

Analysis Load Diagrams in Industry as an Instrument for Energy Efficiency Improvement

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Abstract—In article are presented load diagrams created for chosen area in analyzed year and there are described influence of particular companies on its shape. There are also shown conclusions concerned obtained data and possibilities of changes creating improvement of energy efficiency by reducing electricity consumption.

Keywords—component; load diagrams, energy efficiency

I. INTRODUCTION

The policy of European Union imposes 20% increase of energy efficiency. Method of improving of energy efficiency is rational management of demand for electric energy. Among technical improvements like: modifying manufacturing process, machine park upgrade or use of automatics improving efficiency production process there is a simply, and as the most important, not expensive instrument for influence on energy efficiency. It can be realized by load diagrams formation. Shaping load diagrams in particular industries may correct global load diagrams by reducing energy use in pick hours and increase in off-pick hours [1].

Industry section in Poland currently uses more than 40% of total energy consumption (Fig. 1, Fig. 2). It is significant amount, but there are countries in Europe like: Russia, Finland, Belgium or Italy, where the participation of industry in energy use is bigger. Poland industry's energy consumption is average in comparing with other countries of Europe. (Fig. 2)

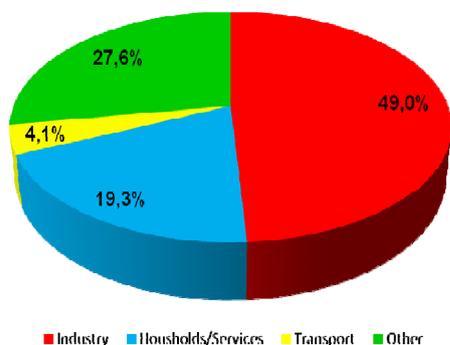


Figure 1. Electricity consumption share by sector of activity in Poland, 2009 [2]

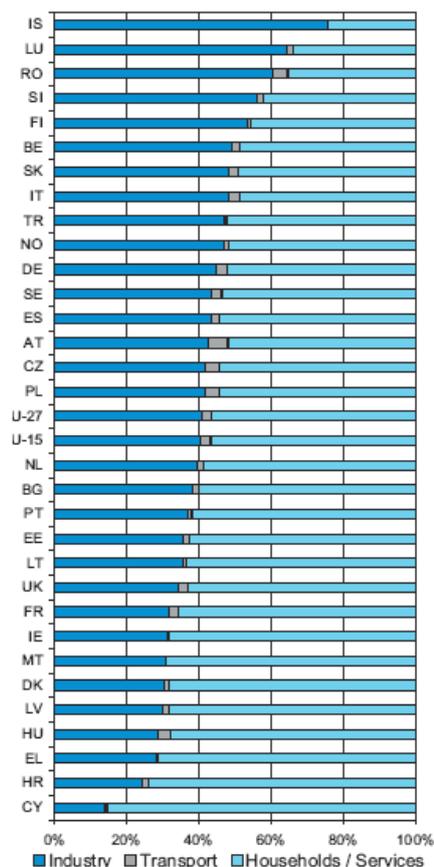


Figure 2. Electricity consumption share by sector of activity in Europe, 2009 [3]

By improving energy efficiency can be achieved financial benefits for national economy. That is the reason why working on industry's energy consumption is so important. Increase of energy efficiency within households can be also significant for the country, because this section uses about 20% of energy in Poland (Fig. 1). However, it is more complicated to interest households by saving energy, because profits for particular consumers are still insignificant.

Results of electric energy consumption management are noticeable for transmission system operator, distribution operator and consumer. There are worth of mentioned: influence on safety of national power system, minimizing energy costs connected with production and distribution or harmful influence on environment, shaping energy prices and increasing availability of power system [4].

II. ELECTRICITY CONSUMPTION IN URBAN AREA

Created analyses relate to Wrocław energy area contained places like: Oborniki Śląskie, Środa Śląska, Strzelin and Oleśnica (Fig. 3).



Figure 3. Analyzed Wrocław area

Average annual energy consumption amount to 4 287 GWh in 2009, what is 3% of national use and 36% of Lower-Silesian area (Tab. 1).

TABLE I. DATA ABOUT ELECTRICITY CONSUMPTION IN 2009

SPECIFICATION		Wrocław AREA	company X	company Y	company Z
ANNUAL ELECTRICITY CONSUMPTION	GWh	4 287	388	22	624
ANNUAL ELECTRICITY CONSUMPTION (% of area)	%	-	9	1	15
AVERAGE LOAD	MW	585	47	4	75
MAX LOAD	MW	732	56	7	94
MIN LOAD	MW	366	2	0	25
AVERAGE MAX LOAD	MW	585	47	4	75
AVERAGE MIN LOAD	MW	359	41	2	68

For chosen area have been created load curves. Three consumers: Company X (chemical industry), Company Y (metallurgical industry) and Company Z (chemical industry), which together take 24% of total energy in Wrocław area (Tab. 1), have been scrutinized. There has been observed their influence on load diagrams for the area.

Basing on data about hourly growth electricity consumption for 365 days, there were created twenty-four-hour load diagrams and were made annual load curves for first and third Wednesdays of every month [5].

A. Analyse of Company X

Company X is factory with chemical activity profile and its part in electricity consumption of area is significant (9%) (Tab. 1).

During the day load is diverse. The difference between max and minimum load is more than 20 MW (month October) (Fig. 4). Annual load oscillate between 8 MW and 55 MW. Minimal load (81% less than annual average load) is while the holiday brake (month July) Reduce of electricity consumption is also during Easter break (50% less than annual average load) and in month October (17% less than annual average load) (Fig. 5).

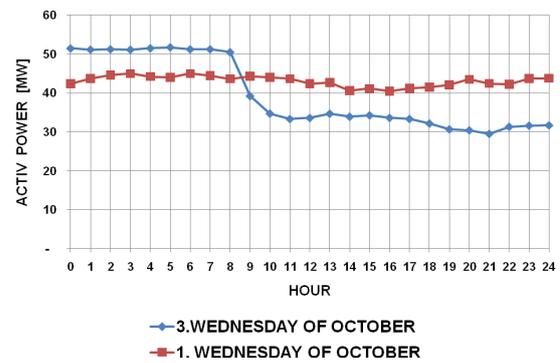


Figure 4. Daily load diagram in Company X, October 2009

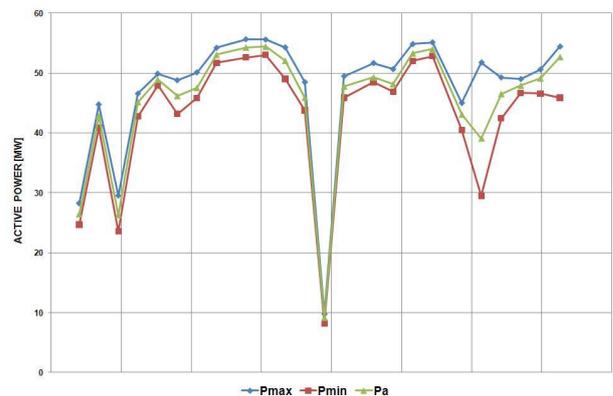


Figure 5. Annual load diagram in Company X, 2009

In smoothing annual load diagram for Wroclaw area there can be important limitations in consumption during the months: July and April, but restriction in month October shouldn't be visible because of its small value. Consumption of Company X has importance for curve position on area's diagram.

In Wroclaw area Company X should have positive influence on the level of diagram smoothing. For this company characteristic is higher consumption at night (between 24:00 and 8:00) and lower during the day (between 8:00 and 24:00) (Fig. 4).

B. Analyse of Company Y

Factory's Y electricity consumption is 10 times less than factory X but still its energy use is significant for the area. Company Y is firm with metallurgical activity profile and it uses at year 22 GWh active energy what is 1% of the area (Tab. 1).

During the day load is diverse but there is only 2 MW difference between max and minimum load (month January) (Fig. 6), what is 10 times less than in company X. Consumption at night (15:00-7:00) is reduced to 50% use during the day (7:00-15:00). Annual load oscillate between 3 MW and 6,5 MW. Minimal load (31% less than annual average load) is in May and it's short-term. Maximum load is in the end of January (62% more than annual average load) (Fig. 7).

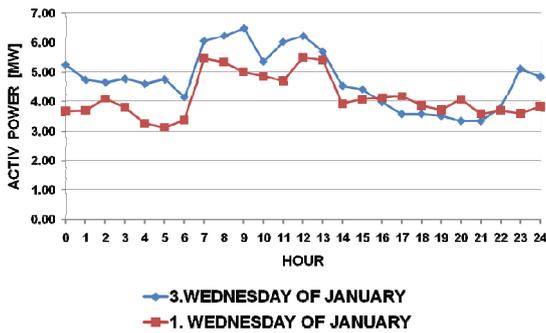


Figure 6. Daily load diagram in Company Y, January 2009

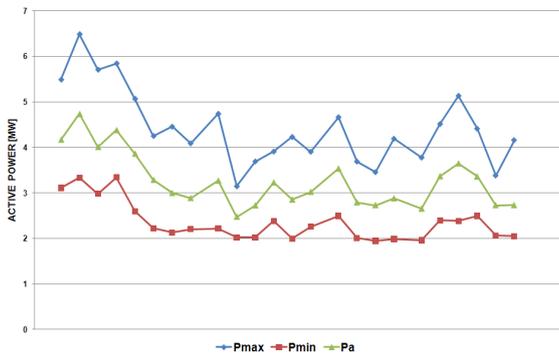


Figure 7. Annual load diagram in Company Z, 2009

There is marginal possibility that reduction of consumption can have noticeable influence on shape of load diagram for Wroclaw area. It is small value in compared to the load value for all area. Consumption of Company Y has importance for curve position on area's diagram, but it is only 1%.

C. Analyse of Company Z

Company with the largest consumption of energy is factory Z. Its activity profile is chemical and its part in electricity consumption of Wroclaw area is important (almost 15%). It uses 15 times more electricity than factory Y and 1,5 times more than factory X. (Tab. 1)

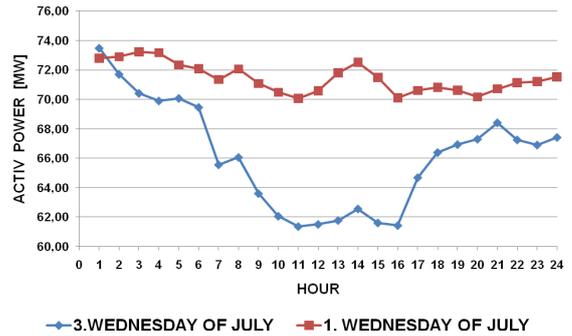


Figure 8. Daily load diagram in Company Z, July 2009

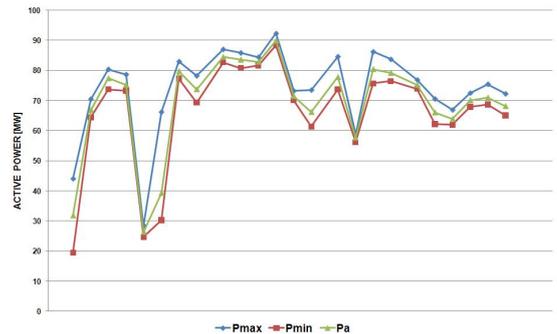


Figure 9. Annual load diagram in Company Z, 2009

As in Company X at day load is not regular. There is difference about 12 MW between max and minimum load (month July) but it should have positive influence on smoothing daily diagram for area, because characteristic is higher consumption at night (between 18:00 and 6:00) and lower during the day (between 6:00 and 18:00) (Fig. 8).

In company Z load diagram during the year is very irregular. There is difference about 11 MW between max and minimum load (month July). Annual load is between 19 MW and 92 MW. Minimal load (75% less than annual average load) is at the beginning of the year after Christmas (month January). Reduce of electricity consumption is also during holiday months (50% less than annual average load) and in March (65% less than annual average load). The maximum energy

consumption is before holiday at June (23% more than annual average load) (Fig. 9).

III. LOAD MODEL FOR WROCLAW AREA

Analyzed area uses 3% of total electricity consumption in Poland and 36% of Lower-Silesia area. Annual energy use is between 315 GWh and 718 GWh the most power-consuming months are: January, February, March, November and December that are cold season. Oscillations during the year weren't higher than 30% of annual average load (Fig. 10).

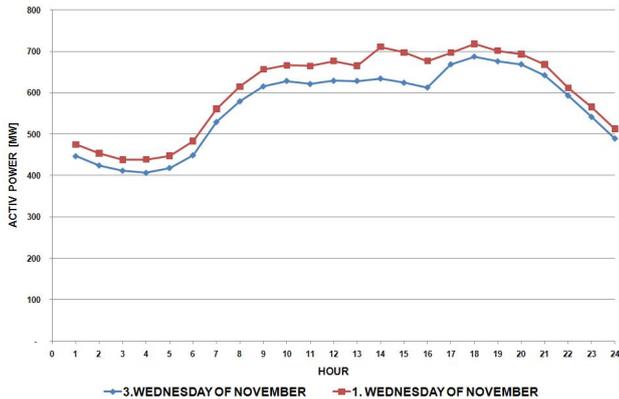


Figure 10. Daily load diagram for the area, 2009

More difference can be seen during observation of daily load diagram. Load is between 406 GW and 718 GW (month November). It means that oscillations during the day are higher than 50% of annual average load. There are characteristic pick hours (9:00-21:00) and off-pick hours (24:00-6:00). There is no well seen difference between morning and evening pick, the use is similar between 9:00 and 21:00 (600 GW-700 GW) (Fig. 11).

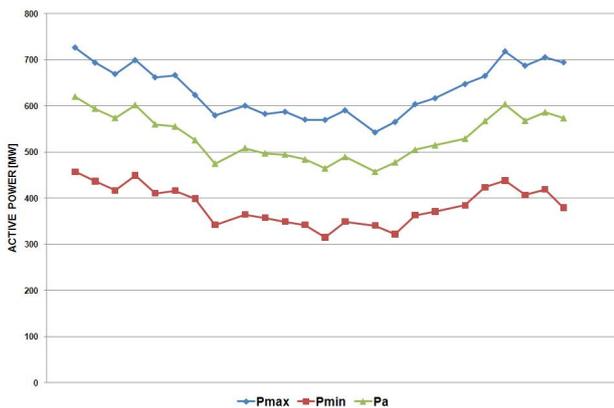


Figure 11. Annual load diagram for the area, 2009

A. Influence Companies X, Y, Z on analyzed area

Diagram on Fig. 12 shows average annual load curve for Wroclaw area. There is also shown how would look annual load curve like if companies X, Y, Z didn't work on this area.

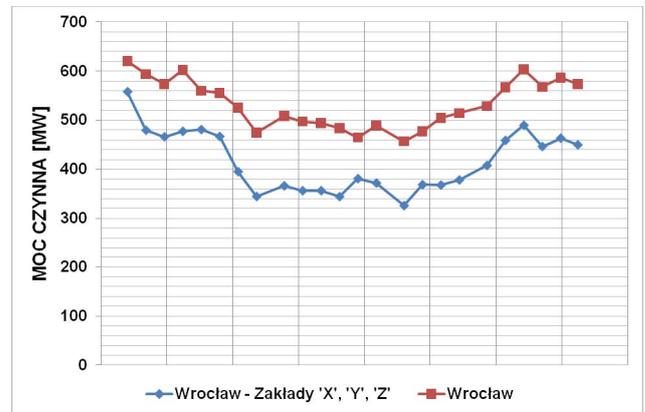


Figure 12. Annual load diagram for the area, 2009

Analyzed factories have a big influence on curves positions on diagrams created for Wroclaw area. Their common electricity consumption is 25% of use in area (Tab. 1).

Described companies also smooth load curves, what is well seen at the beginning of the year (between months January and March). They also have negative influence on smooth of load diagram especially at the end of the year (months October to December) and during the Holiday (months July and August). (Fig. 12)

Companies X and Z has positive influence on shape of daily load diagram because they raise it in night hours and lower at day hours, so they smooth difference between pick and off-pick hours. (Fig. 4, Fig. 8)

Factory Y can have negative influence on smooth of daily load diagram for the area, because it has higher electricity use at night than during the day. It would be advantageous for the Wroclaw area to decrease use between 7:00 and 14:00 and increase between 24:00 and 7:00. Lower use between 14:00 and 24:00 is profitable for the area and shouldn't be higher. (Fig. 6)

IV. SUMMARY

Load diagrams are good source of information about energy management. Because of them possible is assessment in macro (area) and micro (company) scale. Proper load analysis lets for assessment energy possibilities, economic management, finding incorrectness and shows opportunities of effective changes [6]. By suitable load diagrams analyzing in enterprises and National Power System can be reached savings. However it is possible only by effective encouragement for right consumers' behaviors [5,6].

In analyzed area load diagrams indicate possibilities of smoothing. Before moving changes there should be also made

analysis of costs, based on created diagrams and other data (specified for companies and area).

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