Research Journal of Applied Sciences 9 (11): 862-868, 2014
ISSN: 1815-932X

The Analysis of The Possibility of The Energy Management System Integration Inmunicipal Institutionsin Belgorod (Russia)

Kristina Januario Shirrime and Pavel Alekseevich Trubaev
Belgorod State Technological University Named after V.G. Shukhov,
308012 Belgorod, Street 46, Kostyukova, Russia

Abstract: This study presents analyzing of the energy sources consumption in municipal sector for the further application the energy management system in Belgorod facilities (Russia) or budget institutions and organizations to reduce the costs for the power resources demands. These energy demands take more than a half from the total households spending in every organization; therefore the priority spot today for management is how to increase energy efficiency on the factory level. The main keys to energy efficiency enhancement are the systematic analysis of municipal energy consumption, the application of innovative financing models and the implementation and subsequent supervision of energy efficiency projects. That is why, it is necessary to carry out ananalysisof the current situation in the budget sector in Belgorod region to understand how the energy management system can be adopted in Russian organizations in order to bring the same effect as it wasobserving in European countries and USA. This analysis is presented in this study.

Key words: Energy management, energy efficiency, energy savings, budget institutions, energy analysis

INTRODUCTION

For decades, it is known that the energy consumption can be reduced by 10-20% with the systematic introduction of a municipal energy management by means of low or non-investment measures. Savings of this magnitude are also economically interesting for the municipalities. Nevertheless, the systematic energy management is very slowly implemented in the municipalities (SEP, 2013).

Energy management is the proactive, organized and systematic coordination of procurement, conversion, distribution and use of energy to meet the requirements, taking into account environmental and economic objectives (GIZ, 2013).

Energy Management System (EnMS) allows to get information about energy efficiency within the organizations and regions and their branches and objects as well and to identify the bottlenecks and study of energy resources expenditure. All these make it possible to systematically minimize and optimize financial and other resource costs (Inovex, 2014).

According to experts, 10-20% of energy costs can be saved with low-and non-investment measures without sacrificing comfort. In compliance with the calculation example above this equates from 35,000-70,000 Euros a year. That is why, energy management system is considered as a high potential method for any type of the implementation area and should be analyzed in terms of Russian Federation.

METHODOLOGY

The presented methodology helps to reveal all the over-expenditures and bottlenecks in the existing distribution system of the energy resources. This information will be used in the future process of Energy Management System integration within the national organizations of all the types.

Basic part: To estimate the effectiveness of the energy management system implementation it is being considered the structure of energy consumption in Belgorod region. The structure of energy resources consumption within the Belgorod territory is presented in Fig. 1 and Table 1.

As can be seen from Fig. 1, the greatest amount of energy in the city is produced from the natural gas but due to its low cost in comparison with electric power, the largest expenses accounted for electricity.

For comparison of energy consumption, the energy balance of the city in terms of conditional fuel is presented in Fig. 2.

Corresponding Author: Kristina JanuarioShirrime, Belgorod State Technological University Named after V.G. Shukhov, 308012 Belgorod, Street 46, Kostyukova, Russia

Table 1: Energy consumption in the municipal institutions and organizations, Belgorod 2009

Names	Machinery of government	Education	Culture	Public health and social policy	Municipal unitary enterprise	Total according to the budget establishments	Total
The number of objects	21	129	34	63	164	247	411
The number of people							
Staff	1991	7460	821	5888	1919	16160	18079
Students (full time and							
half time day)	-/604	46410/-	-/5161	-	-	46410/5765	46410
Visitors	503968		790286	3141703	3760	4435957	4439717
Total square (m^2)	41370.6	421732.9	18252.1	148810.9	43237.7	630166.5	673404.2

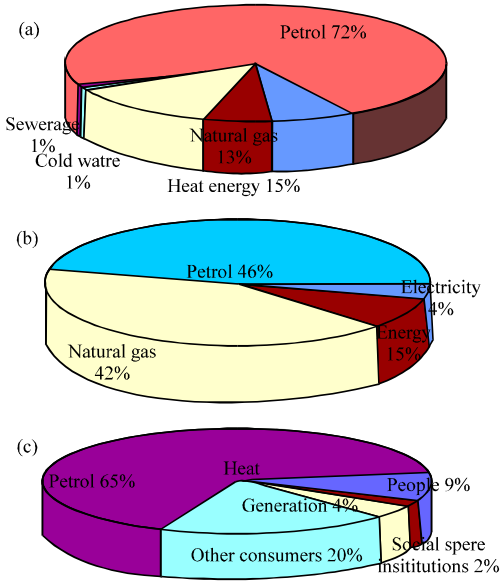

Fig. 1: Energy consumption structure of Belgorod City; a) the financial energy consumption structure in 2009 Belagorod; b) the energy consumption structure in 2009, Belgorod (in-equivalent fuel recalculation) and c) the financial energy consumption structure by the type of the consumers in 2009, Belorod

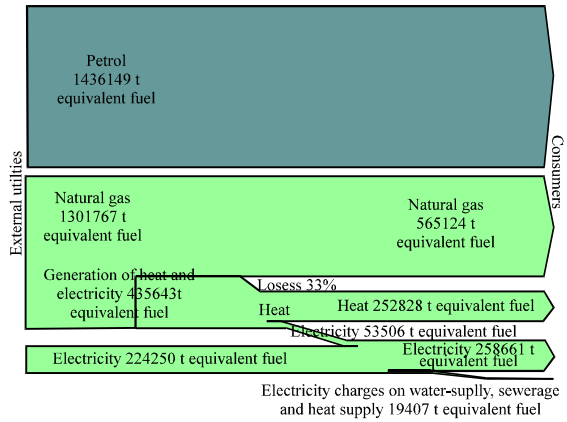

Fig. 2: Energy consumption of Belgorod City

From the Belgorod power consumption analysis, it can be concluded that the biggest energy consumption falls at motor fuel, heating and hot water supply and the biggest financial costs for motor fuel and electricity.

For the energy savings in Belgorod it were accepted the municipal property. From the direct control "other consumers" (business objects), the generation of energy resources, housing are dropped out (Bashmakov and Bashmakov, 2012)

MUNICIPAL INSTITUTIONS AND ORGANIZATIONS CHARACTERISTICS AND CONSUMPTION

Energy consumption in the municipal institutions and organizations of Belgorod in 2009 is presented in the Table 2. The share of municiple institutions and orgnizations in the structure of consumption of energy in Belgorored City is presented in Table 3. The structure of the costs for consumers and energy resources are shown in Fig. 3.

Large energy costs occur in Municipal Unitary Establishments (MUE) "Belgorod water channel" and MUE "Belgorod electric transport" (Fig. 4). In the budgetary organizations most of the money spends on the energy resources consumption. Thus, the main directions to decrease power consumption are following:

- Reduction of heating and hot water supply expenses in budgetary institutions
- Reduction of technological consumption in MUE "Belgorod water channel" and MUE "Belgorod electric transport"

As it can be seen from the analysis, heating and electricity takes most of the energy expenses. Several organizations consume almost the entire volume of energy resources. They are MUE Management "Belgorod accomplishment", Department of Education, Department of Health, municipal unitary enterprise "Belgorod water channel" and Municipal unitary establishments MUE "Belgorod electric transport". The other organization is a small contributor of the total energy consumption. Thus, it is more effective to reduce electricity and heat consumption for the heating and hot water supply in these five major consumers [6].

Table 2: Total energy consumption in 2009

Total energy consumption in 2009	Electricity		Heating		Hot water supply		Cold water		Sewerage		Natural gas	
thou.rub	Thou. (kW)	Thou. (rub)	Gkal	Thou. (rub)	Thou (m^3)	Thou. (rub)	Thou (m^3)	Thou. (rub)	Thou (m^3)	Thou. (rub)	Thou (m^3)	Thou. (rub)
37256.1	12715.97	25496.19	5198.08	6225.52	8.3	120.47	27.58	276.26	37.86	383.67	185.80	457.89
142820.09	9935.47	20467.06	56170.12	71583.20	731.35	37281.33	441.42	3866.31	904.31	8085.43	120.49	393.90
4323.2	454.75	914.80	2446.76	3118.20	1.63	107.6	4.54	48.50	5.74	58.10	45.60	152.00
59169.52	6387.43	12798.04	17316.80	21646.03	290.36	14829.42	227.98	3299.30	426.08	4637.90	148.68	481.49
181070.64	100942.53	173318.73	-	-	-	-	49.04	526.19	48.70	410.12	561.55	2099.04
243568.91	29493.62	59676.09	81131.76	102572.95	1031.64	52338.82	701.52	7490.37	1373.99	13165.10	500.57	1485.28
424639.55	130436.15	232994.82	81131.76	102572.95	1031.64	52338.82	750.56	8016.56	1422.69	13575.22	1062.12	3584.32

Table 3: The share of municipal institutions, organizations and apartment houses in the urban energy consumption

	In Belgorod energy utilities consumption (%)			In Belgorod energy utilities costs (%)		
Names	Municipal establishments and enterprises	Apartment houses	Total	Municipal establishments and enterprises	Apartment houses	Total
Electricity	5.8	12.2	18.0	3.8	12.2	16.1
Heating	7.3	74.0	81.3	7.3	17.0	81.3
Natural gas	0.1	13.5	13.6	0.1	13.5	13.6
Cold water	3.2	81.4	84.6	2.2	71.8	74.0
Seweregе	5.1	75.7	80.8	3.9	74.8	78.7

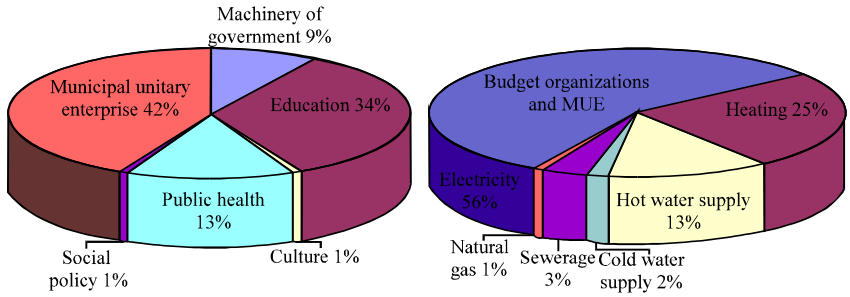

Fig. 3: Structure of energy resources costs

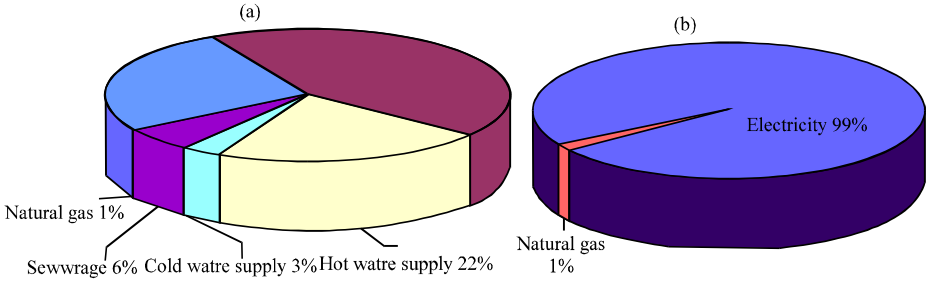

Fig. 4: Energy costs comparison structures in budgetary establishments and MUE; a) Budget organization and b) MUE

GENERAL CHARACTERISTICS OF EDUCATIONAL INSTITUTIONS

In Belgorod, there are 152 institutions with the total area rate at 421 733 m^2, including 46 schools, 64 Preschool Educational Establishments (PEE), 38 Institutions of Additional Education (IAE), 4 administrative units. In 2009, in institutions were working 7,460 employees and studying 4,6410 pupils (Fig. 5).

During the year, all educational institutions consumed energy resources in the amount of 142,82 million rubles (in 2009 year prices). The structure of the energy costs is presented on the Fig. 6 and 7.

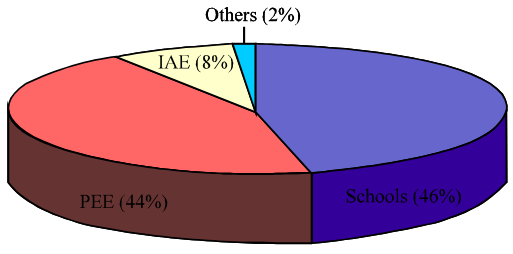

Fig. 5: The sub divisions energy costs

As can be seen from the results of the analysis, heating and hot water supply takes the main part of

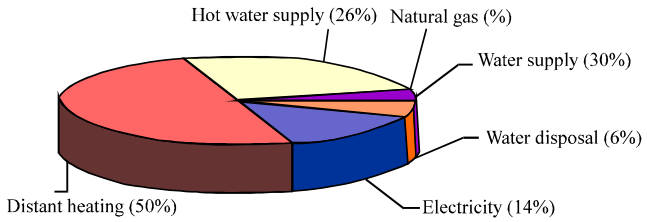

Fig. 6: Types energy costs

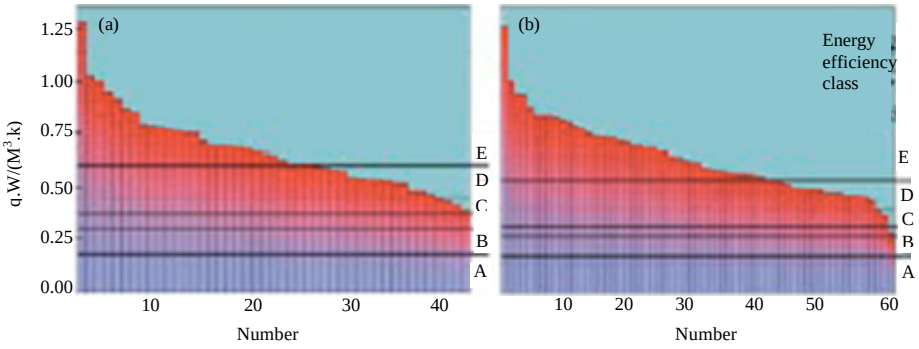

Fig. 7: Belgorod buildingsranking of educational institutions in energy efficiency order; a) school and b) PEE

energy costs (75%). The majority of the education objects were built 20-30 years ago, when the energy resources were very cheap (Podgornyy, 2007). Therefore, at that time improvement the thermal protection of the buildings was simply not economically profitable. Here it is an express-assessment of the educational institutions efficiency in Belgorod, produced according to the annual consumption of the heat (Fig. 7). The specific index is determined as follows:

$$q = 106 \cdot Q / (4183 \cdot S \cdot h)$$

Where:

Q = The heat consumption during year (GJ)
S = Area (m^2)
h = Average height of a floor (m)

According to the results of the analysis more than a half of the buildings belong to the lowest energy efficiency class groups E and the rest to the class of low efficiency which is group D. Currently, the majority of the buildings hasheat lossesthat associated with factors:

- Unsatisfactory state of thebuilding thermal contour (windows and doors)
- Poor ventilation
- Non-regulated heating load that leading to a considerable excess temperature in buildings relatively to the normative and as a result-expenditures of heating energy

ASSESSMENT OF EFFICIENCY AND SAVINGS POTENTIAL

For the analysis of the actual energy resources consumption there were selected institutions which are supplied with metering devices of all energy resources types with defined indicators of the efficiency that is the specific energy consumption (Table 4).

It was estimated the correlation coefficient between energy efficiency indicators and institutions characteristics (the area of buildings, the number of people there, the new window quota (Table 5). There is an inverse relationship between the consumption of thermal energy and the area and number of people, so as between electricity consumption and the amount of people (Konev, 2012). Thus, the larger institutions have greater energy efficiency.

For the total energy costs comparison it was used the estimation rating systems of R:

$$R = \Sigma d \cdot e / e_{av}$$

Where:

d_i = The share of energy in total amount of expenditures
e = Specific consumption of energy resource;
e_{av} = Average consumption of energy resource for all institutions which included in the selection

Table 4: Energy efficiency indicator

Index	Surface (m^2)	Number of employees and pupils (pers.)	Part of modernized window blocks	Thermal energy (J/m^2)	Electric energy (kW*h/pers)	Cold water (m^3/pers)
Schools (20 institutions)						
Total	124693	15149	-	-	-	-
Average	6235	757	12.0	0.59	143.15	7.08
Minimum	1023.6	212	0.0	0.42	69.57	3.78
Maximum	9904	1658	51.3	1.3	286.13	17.33
Preschool educational establishments (34 institutions)						
Total	158536	18370	-	-	-	-
Average	3373	391	10.0	1.09	256.55	11.55
Minimum	947.8	156	0.0	0.42	108.44	3.78
Maximum	9904	1658	57.4	1.51	366.76	21.88
Sum total						
Total	204704	24602	-	-	-	-
Average	3791	456	12.0	0.79	186.72	8.80
Minimum	947.8	156	0.0	0.42	69.57	3.78
Maximum	9904	1658	57.4	1.51	366.76	21.88

Table 5: Correlation parameters

	Energy efficiency indicators		
Parameters	Heat energy	Electric power	Cold water
Surface	-0.80	-0.60	-0.32
No. of employees and pupils	-0.66	-0.68	-0.30
Part of modernized window blocks	-0.09	-0.15	0.01
Heat energy efficiency consumption indicator	-	0.45	0.33
Electric energy efficiency power indicator	-	-	0.33

The ranked calculation results of indicator R is represented in the Table 4. As it can be seen from Table 5, the total energy efficiency of different institutions may differ in three times.

To calculate the potential economy E, it was used deviation of energy efficiency indicators from regulatory or average value:

$$E = \Sigma C \cdot X \cdot (e - e_{av}), \text{ for } e > e_{av}$$

Where:

C = The cost per unit of energy resource

X = The indicator used to calculate the specific consumption (area or number of people)

Potential savings in average is 13% for different institutions it may be up to 40%. For large institutions, it is insignificant but the dependencies between the annual energy costs and potential savings does not exist (Nuzhen, 2012).

Thus to determine the optimal structure of investment in energy saving measures to achieve the greatest energy savings, it is required a differentiated approach that takes into account individual performance of each institution.

THEANALYSIS OF THE POWER CONSUMPTION IN BELGOROD INSTITUTIONS

For more detailed analysis the objects were divided into the categories:

- Pre-school institutions (kindergartens), herein after PEE
- Municipal educational institutions (schools), herein after MEI
- Institutions with partial or full accommodation (houses, boarding schools, nursing homes)
- Institution of the administrative type (administration)

Based on the analysis, it is revealed that the structural type institutions have a significant impact on its energy usage. The total consumption of electricity can be divided into two types (Vinogradov *et al*., 2011; Kushchev and Dronova, 2011):

- Consumption for lighting (internal, external)
- Household consumption (office equipment, computers, household appliances, air conditioner)

Figure 8 shows the average distribution of energy consumption for each type of the institutions. As it can be seen from the diagrams, the prevailing share of electricity consumption varies depending on the kind of institution. Thus, in the kindergartens and institutions with a temporary or permanent accommodation the basis of consumption equals: Household equipment (63 and 55%, respectively). In school educational establishments, it is lightning (54%) and in the administrative purposes buildings-office equipment (51%).

Dividing the electricity cost for the internal and external lighting is caused by working specificity of institutions (Fig. 9).

Table 6: Energy efficiency parameters

Type of organization	Specific quantity of luminaires		Specific capacity of luminaires for 1000 m^2	Annual costs of electricity for lighting. (thous. rub.)	
	For 1000 m^2	Per person		Per person	For 1000 m^2
PEE	137	5.3	6.2	0.235	11.6
MEI	181	0.6	6.8	0.054	31.2
Boarding houses	156	4.8	6.0	0.182	39.0
Administrations	987	14.2	29.6	0.426	115.3

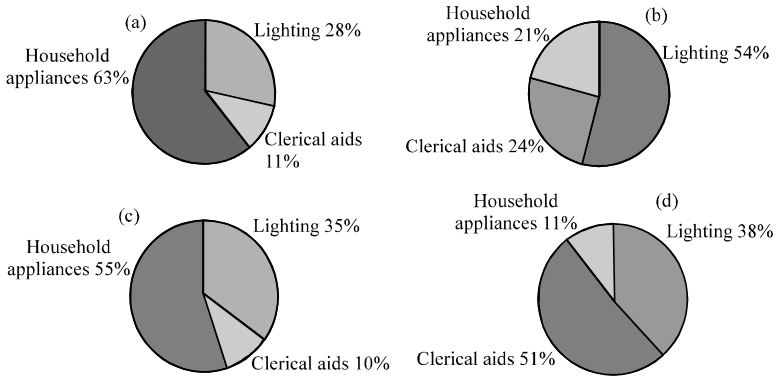

Fig. 8: The structure of electricity consumption in institutions of different types; a) PEE, b) MEI, c) Boarding houses and d) Administration

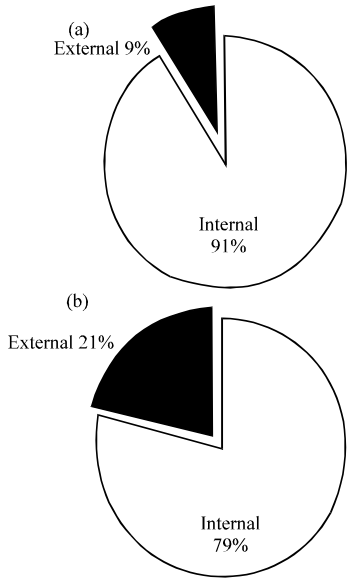

Fig. 9: The structure of electricity consumption for lighting; a) educational insititution and b) administrations

The data demonstrate that municipal educational institution in comparison with the administrative institutions have not so much adjoining territories which requires additional lighting and spend 9 and 21% of the total electricity consumption, respectively. Along with internal lighting the outdoor lighting adds a significant

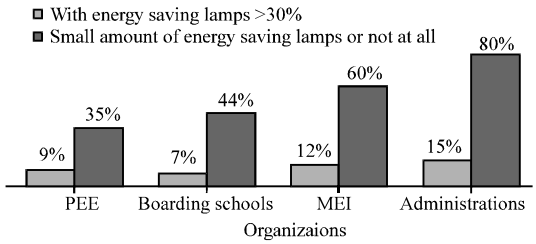

Fig. 10: The share of the electricity consumption for lighting if there are energy saving lamps, orits absence in municipal offices

share in the total consumption of electricity. More clearly, it is reflected in the structures of the administrative direction.

It should be noted that type of the fixed lamps plays an essential role. The presence of energy-saving lamps saves about 70% from the expenditures on electricity lighting (Fig. 10).

On the basis of the actual data there were calculated the coefficients (Table 6) which describes area and number of people per one luminaire. This indicator shows the covering area by one unit of luminaire for different objects.

SUMMARY

The study presents the rating of energy efficiency in Belgorod organizations. The srudy presents the diagrams

of the structural type consumptions, on the basis of the conducted analysis of the municipal objects as well as the indicators of energy-efficiency. It was made the conclusion that:

- The total energy efficiency of various institutions may differ more than in three times
- Larger institutions have greater energy efficiency
- It is shown that for determining the optimal structure of investment in energy saving measures for the greatest energy savings achievement it is required a differentiated approach taking into account individual performance of each individual institution

Also it was presented the rating of the total energy costs, potential savings and energy analysis in the budget institutions.

CONCLUSION

It is significant to note that current situation with the energy consumption in municipal sector is very unacceptable. The over expenditureof public utilities due to underinvestment leads to significant process costs, rising of the production value and deterioration of enterprise competitiveness.

That is why, it was it was necessary to make this research for the purpose of determination the possible ways for integration the energy management system in Belgorod region. And it was shown on the diagrams that municipal unit enterprises takes 42% from the total energy consumptions, educational institutions takes 34% and health authorities and machinery of government takes 13 and 9% accordingly. As for the power resources costs, the biggest parts are taken by the heating and electricity, 43 and 25% correspondently.

Also, it should be said that there is a wide variance between institutions and organizations in its energy consumptions volume and structure. Therefore, for there evaluation it is necessary to apply a differentiated approach.

REFERENCES

GIZ., 2013. Introduction to municipal energy management. Deutsche Gesellschaft fur Internationalle Zusammenarbeit (GIZ) GmbH, June 18, 2013. http://www.sustainable-energybih.org/wp-content/uploads/2013/07/Introduction-to-EnMS-in-Municipalities.pdf.

Inovex, 2014. Energy and environmental management system. http://www.inovex.ca/products/energy-environmental-management-system/.

SEP., 2013. Municipal energy management. North Sea-Sustainable Energy Planning, Berlin, Germany. http://www.northsearegion.eu/files/repository/20131128181836_Municipal_Energy_Management_Infoletter.pdf.