FORECAST POWER CONSUMPTION ASSESSMENT BASED ON "STANDARD" LOAD CURVES

KILYENI ST., BARBULESCU C., DEACU A., AGAPE C.P.
Politehnica University Timisoara, Power Systems Department,
Power Systems Analysis and Optimization Research Center
stefan.kilyeni@upt.ro, constantin.barbulescu@upt.ro, antheia.deacu@upt.ro, cosmin.agape@upt.ro

Abstract - The paper tackles the artificial neural networks (ANN) based load forecasting issue. It aims to define a set of "standard" load curves. They are representing the background to perform a prognostic regarding the forecast quality based on known data set. A case study is used as an example. Daily load curves forecasting is performed. A software tool has been developed in Matlab environment. The results are compared with the ones obtained for "standard" load curves.

Keywords: load curve, forecasting, artificial neural network, standard load curve, global performance index.

1. INTRODUCTION

The "end-use" [1] approach directly estimates the energy consumption using a large domain of available information related to final consumed power and to final user. Statistical consumed power data and dynamic change represent the background for the load forecast. The model applies to residential consumers, commercial ones and, also, industrial ones. According to them, the power demand is modelled as a function of market requests.

There are also presented within the literature several approaches dealing with artificial intelligence methods (ANN – artificial neural networks, evolutive computing, fuzzy based approaches, etc.).

PSO (Particle Swarm Optimization) based algorithm is used in [5]. The goal is to minimize the error associated to the estimated model parameters. The case studies are referring to the load forecasting in case of two real distribution networks and to the peak power. Results are compared with the ones obtained for least square method, conclusions being favorable to the new one.

In [6] the long-term load forecasting is performed based on time series approached in fuzzy manner. Known data (for the Jiangsu area in China) are corresponding to 12 years period: the 1st 10 years are used for load forecasting performing for years 11 and 12, errors comparing with the real values being 2-4 %. The fuzzy logic technique is also used in [8], but the case study is focused on a power distribution company in Turkey.

The short-term load forecasting is performed for 1-5 years period. The ANNs have been used for load forecasting starting with [8]. Usually, backpropagation architecture ANNs are used. They are using real variables functions and supervised learning.

In [9] a mixed approach is proposed, between ANNs and ARIMA (autoregressive integrated moving average with exogenous variables) time series. The linear known load data component is approached using ARIMA and the non-linear one, with ANNs. The qualities of such an approach are highlighted based on analysed case studies with empirical data.

In [10] two models are used for the short-term load forecasting: backpropagation ANN and hybrid model (ANN and fuzzy approach). The case study refers to the New England (USA) consumption area, highlighting the superiority of the 2nd model.

The application presented in [11] refers to the power consumption from a high / medium voltage substation in Iran, the one presented in [12] refers to a power consumption area in Ontario, Canada. In [13] power consumption forecasting is performed for the case of the Egyptian Unified System. All these cases are based on ANNs forecasting methods.

In [14] the ANN based load forecasting is performed for the case when the correlation degree for the known data is extremely reduced.

A mixed technique for load forecasting is used in [15] combining an inference adaptive neuro-fuzzy system (ANFIS), based on Takagi-Sugeno model.

In this paper two standard load curves have been defined. The load curves corresponding to the known years are characterized by a high correlation degree:

- "standard 1": the power consumption evolution is characterized by arithmetic progression. Thus, a linear ascending power consumption evolution is accepted;
- "standard 2": the power consumption evolution is characterized by geometric progression. Thus, a nonlinear ascending power consumption evolution is accepted.

A number of 10 years (2001-2010) has been considered to perform the forecast. 3 years (2011-2013) have been used to validate the obtained forecasts.

Conventional numerical methods and artificial neural networks (ANN) have been used for load curves forecasting, being implemented in an appropriate software tool, developed in Matlab environment [15]:

- conventional numerical methods:
  - linear regression (applied sequentially for each hour);
  - parabolic regression (applied sequentially for each hour);
- ANN based techniques:
  - ANN for the entire load curve (24 hours);
  - ANN for each hour.

Following the introduction already presented, the 2nd and 3rd sections are focusing on presenting the "standard" load curves. A case study regarding a real load is discussed within the 4th section, comparing the quality of the forecast with those obtained for the "standard" curves. The 5th section synthesizes the conclusions.

2. "STANDARD 1" LOAD CURVE

Load curve data set for the 10 years known period (2001-2010) is presented in Table 1 and Fig. 1. These data are useful to perform the forecast. Load curves for the 2011-2013 period are presented in Table 2 and Fig. 2. They are going to be used to validate the performed forecast for 2011, 2012 and 2013 years.

Table 1. Load curves for the known period (2001-2010)

Year/Hour	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	100.0	104.0	108.2	112.5	117.0	121.7	126.5	131.6	136.9	142.3
2	100.0	104.0	108.2	112.5	117.0	121.7	126.5	131.6	136.9	142.3
3	110.0	114.4	119.0	123.7	128.7	133.8	139.2	144.8	150.5	156.6
4	110.0	114.4	119.0	123.7	128.7	133.8	139.2	144.8	150.5	156.6
5	120.0	124.8	129.8	135.0	140.4	146.0	151.8	157.9	164.2	170.8
6	140.0	145.6	151.4	157.5	163.8	170.3	177.1	184.2	191.6	199.3
7	160.0	166.4	173.1	180.0	187.2	194.7	202.5	210.5	219.0	227.7
8	170.0	176.8	183.9	191.2	198.9	206.8	215.1	223.7	232.7	242.0
9	180.0	187.2	194.7	202.5	210.6	219.0	227.8	236.9	246.3	256.2
10	200.0	208.0	216.3	225.0	234.0	243.3	253.1	263.2	273.7	284.7
11	200.0	208.0	216.3	225.0	234.0	243.3	253.1	263.2	273.7	284.7
12	180.0	187.2	194.7	202.5	210.6	219.0	227.8	236.9	246.3	256.2
13	200.0	208.0	216.3	225.0	234.0	243.3	253.1	263.2	273.7	284.7
14	190.0	197.6	205.5	213.7	222.3	231.2	240.4	250.0	260.0	270.4
15	180.0	187.2	194.7	202.5	210.6	219.0	227.8	236.9	246.3	256.2
16	170.0	176.8	183.9	191.2	198.9	206.8	215.1	223.7	232.7	242.0
17	170.0	176.8	183.9	191.2	198.9	206.8	215.1	223.7	232.7	242.0
18	170.0	176.8	183.9	191.2	198.9	206.8	215.1	223.7	232.7	242.0
19	160.0	166.4	173.1	180.0	187.2	194.7	202.5	210.5	219.0	227.7
20	170.0	176.8	183.9	191.2	198.9	206.8	215.1	223.7	232.7	242.0
21	180.0	187.2	194.7	202.5	210.6	219.0	227.8	236.9	246.3	256.2
22	150.0	156.0	162.2	168.7	175.5	182.5	189.8	197.4	205.3	213.5
23	130.0	135.2	140.6	146.2	152.1	158.2	164.5	171.1	177.9	185.0
24	110.0	114.4	119.0	123.7	128.7	133.8	139.2	144.8	150.5	156.6

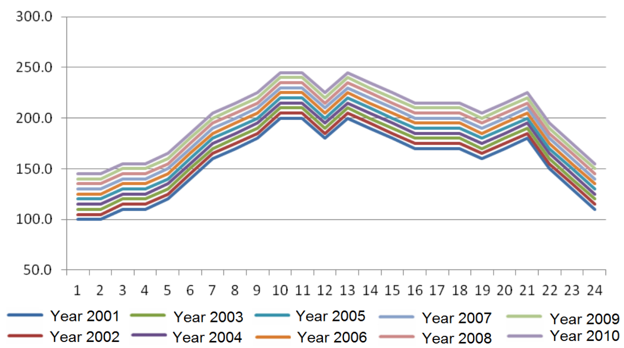

Fig. 1. Load curves for 2001-2010 period [MW]

Table 2. Load curves for the forecasted period (2011-2013)

Year/Hour	2011	2012	2013	Year/Hour	2011	2012	2013
1	100.0	104.0	108.2	13	117.0	121.7	126.5
2	100.0	104.0	108.2	14	117.0	121.7	126.5
3	110.0	114.4	119.0	15	128.7	133.8	139.2
4	110.0	114.4	119.0	16	128.7	133.8	139.2
5	120.0	124.8	129.8	17	140.4	146.0	151.8
6	140.0	145.6	151.4	18	163.8	170.3	177.1
7	160.0	166.4	173.1	19	187.2	194.7	202.5
8	170.0	176.8	183.9	20	198.9	206.8	215.1
9	180.0	187.2	194.7	21	210.6	219.0	227.8
10	200.0	208.0	216.3	22	234.0	243.3	253.1
11	200.0	208.0	216.3	23	234.0	243.3	253.1
12	180.0	187.2	194.7	24	210.6	219.0	227.8

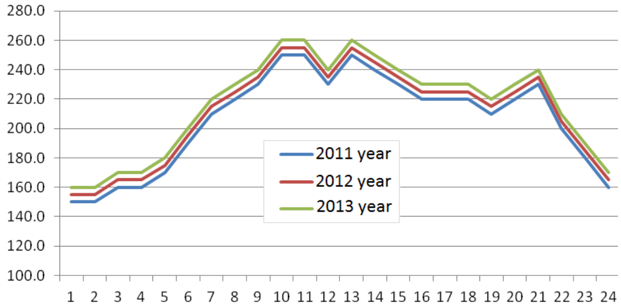

Fig. 2. Load curves for 2011-2013 period [MW]

The following comments are highlighted based on Figs. 1 and 2 and Tables 1 and 2:

- the 2001 year load curve represents the starting point for the remaining ones. A constant rate of 0.5 MW has been added for each hour. Thus, the power consumption values are in arithmetic progression;
- the load curves have the same variation for each year. This means a very good correlation from qualitative and quantitative point of view.

A comparative analysis for the performed forecast is presented in Figs. 3-5. The global performance indices' (2011, 2012, 2013 and total) values are given in Table 3.

$$s = \sum_{i=1}^{24}\left(\frac{P_i^{forecasted} - P_i^{real}}{P_i^{real}}\cdot 100\right)^2 \qquad (1)$$

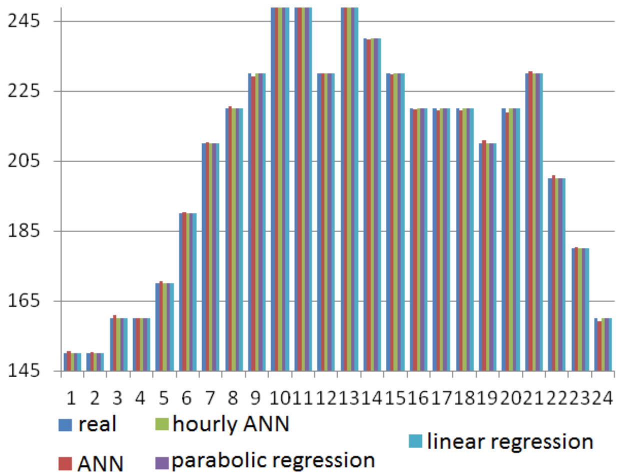

Fig. 3. Comparative analysis – 2011 year [MW]

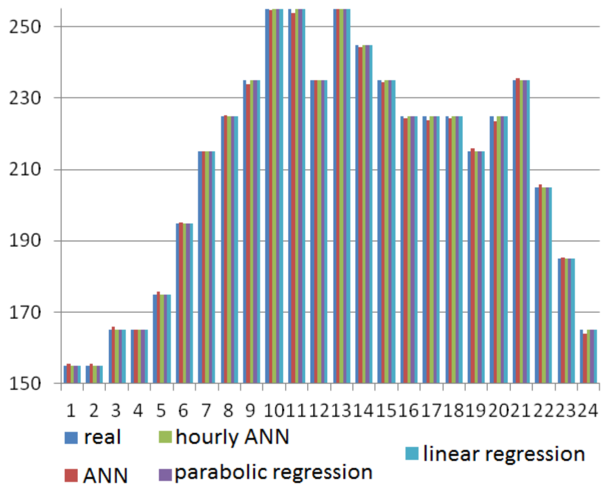

Fig. 4. Comparative analysis – 2012 year [MW]

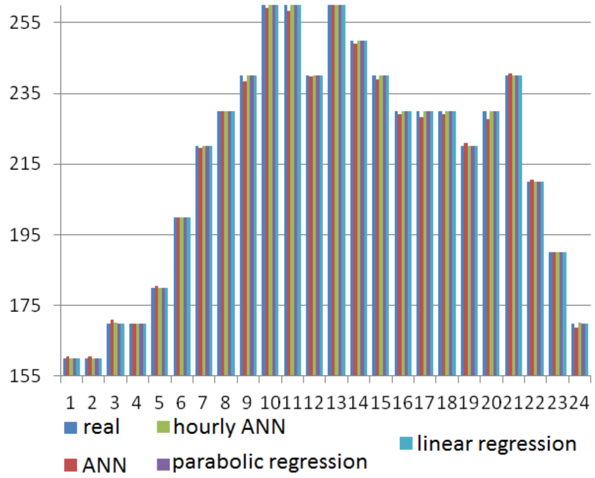

Fig. 5. Comparative analysis – 2013 year [MW]

Table 3. Global performance indices' values

Index	Linear, hourly	Parabolic, hourly	ANN, load curve	ANN, hourly
s_{2011}	0.00	0.00	1.07	0.005
s_{2012}	0.00	0.00	1.29	0.004
s_{2013}	0.00	0.00	2.09	0.005
s_{total}	0.00	0.00	4.45	0.014

The comparative analysis of the values presented in Table 3 highlights the following conclusions:

- comments provided for the 2001-2010, respectively 2011-2013 period are fully sustained by the results;
- conventional forecasting methods (linear and parabolic regression) are leading to "exact" values, thus having an error equal to 0. This is explained by the linear evolution of the hourly consumed power;
- very good results are obtained for the ANN based method for each hour (hourly ANN). Maximum error is 0.03 %, meaning 0.07 MW for consumed power around 150-260 MW (practically, it is obtained an "almost perfect" forecast considering reasonable tolerances);
- acceptable results are obtained in case of ANN for the entire load curve. Maximum error is 0.5 % meaning around 1 MW for consumed power of 150-260 MW;
- analysing Figs. 3-5 (real value – blue colour, ANN load curve forecasted value – red colour) highlights that the tendency of this method is to "blur" the relative maximum and minimum load curve values.

3. "STANDARD 2" LOAD CURVE

Load curve data set for the 10 years known period (2001-2010) is presented in Table 4 and Fig. 6. These data are useful to perform the forecast. Load curves for the 2011-2013 period are presented in Table 5 and Fig. 7. They are going to be used to validate the performed forecast for 2011, 2012 and 2013 years.

The following comments are highlighted:

- the 2001 year load curve represents the starting point for the remaining ones. A constant rate of 4 % has been added for each hour. Thus, the power consumption values are in geometric progression (1.04 rate);
- the load curves have the same variation for each year. This means a good correlation from qualitative and quantitative point of view. However, it is reduced in comparison with "Standard 1" load curve (section 2), especially from the quantitative point of view.

Table 4. Load curves for the known period (2001-2010)

Year/ Hour	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	100.0	104.0	108.2	112.5	117.0	121.7	126.5	131.6	136.9	142.3
2	100.0	104.0	108.2	112.5	117.0	121.7	126.5	131.6	136.9	142.3
3	110.0	114.4	119.0	123.7	128.7	133.8	139.2	144.8	150.5	156.6
4	110.0	114.4	119.0	123.7	128.7	133.8	139.2	144.8	150.5	156.6
5	120.0	124.8	129.8	135.0	140.4	146.0	151.8	157.9	164.2	170.8
6	140.0	145.6	151.4	157.5	163.8	170.3	177.1	184.2	191.6	199.3
7	160.0	166.4	173.1	180.0	187.2	194.7	202.5	210.5	219.0	227.7
8	170.0	176.8	183.9	191.2	198.9	206.8	215.1	223.7	232.7	242.0
9	180.0	187.2	194.7	202.5	210.6	219.0	227.8	236.9	246.3	256.2
10	200.0	208.0	216.3	225.0	234.0	243.3	253.1	263.2	273.7	284.7
11	200.0	208.0	216.3	225.0	234.0	243.3	253.1	263.2	273.7	284.7
12	180.0	187.2	194.7	202.5	210.6	219.0	227.8	236.9	246.3	256.2
13	200.0	208.0	216.3	225.0	234.0	243.3	253.1	263.2	273.7	284.7
14	190.0	197.6	205.5	213.7	222.3	231.2	240.4	250.0	260.0	270.4
15	180.0	187.2	194.7	202.5	210.6	219.0	227.8	236.9	246.3	256.2
16	170.0	176.8	183.9	191.2	198.9	206.8	215.1	223.7	232.7	242.0
17	170.0	176.8	183.9	191.2	198.9	206.8	215.1	223.7	232.7	242.0
18	170.0	176.8	183.9	191.2	198.9	206.8	215.1	223.7	232.7	242.0
19	160.0	166.4	173.1	180.0	187.2	194.7	202.5	210.5	219.0	227.7
20	170.0	176.8	183.9	191.2	198.9	206.8	215.1	223.7	232.7	242.0
21	180.0	187.2	194.7	202.5	210.6	219.0	227.8	236.9	246.3	256.2
22	150.0	156.0	162.2	168.7	175.5	182.5	189.8	197.4	205.3	213.5
23	130.0	135.2	140.6	146.2	152.1	158.2	164.5	171.1	177.9	185.0
24	110.0	114.4	119.0	123.7	128.7	133.8	139.2	144.8	150.5	156.6

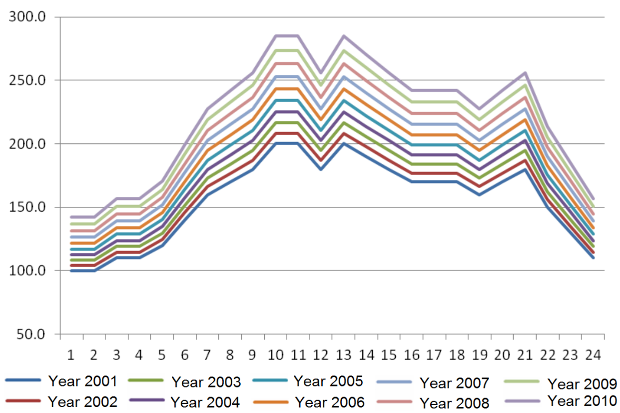

Fig. 6. Load curves for 2001-2010 period [MW]

Table 5. Load curves for the forecasted period (2011-2013)

Year/ Hour	2011	2012	2013	Year/ Hour	2011	2012	2013
1	148.0	153.9	160.1	13	296.0	307.9	320.2
2	148.0	153.9	160.1	14	281.2	292.5	304.2
3	162.8	169.3	176.1	15	266.4	277.1	288.2
4	162.8	169.3	176.1	16	251.6	261.7	272.2
5	177.6	184.7	192.1	17	251.6	261.7	272.2
6	207.2	215.5	224.1	18	251.6	261.7	272.2
7	236.8	246.3	256.2	19	236.8	246.3	256.2
8	251.6	261.7	272.2	20	251.6	261.7	272.2
9	266.4	277.1	288.2	21	266.4	277.1	288.2
10	296.0	307.9	320.2	22	222.0	230.9	240.2
11	296.0	307.9	320.2	23	192.4	200.1	208.1
12	266.4	277.1	288.2	24	162.8	169.3	176.1

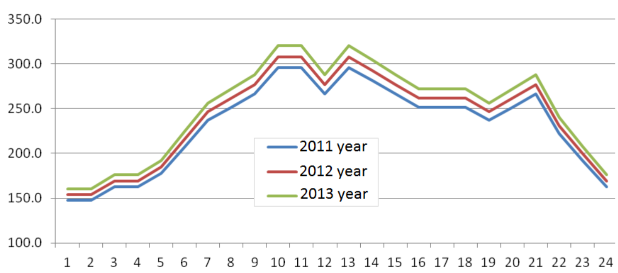

Fig. 7. Load curves for 2011-2013 period [MW]

A comparative analysis for the performed forecast is presented in Figs. 8-10. The global performance indices' values are presented in Table 6.

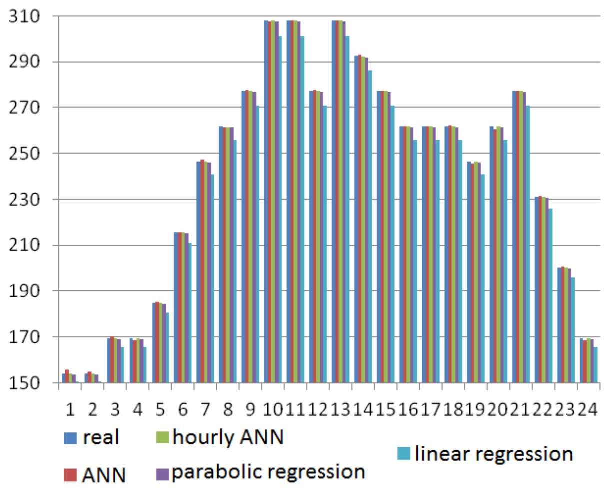

Fig. 8. Comparative analysis – 2011 year [MW]

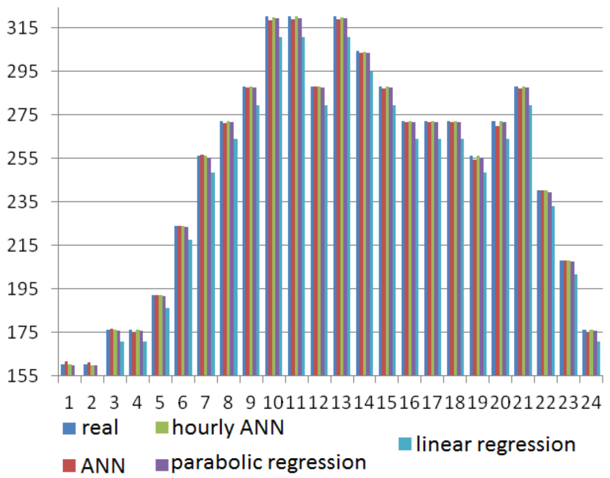

Fig. 9. Comparative analysis – 2012 year [MW]

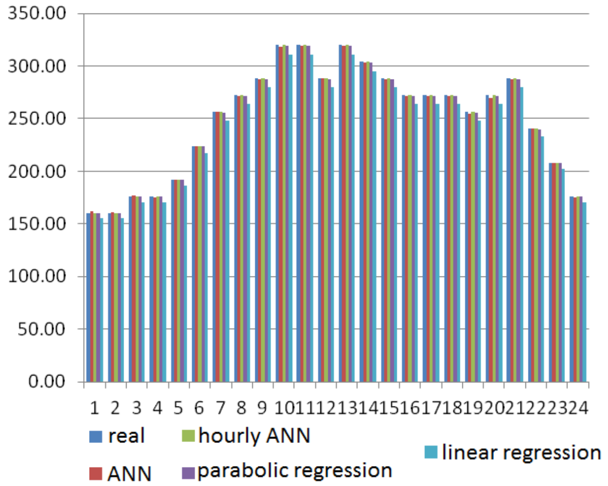

Fig. 10. Comparative analysis – 2013 year [MW]

Table 6. Global performance indices' values

Index	Linear, hourly	Parabolic, hourly	ANN, load curve	ANN, hourly
s_{2011}	48.4	0.08	2.67	0.043
s_{2012}	112.9	0.47	2.75	0.014
s_{2013}	216.9	1.54	4.16	0.052
s_{total}	378.2	2.09	9.58	0.11

The comparative analysis of the values presented in Table 6 highlights the following conclusions:

- comments provided for the 2001-2010, respectively 2011-2013 period are fully sustained by the results;
- linear regression based forecast is fully inadequate for the current load curve type. Hourly consumed power variation is nonlinear (geometric progression). Errors are higher than 3 %;
- parabolic regression based forecast leads to much better results compared to the linear one. Total performance index is 2.09 compared with 378.2;
- ANN based method applied for each hour (hourly ANN) leads to exceptional results. Thus, the algorithm and developed software tool are validated. Maximum error is 0.09 %, meaning around 0.2 MW for consumed power of 150-260 MW; practically, it is obtained an "almost perfect" forecast considering completely reasonable tolerances;
- acceptable results are obtained in case of ANN for the entire load curve. Maximum error is below 1 % meaning around 1.5-2.6 MW for consumed power around 150-260 MW;
- analysing Figs. 8-10 (real value – blue colour, ANN load curve forecasted value – red colour) highlights that the tendency of this method is to "blur" the relative maximum and minimum load curve values.

Starting from the global performance indices' values, the equivalent ones have been computed dividing with 72 (3 years x 24 hours = 72). A comparative analysis based on these indices is provided in Table 7. The ANN based forecast for each hour and for the entire load curve are included within the analysis.

Table 7. Equivalent performance indices

No.	Load curve	ANN, load curve		ANN, hourly	
		Global	Equivalent	Global	Equivalent
1	"Standard 1"	4.45	0.06	0.014	1.9×10^{-4}
2	"Standard 2"	9.58	0.13	0.11	2.0×10^{-3}

The results for the "Standard 1" load curve are superior to the ones corresponding to "Standard 2" load curve. Also, the hourly ANN based forecasts are better than the ones for the entire load curve.

4. REAL LOAD FORECAST. RESULTS AND DISCUSSION

The case study refers to a real consumer area from Enel Distribution Banat. The known daily load curves for the 2001-2010 period are presented in Table 8 and Fig. 11. The selected day refers to the most significant summer day – June 21st. The forecast is performed for the next three years (2011, 2012, 2013).

The daily load curves for the 2011-2013 period are presented in Table 9 and Fig. 12. The same summer day has been considered. These data are used to validate the forecast.

A brief analysis of the provided data highlights from the beginning the following conclusions:

- for the 2001-2010 period there is not highlighted a general power increase or decrease tendency for the entire time horizon;
- load curves are characterized by a relative good correlation degree;

Table 8. Load curves for the known period (2001-2010)

Year/ Hour	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	122.0	134.0	127.2	114.9	116.0	113.1	110.9	108.9	117.0	112.6
2	113.6	126.9	119.5	107.7	108.7	106.2	102.6	100.6	107.5	104.8
3	111.4	123.5	116.2	104.8	105.2	102.7	100.9	99.20	102.4	100.6
4	111.9	121.8	115.4	104.3	103.3	101.0	98.0	99.70	100.2	102.6
5	113.6	123.0	115.6	106.5	104.8	102.1	99.4	99.00	101.5	102.2
6	120.8	131.4	122.5	113.5	109.5	106.0	103.9	103.6	104.6	102.6
7	139.3	151.4	138.7	127.2	119.9	117.4	115.3	114.6	115.0	116.0
8	160.2	172.7	156.5	143.3	137.0	135.8	134.4	135.2	134.7	135.7
9	162.8	177.0	161.7	150.1	147.0	146.0	144.9	143.1	144.0	144.5
10	161.6	166.0	160.5	148.5	148.6	147.5	146.5	142.6	145.1	145.3
11	154.6	161.1	153.4	143.4	147.5	144.2	143.9	141.1	143.7	143.3
12	152.5	160.4	152.4	145.9	147.3	146.0	145.1	143.5	146.2	146.4
13	148.3	156.3	149.2	143.5	145.1	144.2	143.8	142.6	146.2	145.4
14	148.0	155.6	148.1	144.3	143.4	143.0	143.0	143.6	145.1	146.9
15	146.8	151.2	145.6	141.1	138.9	140.0	141.9	141.3	144.1	143.1
16	135.5	148.6	136.4	131.1	129.2	132.2	135.3	134.2	137.0	135.4
17	128.9	147.8	133.1	126.5	123.5	126.9	131.3	127.4	132.3	129.7
18	127.7	147.4	128.9	123.6	122.4	124.6	127.8	125.7	129.3	126.7
19	126.4	148.7	127.2	122.3	120.1	122.4	125.3	121.4	126.7	124.7
20	133.3	156.2	131.3	125.4	119.8	121.1	123.3	120.6	125.0	122.7
21	158.4	174.4	148.2	140.8	131.0	129.2	128.3	125.5	133.0	127.3
22	170.8	185.7	168.7	160.2	152.8	150.0	148.2	141.0	142.3	139.7
23	157.7	169.1	156.9	150.0	147.9	147.7	147.8	143.6	139.9	149.3
24	142.5	151.4	141.9	134.8	130.6	130.4	130.2	127.2	126.0	131.0

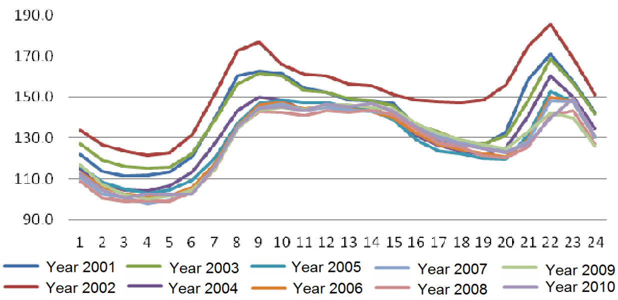

Fig. 11. Load curves for 2001-2010 period [MW]

Table 9. Load curves for the forecasted period (2011-2013)

Year/ Hour	2011	2012	2013	Year/ Hour	2011	2012	2013
1	115.4	118.5	116.2	13	143.0	144.2	146.6
2	108.9	109.2	108.1	14	148.1	150.3	147.2
3	102.8	103.9	104.8	15	144.2	143.5	142.8
4	103.7	103.2	102.1	16	137.4	136.5	136.2
5	100.9	104.3	104.2	17	136.2	131.6	132.1
6	107.8	105.0	106.8	18	126.0	125.5	127.2
7	120.9	122.1	122.7	19	124.7	124.5	126.7
8	137.4	142.6	146.9	20	124.7	123.3	125.2
9	145.6	141.2	143.1	21	136.6	137.8	136.5
10	151.1	148.4	151.3	22	152.2	151.1	150.2
11	151.2	148.0	150.8	23	150.1	148.5	149.0
12	146.0	145.0	144.0	24	134.5	133.6	133.3

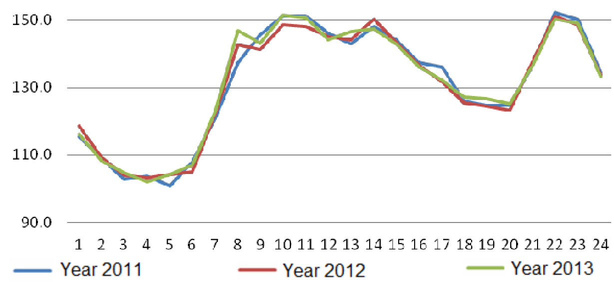

Fig. 12. Load curves for 2011-2013 period [MW]

- the unclear tendency is also sustained for the 2011-2013 period, but their curves' shape are roughly the same;
- load curves' correlation degree is relatively good from the shape point of view, during a day. Thus, the possibility to obtain accurate forecasts based on ANN methods is envisaged.

In the following, the results provided using different load forecasting techniques are presented. A comparative analysis is provided in Figs. 13-15. The global performance indices have been synthesized in Table 10.

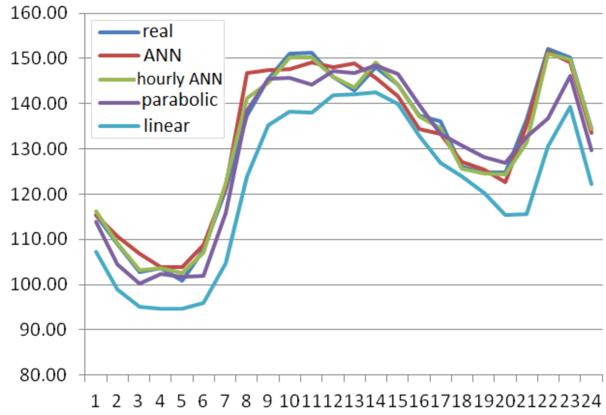

Fig. 13. 2011 year comparative analysis [MW]

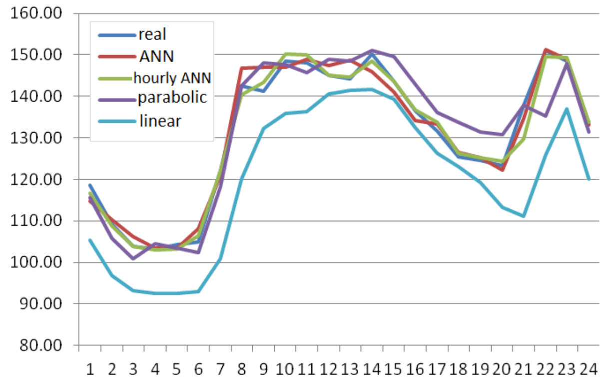

Fig. 14. 2012 year comparative analysis [MW]

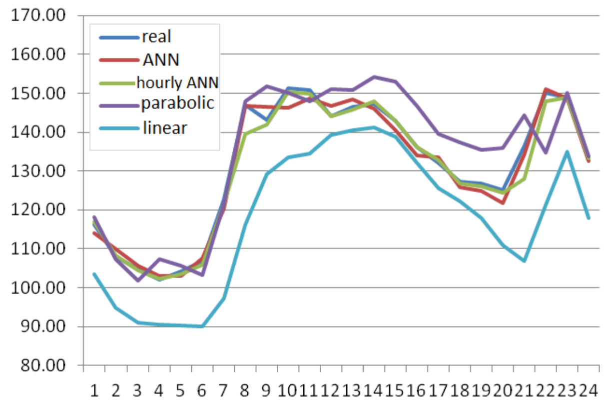

Fig. 15. 2013 year comparative analysis [MW]

Table 10. Global performance indices – case study

Index	Linear, hourly	Parabolic, hourly	ANN, load curve	ANN, hourly
S_{2011}	1630.2	282.17	123.80	16.41
S_{2012}	2421.1	361.62	88.24	15.65
S_{2013}	3545.8	614.01	58.58	8.33
S_{total}	7597.1	1257.8	270.62	40.39

The highest values for the global performance index are recorded for the conventional methods.

The quality of the parabolic extrapolation is better than the linear one. Global performance index is 1257.8 in comparison with 7597.1. Load increase evolution periods are alternated with decreasing ones. The yearly global indices have the same magnitude order.

The best results are obtained in case of hourly ANN based method. In this case the global index is 40.39 versus 270.62 (load curve ANN). The difference is explained by the few correlation issues from the load curve shape. Yearly performance indices are characterized by the same magnitude order. There is only one exception – s_{2011} for ANN entire load curve forecasting.

Analysing Fig. 13 there are highlighted 3 hours – 3, 8 and 13 – where the difference is relatively high between the red colour curve (entire load curve ANN forecast) and the blue (real value) and green ones (hourly ANN). The hourly ANN forecast, considering the power consumption at different independent hours, better succeeds to solve these situations.

A comparative analysis based on equivalent indices is provided in Table 11. The information regarding the "standard" load curves and the one corresponding to the case study are gathered.

Table 11. Equivalent performance indices

No.	Load curve	ANN, load curve		ANN, hourly	
		Global	Equivalent	Global	Equivalent
1	Case study	270.62	3.8	40.39	0.56
2	"Standard 1"	4.45	0.06	0.014	1.9×10^{-4}
3	"Standard 2"	9.58	0.13	0.11	2.0×10^{-3}

Based on [16] the characteristic global quadratic indices have been computed (Table 12): IC_y – characteristic global quadratic index computed based on yearly finite differences; IC_{ye} – equivalent IC_y; IC_h – characteristic global quadratic index computed based on hourly finite differences; IC_{he} – equivalent IC_h.

Table 12. Characteristic global quadratic indices

No.	Load curve	IC_y	IC_{ye}	IC_h	IC_{he}
1	Case study	92×10^6	6×10^3	197×10^6	13×10^3
2	"Standard 1"	0	0	0	0
3	"Standard 2"	0.03×10^6	0	0.04×10^6	0

According to Table 11 and Table 12, the hierarchy is as follows: "Standard 1" load curve, "Standard 2" and the one corresponding to the case study. The hierarchy is maintained for both ANN techniques (hourly and entire load curve).

5. CONCLUSION

Two "standard" load curves have been discussed within the paper. They have been used for tuning the load forecasting software tools using conventional and ANN based methods. Also, they have been used to assess the magnitude order for the performance indices and characteristic global indices.

The utility of the "standard" load curves is proven by the presented results. The comparison with the forecast study for a real consumer is a case in point.

Thus, the provided results by the ANN based methods' highlight that they are able to "catch" the load values evolution.

REFERENCES

[1]. Chow J.H, Wu F.F., Momoh J.A. – Applied mathematics for restructured electric power systems, Optimization, Control, and Computational Intelligence, Springer's Power Electronics and Power Systems Series, 2004

[2]. Kilyeni St. – Optimization techniques in power engineering, Orizonturi Universitare, 2015 (in Romanian)

[3]. Lustrea B. – Energy consumption forecasting, AGIR, 2001 (in Romanian)

[4]. Fu C.W., Nguyen T.T. – Models for Long-Term Energy Forecasting, in Power Engineering Society General Meeting, Toronto, Canada, Vol.1, 2003, pp. 1-6

[5]. Al Rashidi M.R., El-Naggar K.M. – Long term electric load forecasting based on particle swarm optimization, Applied Energy, 2010, pp. 20-326

[6]. Tao Z., Zhong T., Shuyan R. – Medium and long term load forecasting based on fuzzy times series, in Proceedings of the 2013 IEEE International Conference on Advanced Mechatronic Systems, Luoyang, China, pp. 671-673

[7]. Bolturk E., Oztay B., Sari I.U. – Electricity consumption forecasting using fuzzy time series, in Proceedings of the 13th IEEE International Symposium on Computational Intelligence and Informatics, Budapest, Hungary, 2012, pp. 245-249, 2012

[8]. Peng T.M., Hubele N.F., Karady G.G. – Advancement in the application of neural networks for short-term load forecasting, IEEE Transactions on Power Systems, vol.7, no. 1, 1992, pp. 250-257

[9]. Lu J.C., Niu D.X., Jia Z.Y. – A study of short-term load forecasting based on ARIMA-ANN, in Proceedings of the 3rd International Conference on Machine Learning and Cybernetics, Shanghai, China, 2004, pp. 3183-3187

[10]. Chauhan B.K., Sharma A., Hanmandlu M. – Neuro-fuzzy approach based short term electric load forecasting, IEEE Transmission and Distribution Conference & Exhibition Asia and Pacific, Dalian, China, 2005, pp. 1-5

[11]. Ramezani M., Falaghi H., Haghifam M.R. – Short-term electric load forecasting using neural networks, in Proceedings of the IEEE International Conference Eurocon, Belgrade, Serbia, 2005, vol. 2, pp. 1525-1528

[12]. Liu F., Findlay D.R., Song Q. – A neural network based short term electric load forecasting in Ontario Canada, in Proceedings of the IEEE International Conference on Computation Intelligence for Modelling Control and Automation, Sydney, Australia, 2006, pp. 1-7

[13]. Osman Z., Awad M.L., Mahmoud T.K. – Neural network based approach for short-term load forecasting, in Proceedings of the IEEE Power Systems Conference and Exposition, 2009, pp. 1-8

[14]. Qingle P., Min Z. – Very short-term load forecasting based on neural network and rough set, in Proceedings of the International Conference on Intelligent Technology and Automation, Changsa, China, 2010, pp. 1132-1135

[15]. Ismail M.M., Hassan M.A.M. – Artificial neural network based approach compared with stochastic modelling for electrical load forecasting, in Proceeding of the International Conference on Modelling, Identification & Control, Cairo, Egypt, 2013, pp. 112-118

[16]. Deacu A. – Artificial neural network based energy consumption forecast, Politehnica University Timisoara, PhD Thesis, 2015