475
r_{335}	0,003	0,353	0,49
r_{336}		**0,354**	**0,49**
r_{337}		0,346	0,474
r_{338}		0,328	0,451
r_{339}		0,304	0,421
…		…	…
r_{669}		0,001	0,24
r_{670}		0,002	0,248
r_{671}		0,001	0,254
r_{672}			**0,254**
r_{673}			0,235
r_{674}			0,216
...			…
r_{1006}			0,0003
r_{1007}			0
r_{1008}			**0**

Consequently, the conduction of the autocorrelation analysis allowed to emphasis in the time-series the presence of the seasonal and trend components. Thus, for the forecasting of the energy use of this object, the method of exponential smoothing with inclusion of trend and seasonal variations has been chosen - Holt-Winters method with multiplicative model.

The specific equations for the Holt-Winters method are:

- overall smoothing:

$$L_t = \alpha \frac{Y_t}{S_{t-s}} + (1-\alpha)(L_{t-1} + T_{t-1}) \qquad (2)$$

- trend estimation:

$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1} \qquad (3)$$

- the estimation of seasonality:

$$S_t = \gamma \frac{Y_t}{L_t} + (1-\gamma)S_{t-s} \qquad (4)$$

- the forecast for the p future periods:

$$\hat{Y}_{t+p} = (L_t + pT_t)S_{t-s+p}, \qquad (5)$$

where:

L_t - the new smoothed value or the estimation of the current level;

α - the smoothing constant for the data, 0< α <1;

Y_t - the actual value of series in the moment t;

β - the smoothing constant for the trend estimate, 0< β <1;

T_t - the trend estimate;

γ - the smoothing constant for the seasonality estimate, 0≤ γ ≤1;

S_t - the seasonal estimate;

p - the periods to be forecast into the future;

s - the length of seasonal period;

$\hat{Y}_{t+p}$ - the forecast for p periods in the future (Hanke *et al*, 2001).

Within the investigation, the forecast model was developed on the base of the actual data for the period from the 1st until 21st day (3 weeks). This model was used for the forecasting for the next period, from 22nd until 28th day (the 4th week).

When using the Equation 1, the first actual value was accepted as initial smoothed value. Therefore, the trend estimation T_t is equal 0 (Hanke *et al*, 2001). As far as the load curve contains corresponding weekly changes, the duration of the seasonal period is equal to the amount of the obtained measurements during one week – 336. According to (Hanke *et al*, 2001), the seasonal estimate S_t for the first seasonal period is taken equal to 1. The optimal values of the model parameters α, β, γ have been chosen by the minimization of the accuracy indices, particularly forecast errors. They are equal to 0,05; 0,029; 0,71 correspondingly. The selection of parameters is observed in details in (Hanke *et al*, 2001).

For the estimation of the adequacy of the model and accuracy of the forecasted results the following indices were used:

Mean Absolute Percentage Error:

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\frac{|e_t|}{Y_t}\cdot 100 \qquad (5)$$

Mean Absolute Derivation:

$$MAD = \frac{1}{n}\sum_{t=1}^{n}|e_t| \qquad (6)$$

Mean Squared Error:

$$MSE = \frac{1}{n}\sum_{t=1}^{n}e_t^2 \qquad (7)$$

Sum Squared Error:

$$SSE = \sum_{t=1}^{n}e_t^2 \qquad (8)$$

Coefficient of Determination:

$$R^2 = 1 - \frac{SSE}{\sum_{t=1}^{n}(Y_t - \bar{Y})^2} \qquad (9)$$

where:

n - the amount of the forecasted values;

Y_t - the actual value of series in the moment *t*;

$\bar{Y}$ - the average value of Y;

$\hat{Y}_t$ - the forecast value for the moment *t*;

$|e_t|$ - forecast error, $|e_t| = Y_t - \hat{Y}_t$ (Hanke *et al*, 2001).

For determination of the forecast accuracy the obtained results were compared with the data of actual energy use for the period from the 22nd until 28th day. The Figure 3 presents the object's actual and forecasted load curves. Although the forecast model was developed on the base of the actual data for the period from the 1st until the 21st day, this figure presents the actual load curve for the period from the 15th day for clarity.

For the estimation of the possibility of the option B usage in the adapted form, the results of the expected baseline energy use, obtained through forecast, can be compared with the results, which could be obtained in the case of the option B usage in the existed pure form. As it was mentioned above, the simplified form of the option B foresees the equating of the expected baseline energy use to the actual baseline energy use without adjusting. In this research two cases of the option B usage in a simplified form were envisaged: when the values of the expected baseline energy use for the period from the 22nd until 28th day were taken equal to the actual data of the previous periods: from the 8th until 14th and from the 15th until 22nd day. The obtained results are presented in the Table 3.

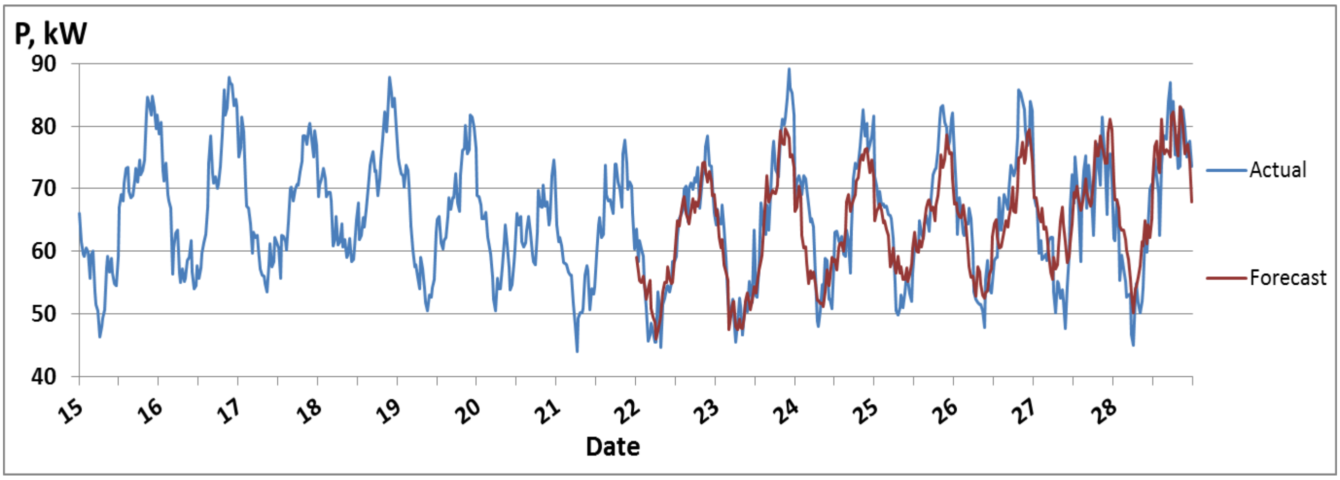

Figure 3. Actual and Forecasted Load Curves.

DOI
10.3384/ecp15119229

Table 3. Energy Demand, kW.

Data	*Period*	*Actual data*	*Values obtained through forecasting*	*Values were taken equal to the actual data from the 8^{th} until 14^{th}*	*Values were taken equal to the actual data from the 15^{th} until 22^{nd}*
22	1	63,6	59,14	73,68	66
22	2	58,32	56,71	74,88	61,56
22	3	61,68	55,41	73,44	59,64
22	4	60,48	55,10	72,48	59,16
22	5	59,28	56,05	72	60,6
….	….	….	….	….	….
25	145	71,94	64,92	68,94	68,76
25	146	70,44	66,37	70,86	70,56
25	147	67,38	67,12	71,82	71,64
25	148	69,66	67,60	70,08	73,2
25	149	67,44	66,53	70,86	71,64
…..	…..	…..	…..	…..	…..
28	332	79,8	75,60	73,32	69,84
28	333	75,12	76,69	75,24	71,16
28	334	77,16	77,02	80,76	70,44
28	335	77,52	74,25	84,48	66
28	336	73,56	67,97	74,88	60,36

Table 4. The Indices of the Forecast Model Accuracy.

Indices	*The values obtained through forecasting (based on the actual data for the 3 previous weeks)*	*The values were taken equal to the actual data from the 8^{th} until 14^{th} day*	*The values were taken equal to the actual data from the 15^{th} until 22^{nd} day*
MAPE	6,53	8,86	8,24
MAD	4,20	5,64	5,22
MSE	26,7	54,25	42,34
R^2	0,76	0,50	0,61
Range of the errors values	-13,78…12,50	-20,16…20,88	-15,84…20,7

For the comparison of the results, that obtained through usage of the option B in the existing and adapted forms, the accuracy indices were analyzed. As it is presented in the Table 4, all three accuracy indices MAPE, MAD, MSE for the results obtained through forecast with Holt-Winters method are lower than the relevant indices for the energy use that was taken equal to actual baseline energy use. The smaller values indices MAPE, MAD, MSE have the more accurate results are provided by this model usage. The value of the determination coefficient R^2 indicates the adequacy of the forecasting results and can have the value between 0 and 1. The model is considered to be adequate if R^2 is close to 1. As we can see from the Table 4, the range of the errors values is the most narrow for the results obtained through forecasting. As we can see from the Table 4, for this object the results, obtained through forecasting, are more accurate than the results, obtained through the usage of the option B in the existing form, particularly by equating the expected energy use to the actual energy use without adjustments. In the cases when the other sets of actual data are available for model development (for example, the data of a shorter/longer period) it is possible to use the same forecasting method for the model development but with finding the new optimal values of model parameters α , β , γ .

5 Conclusions

The analysis of the electricity market activity in the field of energy saving and increasing of energy efficiency allows to define the main mechanisms and results of the attraction of energy efficiency for participation in the markets. It is expected, that implementation of the mechanisms for trading of the EE resources, saved due to EE projects, into the BCM&BM will stimulate market participants for energy saving activity and energy efficiency improvement.

In such a manner, the usage of the consumers' technical abilities to reduce demand and to increase the level of energy efficiency will result in decreasing fossil fuel usage, harmful emission reduction, delaying of the growth rate of the electricity demand and reduction of the expenses on building new generation.

The investigation of the existing approaches for the determination of the EE resources value has allowed to specify the set of conditions and tasks, that can occur during their usage at the Ukrainian energy consumption objects. Particularly, the difference between the organization of the energy use measurements and the distinction of the available data sets restrict the usage of the existing approaches and M&V options in the pure form.

Taking into consideration the above mentioned restrictions, the usage of the existing options in the adapted form was offered. Particularly, the usage of forecasting methods during the determination of the expected baseline energy use model. In the case of the certain type of object this allowed to obtain the results which satisfy the adequacy requirements. The accuracy of these results exceeds the accuracy of the results, obtained through the usage of the existing options. For the other types of objects it is advisable to choose the most appropriate forecasting methods according to particular features of the objects.

Consequently, the usage of the forecasting can allow final consumers, that implement EE projects, to estimate in advance the expected EE resource value and to plan the activity for the trading of such resource in the energy market.

Besides that, under conditions of the BCM&BM, the existence of the premature precise data of the expected demand reduction can provide a possibility to estimate more accurately trends of the increasing of the load and correct the plans of the exploitation and building of new generation capacities.

References

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). *ASHRAE Guideline 14-2002. Measurement of Energy and Demand Savings*, June 2002. Available at the official website of ASHRAE: https://www.ashrae.org

Jeff Bastian. *PJM Manual 18B: Energy Efficiency Measurement & Verification. Revision*: *01*, 2010.

Paolo Bertoldi and Silvia Rezessy. Energy Saving Obligations and Tradable White Certificates, 2009, Joint Research Centre of the European Commission. p. 62.

S. Denysiuk. Policy Formation Increase Energy Efficiency – Current Challenges Guidelines and European. *Power Engineering: Economics, Technique, Ecology,* vol. 2, No. 33, pp. 7-22, 2013.

Efficiency Valuation Organization (EVO). *International Performance Measurement and Verification Protocol, EVO 10000 – 1:2014,* June 2014. Available at the official website of EVO: http://www.evo-world.org

John E. Hanke, A.G.R., Dean W. Wichern, *Business Forecasting. 7th ed*. 2001, New Jersey: Prentice Hall.

Prajakta S. Kalekar, Time series forecasting using holt-winters exponential smoothing. Kanwal Rekhi School of Information Technology, 2004. 4329008: p. 1-13.

South-central Partnership for Energy Efficiency as a Resource (SPEER), Toward a More Efficient Electric Market: New Frameworks for Advancing Energy Efficiency in Texas, June 2013. Available at: http://eepartnership.files.wordpress.com/2013/06/toward-a-more-efficient-electric-market-june-2013.pdf

 DOI 10.3384/ecp15119229