Load profiles analysis for electricity market

Radu Porumb[1*], Petru Postolache[2], George Serițan[3], Ramona Vatu[4], Oana Ceaki[5]

[1]University Politehnica of Bucharest, Faculty of Power Engineering, e-mail: radu.porumb@upb.ro, Splaiul Independenței nr. 313, București, România
[2]University Politehnica of Bucharest, Faculty of Power Engineering, e-mail: petrupostolache@yahoo.com, Splaiul Independenței nr. 313, București, România
[3]University Politehnica of Bucharest, Faculty of Electrical Engineering, e-mail: serigeorge1973@yahoo.com, Splaiul Independenței nr. 313, București, România
[4]University Politehnica of Bucharest, Faculty of Power Engineering, e-mail: vatu.ramona@gmail.com , Splaiul Independenței nr. 313, București, România
[5]University Politehnica of Bucharest, Faculty of Power Engineering, e-mail: ceaki.oana@yahoo.com, Splaiul Independenței nr. 313, București, România

Abstract

In the wake of electric power system transition towards smart grids, and the adoption of the electric market schemes, electric utilities are facing the need of a better load profiles understanding for their customers. In this work, some key objectives were addresses, such as definition of the mathematical model for calculating the hourly energy specific, identification of the three target groups for users who have developed consumer profiles, definition of the two types of significant load and assessment of the impact of using consumer profiles on users.

Keywords: Distribution system, electricity market, load profile.

1. Introduction

In the free market of electricity, electricity suppliers need to have information on the customer electricity consumption evolution in order to buy sufficient energy from the wholesale market to cover the hourly consumption at negotiated prices and average periods [1-15].

In the absence of such information, the service provider will be obliged to purchase the electricity wholesale market. The quantities of purchased energy may be smaller than its customer's needs – in which case, the deficit will be covered by purchasing the missing quantities in the market for next day or balancing market at higher prices. Where the supplier will buy power on the wholesale market more energy than is necessary for the customer, will be forced to sell the surplus, balancing market at a price lower than that with which the energy was purchased [16-36].

For those customers that have implemented smart metering devices (which can record consumption at different time intervals, memorize the values and remotely transmit the information), this consumption variation is known [37-42]. For customers that have not installed such intelligent devices, it requires a method by which the total electricity consumption over a period of time to be assigned to time slots [43,44]. Typically, the issue of the load curve profile determination is posed for small users and for users. In their case, the installation of meters with registration of hourly electricity consumption is economically unjustified [45,46].

2. Operational and functional requirements for accurate load profiling – analytical assessment

Average daily consumption which is scheduled by using weights specified in a table which contains data relating to consumer profile (differentiated for working day and non-working day) is defined from the relations detailed in sequel.

[*] Corresponding author : radu.porumb@upb.ro

2.1 Monthly energy aggregation

For an average month, some using the data presented in a table that contains the results of the measurements of energy for all hourly intervals (curves, as the average consumer used to establish the data measured consumer profile):

$$\overline{Q}_{WD} = q_{WD} * N_{ZD} \tag{1}$$

$$\overline{Q}_{NWD} = q_{NWD} * N_{NWD} \tag{2}$$

$$\overline{Q}_{WD} = Q_{WD} + Q_{NWD} \tag{3}$$

where:

$\overline{Q}_{WD}$ = amount of energy distributed on working days for a month, according to the measured values;

$\overline{Q}_{NWD}$ = amount of energy distributed in non-working days for a month, according to the measured values;

q_{WD} = average daily consumption associated with any working days for a month, according to the values given in the table containing the results of the measurements of energy for all hourly intervals;

q_{NWD} = average daily consumption associated with any non-working days for a month, according to the values given in the table containing the results of the measurements of energy for all hourly intervals;

Q = energy distributed within one month according to measured values

N_{WD} = number of working days in the month;

N_{NWD} = number of non-working days in the month

2.2 Evaluation of energy weights

$$P_{WD} = \frac{\overline{Q}_{WD}}{\overline{Q}} \tag{4}$$

$$P_{ZNL} = \frac{\overline{Q}_{NWD}}{\overline{Q}} \tag{5}$$

where:

P_{WD}, P_{NWD} is the weight of the energy distributed for one month with respect to working days/holidays, determined accordingly to the measured values which underline the consumer profile, according to the table that contains the results of the measurements of energy for all hourly intervals;

2.3 Monthly energy calculation

Energy distributed in the settlement month, differentiated according to type of day (working/nonworking) shall be established according to the following relationship:

$$\overline{Q}_{monthWD} = Q_{month} * P_{WD} \tag{6}$$

$$\overline{Q}_{monthNWD} = Q_{month} * P_{NWD} \tag{7}$$

$$\overline{Q}_{monthWD} + \overline{Q}_{monthNWDZNL} = Q_{month} \tag{8}$$

where:

Q_{month} = the amount of energy distributed in the settlement,

2.4 Monthly calculation of energy weights

Daily quantities of energy distributed in paying month must be approved according to profile schedule (using the weights shown in a table containing data relating to consumer profile) is determined according to the relationship presented in sequel:

$$Q_{WD} = \frac{Q_{monthWD}}{N_{WD}} \tag{9}$$

$$Q_{NWD} = \frac{Q_{monthNWD}}{N_{NWD}} \tag{10}$$

2.5 Daily/hourly energy calculation

Monthly representation of quantities of energy will be distributed on the basis of the approved profile on differentiated working days / non-working days, according to the following relationship:

a). working day

$$Q_{hourWD} = Q_{WD} * \gamma \tag{11}$$

where:

$Q_{hourrWD}$ = energy distributed according to a time interval for a working day;

γ = represents the percentage determined for the characteristic profile of working days, for a given time interval (according to the table containing data relating to consumer profile)

b). non-working day

$$Q_{hourNWD} = Q_{NWD} * \eta \tag{12}$$

where:

$Q_{hourNWD}$ = energy distributed according with a time interval for a working day;

η = is the percentage determined for the characteristic profile of working day, for a given time interval (according to the table containing the data relating to consumer profile).

Hourly quantities are expressed in, MWh with 3 decimals, so that the difference between the amount of energy distributed monthly and the sum of hourly energies to be less than 1 kWh.

3. System application

The question of determining the load curve profile is very economically-efficient for small users and for users. Under these circumstances, the establishment of hourly values of energy associated with a supplier can realize, for each point of consumption for providing hourly consumption by spreading recorded on a calculation based on a consumer profile.

Within current paper, the following consumers were took under consideration:

1. Fuel stations
2. Small businesses without cooling
3. Small businesses with cooling
4. Schools

3.1 Fuel stations

This illustrates loading profile contributions such as lighting, cooling, ventilation and other tasks performed throughout the day. Evaluation of total energy consumption in energy will show a rapid increase during the morning because of the transitional arrangements of the receivers. Once the systems are started, the demand is relatively constant throughout the day.

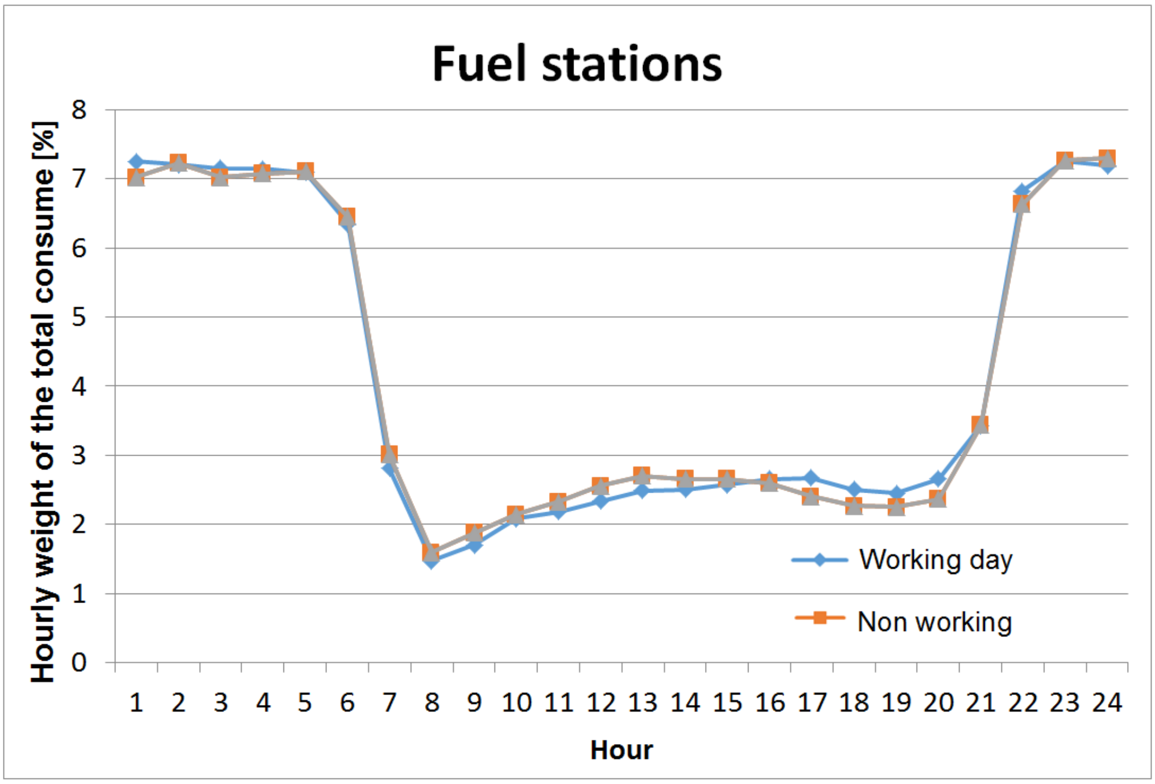

Fig. 1. Load curves for fuel stations

Table 1 Measurements results

Average consume curve [MWh]		
Interval	Interval	Interval
00:00:00	0.004292661	0.00403134
01:00:00	0.004293374	0.004025699
02:00:00	0.00431324	0.004067442
03:00:00	0.004339073	0.004211893
04:00:00	0.0043308	0.004205129
05:00:00	0.004474134	0.004150411
06:00:00	0.004486111	0.004113899
07:00:00	0.004406811	0.00390353
08:00:00	0.006805816	0.003982609
09:00:00	0.011768425	0.004847129
10:00:00	0.012067337	0.004919832
11:00:00	0.012192786	0.004936485
12:00:00	0.012029691	0.004917517
13:00:00	0.012074995	0.004672229
14:00:00	0.012670302	0.005389044
15:00:00	0.012493785	0.005340656
16:00:00	0.012752344	0.005375426
17:00:00	0.012025259	0.005502721
18:00:00	0.009438688	0.005893038
19:00:00	0.006964362	0.005928727
20:00:00	0.004961839	0.004721399
21:00:00	0.00419137	0.004045598
22:00:00	0.004175531	0.004062494
23:00:00	0.004159727	0.004051396
Q_{WD}	**0.185708461**	
Q_{NWD}		**0.111295642**

Table 2 Data for fuel stations (hourly weights of energy consume)

	Consume profile	
	Mean WD [%]	Mean NWD[%]
00:00:00	2.311505444	3.622190662
01:00:00	2.311889189	3.617122116
02:00:00	2.322586538	3.654628397
03:00:00	2.336497257	3.784418488
04:00:00	2.332042219	3.778340724
05:00:00	2.40922455	3.729176304
06:00:00	2.415674017	3.69636986
07:00:00	2.372972836	3.507352062
08:00:00	3.664785357	3.578405416
09:00:00	6.337043236	4.355183359
10:00:00	6.498000695	4.42050712
11:00:00	6.565552497	4.435469842
12:00:00	6.477728882	4.418427075
13:00:00	6.502124331	4.198033707
14:00:00	6.82268434	4.842098201
15:00:00	6.727633712	4.798620693
16:00:00	6.866862061	4.82986245
17:00:00	6.475342473	4.944237998
18:00:00	5.082529611	5.294940665
19:00:00	3.750158578	5.327007124
20:00:00	2.671843172	4.242213655
21:00:00	2.256962489	3.635000816
22:00:00	2.248433386	3.650182388
23:00:00	2.239923131	3.640210877

3.2 Small businesses without cooling

This illustrates loading profile contributions such as lighting, cooling, ventilation and other tasks performed throughout the day. Evaluation of total energy consumption in energy will show a rapid increase during the morning because of the transitional arrangements of the receivers. Once the systems are started, the demand is relatively constant throughout the day.

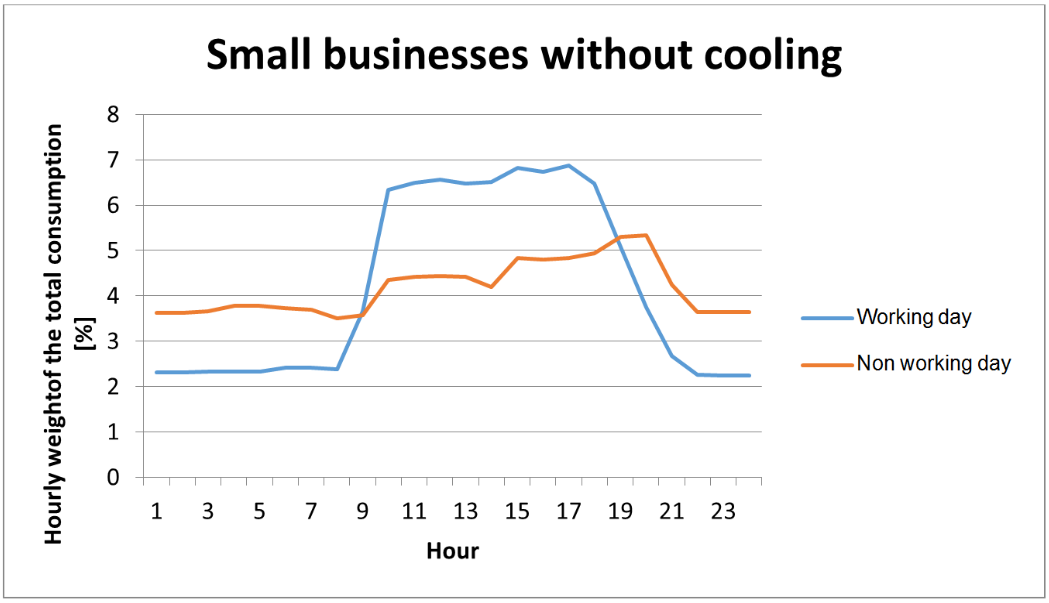

Fig. 2. Load curves for SBwC (WD and NWD) Small businesses with cooling

Minimum and maximum limits presents a limited variation of about 2%, which indicates the uniformity of type SBC users consumption. The load curve flattening we can say that it has a high value which indicates that in the case of SBC have a flat load curve.

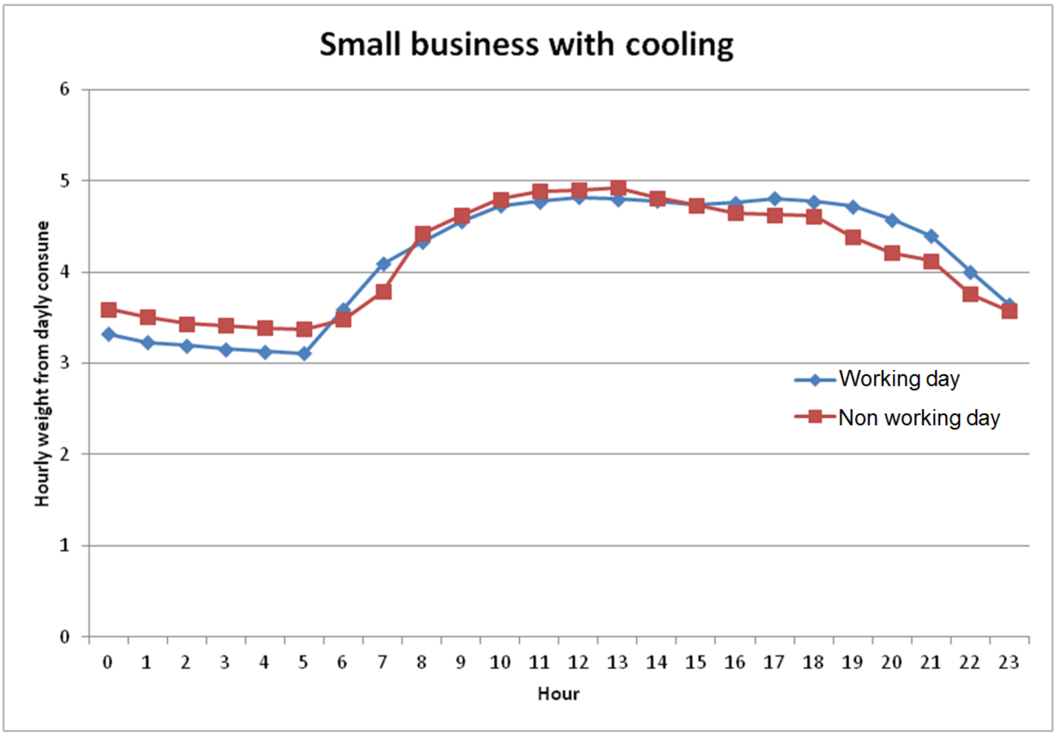

Fig. 3. Load curves for SBC (WD and NWD)

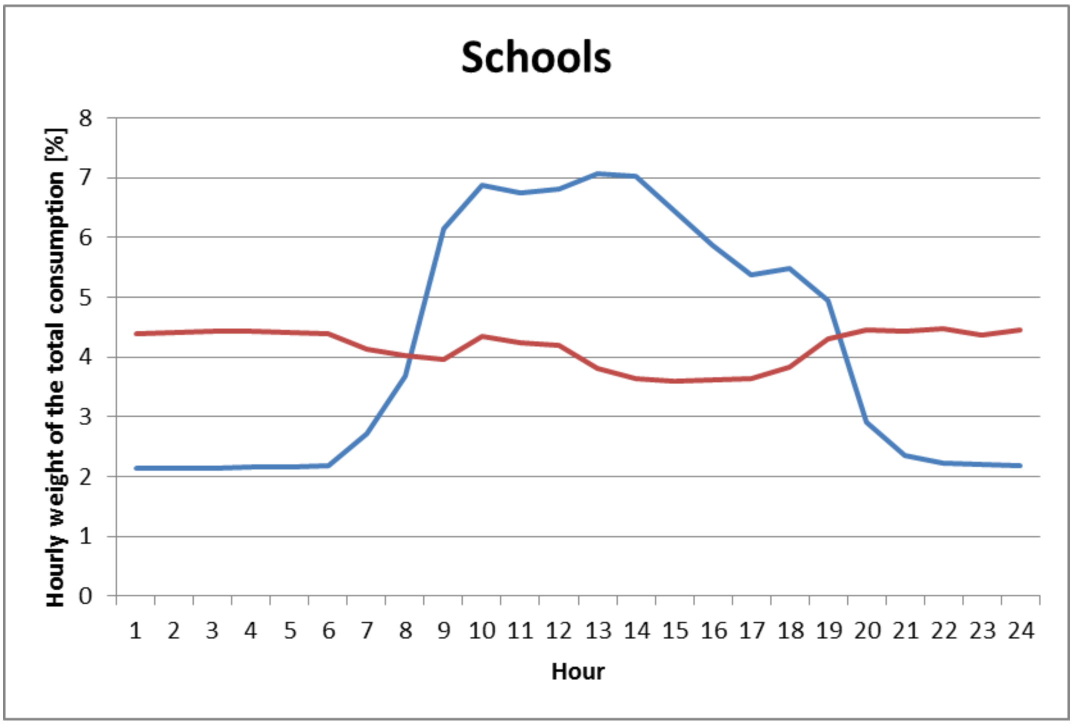

Fig. 4. Load curves for Schools

The overall purpose of this section is to reach the final economic target of fully describe the customers' behavior by exactly quantifying their consumption patterns, starting from monthly energy aggregation.

4. Conclusions

In this work, some key objectives were completed, such as definition of the mathematical model for calculating the hourly energy specific, identification of the three target groups for users who have developed consumer profiles, definition of the two types of significant load and assessment of the impact of using consumer profiles on users

Also, throughout the whole paper, the authors have tried to create a framework that can be used later by the beneficiary for mathematical models. In sequel are listed the obstacles in the face of improving energy distribution activity and the action required to be taken with a view to the removal of obstacles.

There are a few issues that pose a serious threat to the future development of electric distribution system. A brief collection of these issues are presented in sequel:

- Lack of investment in facilities for low voltage networks, a significant proportion of the consumers having old installations with access to conductors.
- Poor status of the electric distribution power system, namely network areas with great lengths, LV overload, with inadequate insulation.
- Action to raise awareness of the extent of the economic agents who work with very low loads. Actions required in order to mitigate the upper-mentioned issues:
- Continuance of control actions for faulty consumers of electrical energy,
- Recovery and restoration of the electric power system is compulsory for reaching the goal of having a secure system
- Development of electric distribution systems using economic-based strategies

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