# Modern energy challenges: economic and managerial approach

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Content

Vorwort / Introduction……………………………………………………………..3

1. Energy efficiency challenges: international and Ukrainian context……………..4
1.1. State & trends in global energy sector……………………………….4
1.2. Ukrainian energy sector: features and indicators…………………..7
1.3. Comparable energy efficiency ………………………………..11
2. Energy controlling challenges………………………………………………..16
2.1. Energy controlling vs energy management……………………..16
2.2. Development and implementation of energy controlling tools…21
3. Practical challenges of energy efficiency and sustainability: implementation of energy controlling……………………………………………………………31
3.1. Energy sustainability as an objective of implementation of energy controlling ……………………………………………………………….31
3.1.1. Determination of the sustainability level in energy systems of educational organizations. Case of Rozdilna district in Odessa region, Ukraine…………………………………………………………31
3.1.2. Organization of energy controlling in the district management structure…………………………………………………………….41
3.1.3. Ways to improve the sustainability level of energy system…….51
3.2. Usage of energy controlling tools in industrial enterprise. Case of “ODESKABEL” PJSC…………………………………………………….55

## Vorwort

Derzeit stellt der Energiesektor die Menschheit vor lokale und globale Probleme. Die Antworten auf jene Probleme finden wir in den verschiedensten Sphären menschlicher Aktivität und wissenschaftlicher Gedanken. Natürlich denkt man hierbei zuerst an die Bereiche der Technik und Technologie, aber auch andere wissenschaftliche Bereiche sind nicht weniger wichtig und können ihren Teil zum übergeordneten Ziel, der Verbesserung des existierenden Energiesystems, beitragen. Wenn es um Energieeffizienz geht, sind die Wirtschaftswissenschaften mit einer Vielzahl von Ansätzen sehr hilfreich. Somit sehen sich Manager täglich mit Herausforderungen der Energiethematik konfrontiert und fällen Entscheidungen in den Bereichen der Energieeffizienz, der Energiesicherheit und Energiespeicherung. Ihr Verständnis der Energieherausforderungen definiert Energiepolitik und die strategische Organisation des Energiesystems. Die Vorgehensweise und ihre Entscheidungen sind notwendig, um jegliche technische Ideen in die Praxis umzusetzen. Daher bedeutet ein Managementansatz für Energieherausforderungen Planung und Kontrolle, um die Effizienz der Energiekosten, die Energiesicherheit und ein erforderliches Maß an Energieeinsparung zu gewährleisten. Energiecontrolling ist eine relativ neue Dimension in Controllingkonzepten und in der ökomischen Theorie. Die Aufgaben der Controllingsysteme wie Planung, Effizienzverbesserung, Transparenz, Kontrolle und Optimierung lassen sich übertragen in die Sektoren des Energiesystems, angefangen von kleinen, lokalen Familienbetreibern bis hin zu regionalen und nationalen Strukturen, Diese Ausgabe widmet sich den Energiesektor betreffenden Herausforderungen, mit denen die Ukraine derzeit im Zusammenhang mit globalen Prozessen im Energiesektor konfrontiert wird. Im ersten Teil wird ein Vergleich von Trends des ukrainischen und globalen Energiesektor gezogen sowie die Analyse vergleichbarer Energieeffizienz untersucht. Der zweite Teil umfasst das Energiemanagement mit speziellem Fokus auf das Energiecontrolling. Der dritte Teil enthält Fallstudien über die Einführung von Energiecontrollingsystemen in privatwirtschaftlichen und öffentlichen Organisationen.

## Introduction

Current energy sector challenges locally and globally. Solutions are to be found in different spheres of human activity and scientific thoughts. Of course, first of all this is about technique and technology, but other sciences are not less important and are able to contribute the common goal to improve the existing energy system. If it concerns energy efficiency, the economic sciences are very useful and have a big variety of tools and approaches to increase it. Thus, managers face energy challenges and try to operate with energy efficiency, energy security, and energy saving on their level of decision making. Their way to understand energy challenges defines energy policy and energy strategy of organization. Their actions and decisions are needed to implement any technical idea into practice. Therefore managerial approach to energy challenges means managerial control and incorporation of energy issues to guarantee the efficiency of energy costs, energy security of organization and a needed level of energy saving. Energy controlling is a relatively new dimension in controlling concept and economic sciences. As far as controlling system is to provide efficiency, transparency, optimality, controllability and so on into organization, energy controlling is to provide the same into energy system on any economic level – starting from small company and till national or regional structures. Obviously it can enrich the managerial approach by performance evaluation, constant monitoring and visualization, as well as by promoting processes of digitalization into organization. This issue is dedicated to energy challenges that Ukraine currently faces in context of global processes in energy sector. So, in the first chapter there is comparison of trends in Ukrainian and global energy sector, as well as the analysis of comparable energy efficiency. The second chapter covers energy management and energy controlling with the special focus on the last one. The third part includes practical cases of implementation of energy controlling in commercial and public organizations. Addressees of the study are foremost scholars in energy management and controlling, as well as in international management since it gives a few case studies from Ukraine. It can also add value for practitioners by promoting managerial tools and instruments for controlling of energy efficiency.

# 1. ENERGY EFFICIENCY CHALLENGES: INTERNATIONAL AND UKRAINIAN CONTEXT

## 1.1. State & trends in global energy sector

Energy plays an important role in human activity. Energy services are essential for labor productivity, health-care systems, education, climate change, food and water safety as well as communication services. Access to energy sources guarantees improvements of the well-being of society. Nearly all processes of enterprise activities are related to energy use. It is clear that in these terms growth of industrial outputs requires that the state and legal entities seek to more environmentally friendly, cheap and reliable energy sources.

The high rates of production in the early 21st century are accompanied by quality changes in energy sector development. The increased demand for fuel and energy makes it necessary to involve an increasing demand of energy resources in the economic processes. Their inefficient usage, depletion of their sources and high pollution jeopardize the future development of humanity. In accordance with this, modern businesses should not only take care of their profitability, but take responsibility for the results of their activity to the society.

World energy consumption has been rising over the years. According to BP-Global it is possible to observe the trends in the world primary energy consumption within the period from 1965 to 2017 (Figure 1.1).

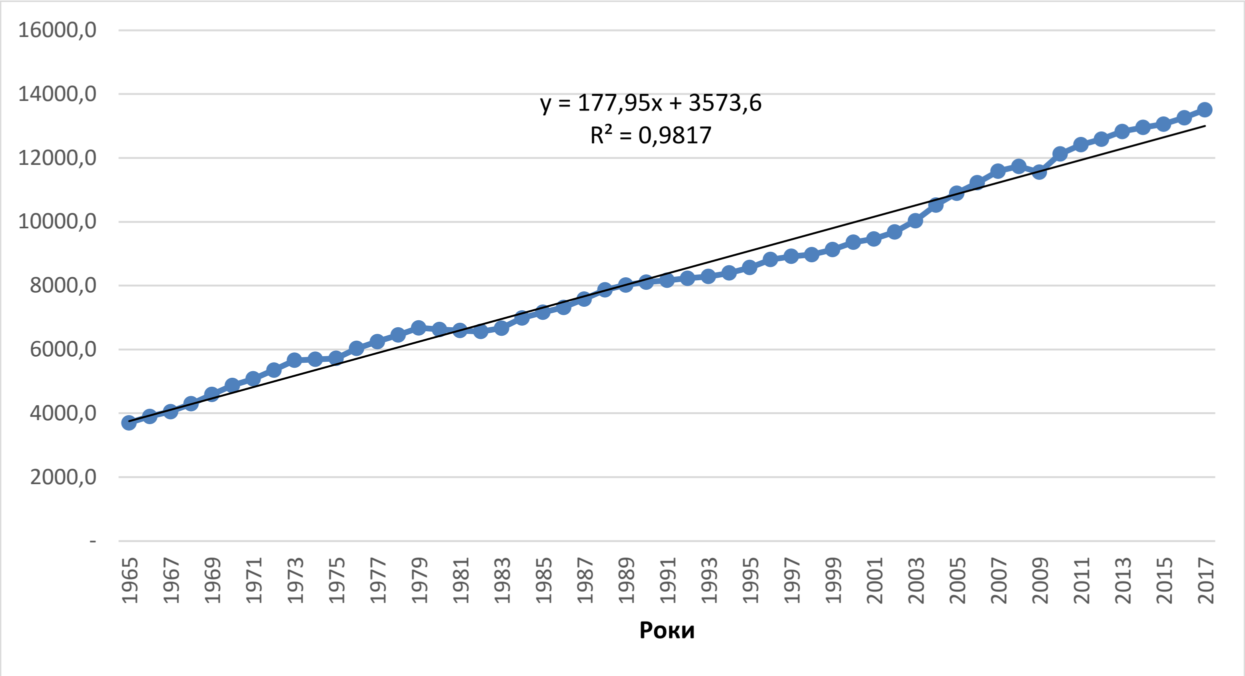



Fig. 1.1 – World primary energy consumption within the period from 1965-2017, mtoe.

Source: built on data of Beyond Petroleum [1]

As shown in figure 1.1, primary energy consumption in the world is increasing constantly within the period from 1965 to 2017. Only during the period from 1979 to

1981 there was a slight decline in primary energy consumption. In 2017 it counted 13511.2 mtoe, e.g. on 252.7 mtoe or 1.9 % more than in 2016 and comparing to 1965 - 9809.6 mtoe or 265 % more. Therefore, over the half of the century primary energy consumption in the world has been increasing by 2.5 % per year on average and has increased by more than 3.5 times.

Furthermore, looking at the structure of energy consumption in 2017 (Figure 1.2) it could be noticed that the largest share of consumed energy is fossil, namely oil (34.2 %), coal (27.6 %) and natural gas (23.4 %). The share of renewables in the world is only 3.6 % of the total energy consumption; in EU their share is slightly higher and accounts for 9 % of total energy consumption (Figure 1.3).

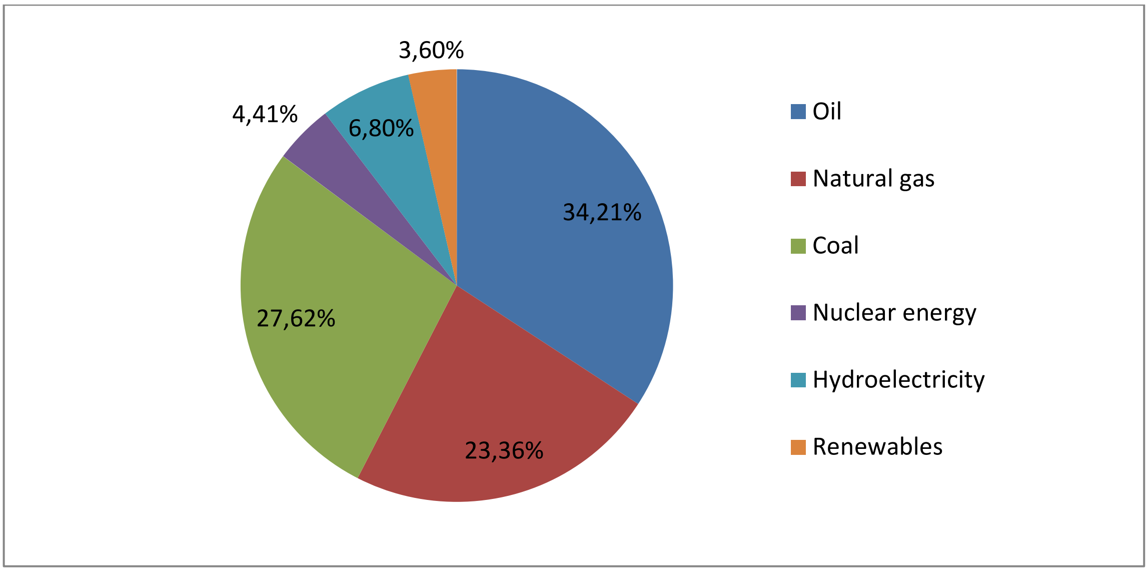



Fig. 1.2 – Primary energy consumption structure by sources globally in 2017, %.
Source: built on data of Beyond Petroleum [1]

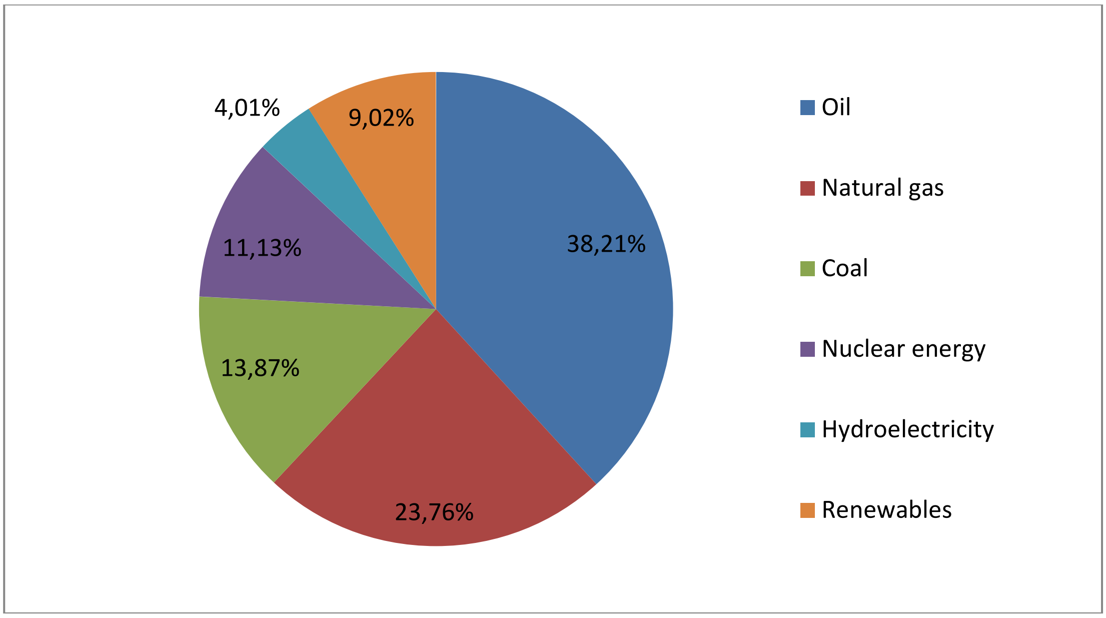



Fig. 1.3 – Primary energy consumption structure by sources in EU in 2017, %.
Source: built on data of Beyond Petroleum [1]

Let's determine main trends in global energy sector in 2017:

1. There is a significant growth of primary energy consumption, especially through natural gas and renewable usage. At the same time the share of coal in total energy consumption continues to decline. Energy consumption in China has increased by 3.1 % in 2017. For 17 years China remains the largest energy consumer.

2. Growth in energy consumption has lead to the growth of greenhouse gas emission. Carbon emission from energy consumption has increased by 1.6 % after little or no growth for the three years from 2014 to 2016.

3. Oil price has shown annual increase from $43.73 to $54.19 per barrel for the first time since 2012. The growth of oil production has slowed down. World oil consumption rose by 1.4 % compared to the previous year.

4. Natural gas consumption rose by 96 billion cubic meters (bcm), or 3% that is the largest growth since 2010. The main consumers were China, the Middle East and Europe. Global natural gas production increased by 131 bcm or 4 %; Russia and Iran showed the largest growth (46 bcm and 21 bcm, respectively).

5. Coal consumption rose by 25 mtoe or 1 %. That increase has been observed for the first time since 2013. However, coal's share in total primary energy fell to 27.6 %, the lowest since 2004.

6. Renewables usage grew by 17 %, which is the largest increment on record. Wind generation provided this growth more than by 50 %. Solar energy contributed 21 % of total consumption. The growth of hydroelectricity slowed down compared to 10-years average 2.9 %, and rose by just 0.9% in 2017. Global nuclear generation rose by 1.1 % [2, p.2].

Identifying the key features of 2017, it was noticed in the report [3] that this period showed the growth in energy consumption, however, at the same time the increase in world GDP has resulted in certain energy efficiency increase. Therefore world energy took "two steps forward and one step back" [3, p.4].

Therefore, humanity is facing the challenges related to the current trends of energy development. Firstly, energy resources consumption is constantly growing, in particular through the fossil fuel. Secondly, the structure of energy consumption remains unbalanced, namely the share of renewable in the total primary energy consumption is lowest. Increase in usage of fossil fuels leads to intensification of environmental problems that has a negative impact on climate change and human well-being.

## 1.2. Ukrainian energy sector: features and indicators

Having analyzed the state of Ukrainian energy sector during the period from 2008 to 2017, it is worth mentioning that unlike worldwide trends, energy consumption in Ukraine is shrinking (Fig. 1.4).

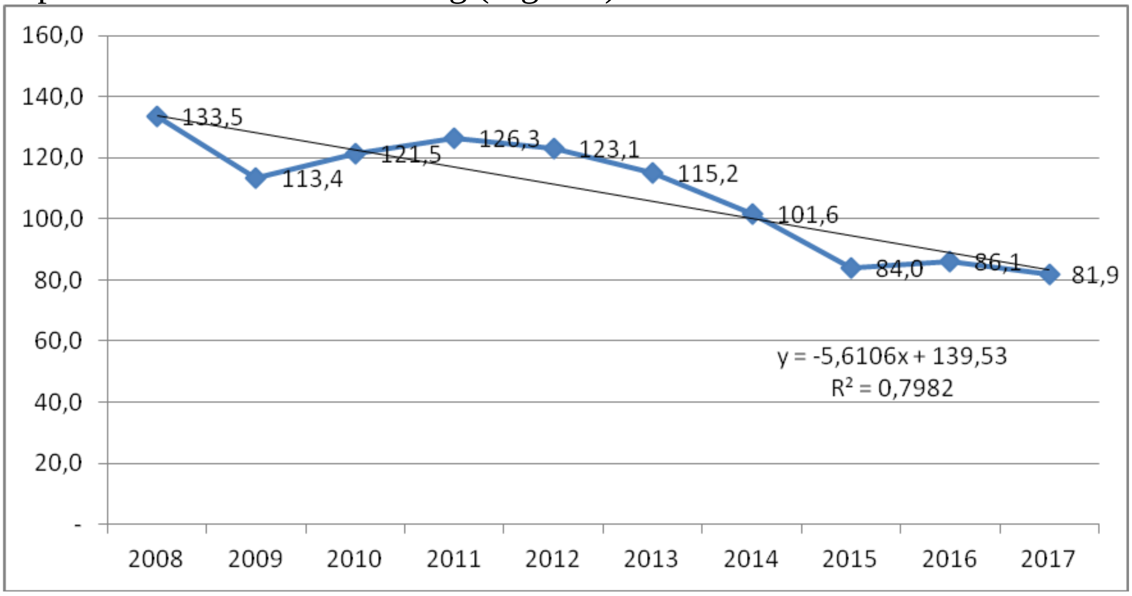



Fig. 1.4 – Primary energy consumption in Ukraine within the period from 2008-2017, mtoe.

Source: based on [2]

As you can see from Figure 1.4, there was a slight increase in primary energy consumption only in 2010, 2011 and 2016 in comparison with previous years by 8.1 mtoe (7.1%), 4.8 mtoe (4.0 %) and 2.0 mtoe (2.4 %) respectively. For the other years, there was a reduction in the primary energy consumption. This indicator dropped by 51.6 mtoe or 38.7 % in 2017 as compared with 2008. However this was not the result of energy efficiency improvement.

Analysis of the structure of primary energy consumption in Ukraine in 2017 (Fig. 1.5) highlights that natural gas and coal, which are fossil energy resources, make up the largest shares in total energy resources (31.27 % and 30.03 % respectively). Renewables represents the lowest share of total energy consumption (0.48 %).

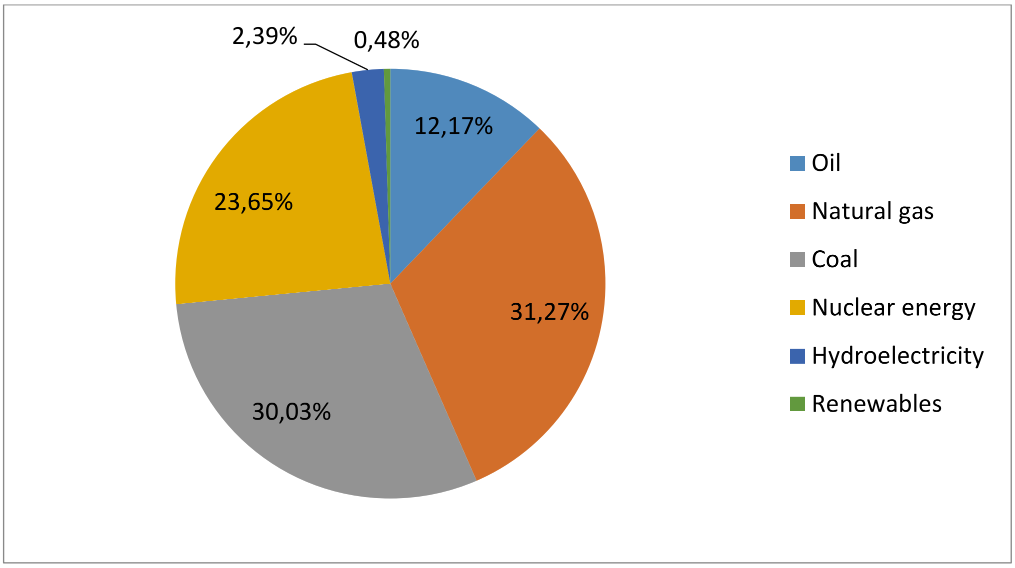



Fig. 1.5 – Primary energy consumption structure by sources in Ukraine in 2017, %.
Source: based on [1]

The main indicator, which reflects efficiency of energy using in national economy, is energy intensity. It can be calculated as units of energy per unit of GDP.

World energy intensity over the last decade (2008-2017) was analyzed. The dynamics of this indicator can be seen in Figure 1.6.

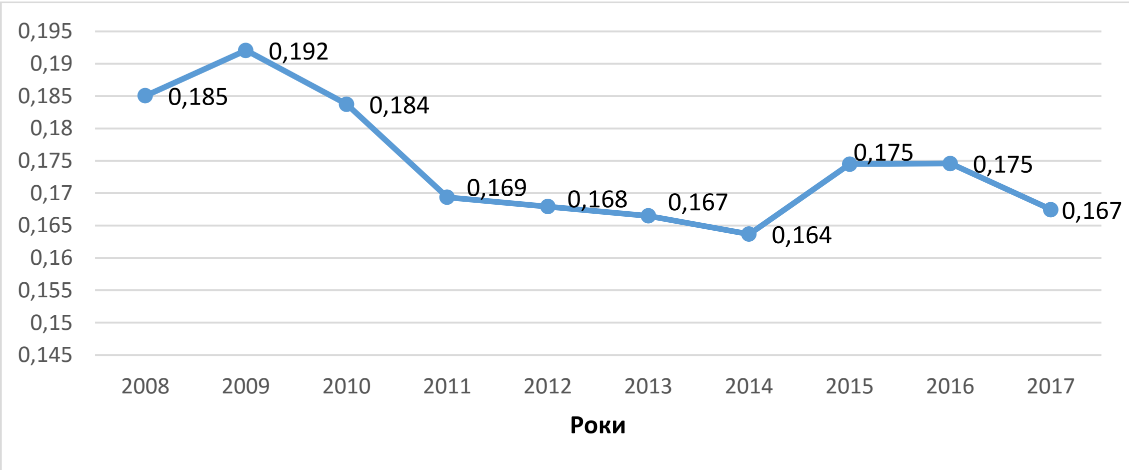



Fig. 1.6 – World energy intensity within the period from 2008 to 2017, kg of oil equivalent / $
Source: based on [1] and [4]

As you can see from Figure 1.6, the average level of energy intensity in the world has been gradually declining over the past ten years, although this dynamics is uneven. There was an increase by 0.011 kg of oil equivalent/$ (6.7 %) in 2015 in comparison with 2014. In 2017 this indicator fell to 0.167 kg of oil equivalent/$ (by 0.08 kg of oil equivalent/$ or 4.6 %. Countries of the former USSR, South Africa, Taiwan and Iran have the highest level of energy intensity in the world. EU countries have the lowest level of this indicator.

Ukraine remains one of the countries, in which energy intensity is considerably higher than in EU countries (Fig.1.7).

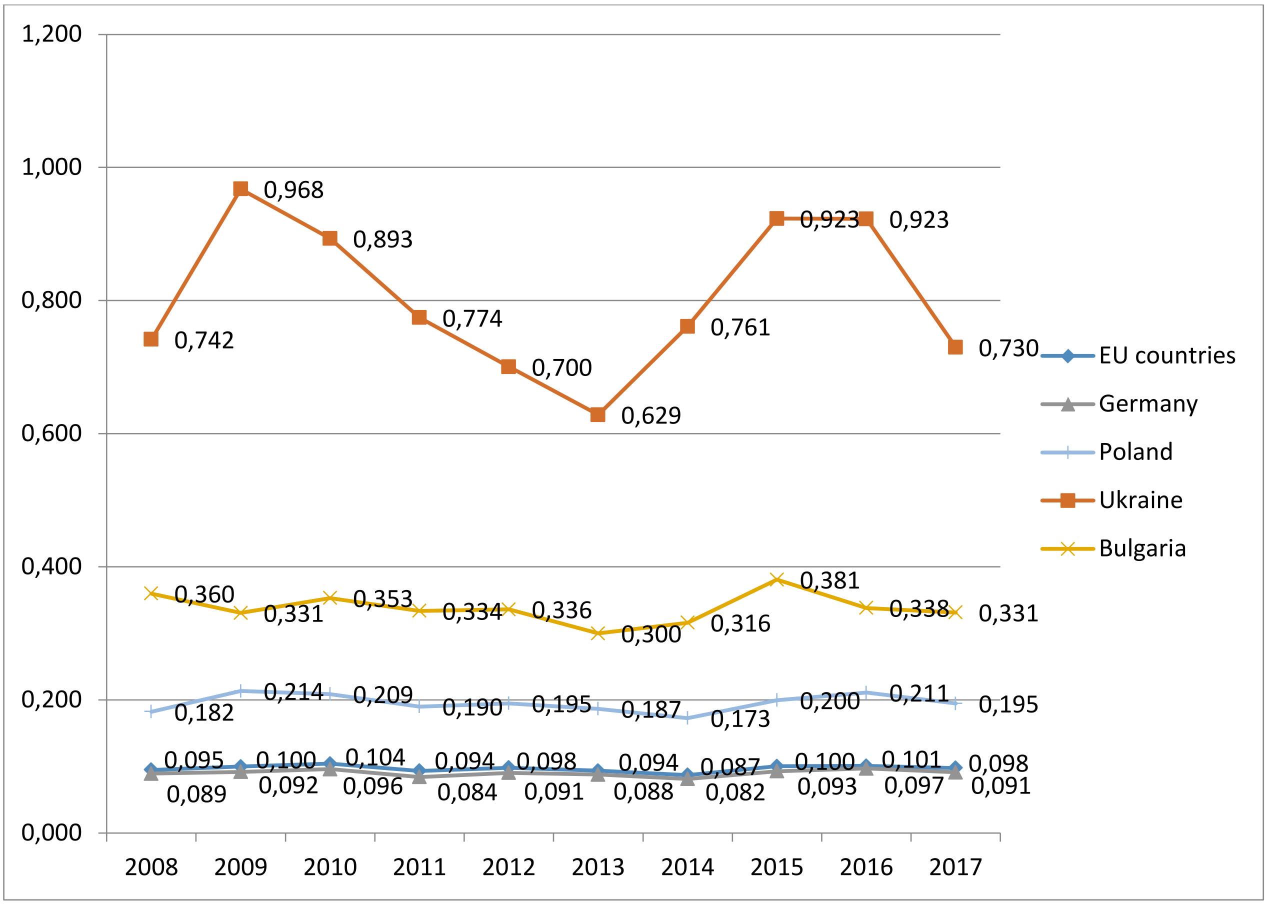



Fig. 1.7 – Energy intensity in Ukraine and EU countries within the period from 2008 to 2017, kg of oil equivalent / $
Source: based on [1] and [4]

Among the countries of the European Union, Bulgaria has the highest level of energy intensity. However, Ukraine has even worse situation as its energy intensity was more than twice the Bulgarian indicator.

Germany, for its part, is one of the leaders in energy intensity in the EU and in the world. Its energy intensity was 0.091 kg of oil equivalent / $ in 2017, that is by 87.5 % less than in Ukraine, by 45.5 % less than in the world and by 7.1 % less than on average in the EU countries.

Therefore the state of Ukrainian energy system and its low energy efficiency threaten Ukrainian energy, economic and national safety that is formed within the European Union, since energy resource endowment is insufficient.

This situation is compounded by a number of other challenges. Among other things, there is a lack of cohesion in Ukrainian legislative basis on issues related to energy efficiency. For example, so far more than 250 legal and regulatory instruments are operating, however, the amount of successful projects in this area remains low.

The main consumers of energy resources are industry and utilities and residential sector. Obsolete and ineffective equipment use in technological processes leads to energy loss, production cost increase and, therefore, reduces competitiveness of domestic products in the world market. With regards to housing facilities, there is a present need of thermo-modernization of buildings that would allow to reduce energy consumption for household needs.

Ukraine has quite enough energy resources. Natural gas exploitable reserves account for 452.8 billion cubic metres. There are 269 out of 402 deposits of hydrocarbons in the industrial exploitation. In all, 905.6 billion cubic metres of all reserves (68.9 %) have been extracted. Thus, proven natural gas reserves are enough for 22 years, if progress is maintained (about 20.5 billion cubic metres annually) [5].

Despite the fact that Ukraine has significant reserves of oil, natural gas, coal and shale gas, it is an energy-deficient country. Moreover, most of the deposits are on their final stage of exploitation [6]. This necessitates structural transformation of Ukrainian energy sector, implementation of energy efficient technologies and transition to renewable.

The main consumer of energy resources in Ukraine is industrial sector that used 71.2 % of total consumed thermal energy (41927489 Gcal) and 75.2 % (67365227 thousand kWh) of total consumed electricity in 2017.

At the same time, the problem of efficient use of resources concerns not only creation and implementation of energy saving technologies in industrial enterprises, but also non-profit organizations of public sector, among which educational establishments.

Today problems of Ukrainian energy sector can be solved by means of implementation of renewables, as Ukraine has at its disposal the significant potential of them. Enterprise energy sector could use such equipment as wind generators, solar collectors, heat pumps of different types, as well as boilers that operate on bio-fuel. Their application is interesting in relation to their economical effectiveness in operation and reducing the negative impacts on the environment.

However, the race of renewable implementation remains rather slow. This is due to inertia of energy sector as a whole, which is caused by “path dependence”.

Firstly, this sector is centralized enough, due to the fact that most consumers are connected to the general energy network. Secondly, the structure of energy balance is a result of available resource and economic potential, political choice and history. As a result of keeping set direction of the development the pressure on the fossil energy resources is magnified, the unsustainable basis for the future economic development is formed. Supporting of renewable energy and decentralization of energy supply can form the new way of more efficient energy use. Thus, formed sustainable energy sector will contribute to sustainable development of the country.

## 1.3. Comparable energy efficiency

In order to estimate effectiveness of the energy resources use, the indicators of energy efficiency are used. Energy efficiency is using less energy for providing target level of useful effect at home and technological processes of production.

Concept of energy efficiency is broader than technological renovation and "includes minimization of costs and inconsistencies in comparative triad of costs "energy – labor – capital" in all forms and levels of their transformation" [7, p. 16].

This means that understanding of energy efficiency can be changed under different socio-economic conditions and from various industrial angles. This is reflected in quantitative indicators of energy efficiency level. In interdisciplinary researches on energy efficiency multi-vectoral nature of the concept of energy efficiency is determined and different indicators are used for its level identification [8, p. 64-65]. Table 1.1 brings together the most common approaches of energy efficiency level identification from different branches of science.

Table 1.1 – Indicators of energy efficiency in different science

| Branch of science | Indicators |
|---|---|
| Technical sciences | $\mathrm{EE} = \frac{Energy\ output}{Energy\ input}$<br><br>$\mathrm{EE} = \frac{Reduced\ energy\ consumption}{Basic\ energy\ consumption}$ |
| Economic sciences | $\mathrm{EE} = \frac{GDP}{Energy\ consumption}$<br><br>$\mathrm{EE} = \frac{Production\ volume}{Energy\ costs}$ |
| Social sciences | $\mathrm{EE} = \frac{Available\ energy}{Energy\ need}$ |

In technical sciences for modern technologies or for equipment replacement energy efficiency is calculated as a ratio of reduced energy consumption to Basic energy consumption. In energy audit energy efficiency is calculated as a ratio of useful energy to total or normative (for instance, in construction) energy consumption. This means that in this case it can be interpreted as coefficient of useful energy efficiency. Indeed, the less energy consumption, the more proportion of useful energy and the higher energy efficiency. Reduction of energy loss in power grid, that is an increase of coefficient of useful energy efficiency, is one of the aims of EU Energy Efficiency Directive [9]. From a social perspective it is estimated meeting the demand for energy and level of energy efficiency is interpreted as a ratio of energy required for meeting the demand for it. This ultimately boils down to identification of amount of energy and the mobility of appropriate services. That is why an increase in the efficiency of energy resources consumption includes using less amount of energy for the same level of service. From the viewpoint of ecologists it is necessary to estimate the influence of production and energy consumption on the environment. It is proposed to compare the coefficient of average level of destructive influence on the environment under different conditions and in the dynamics, as well as coefficient of the intensity of energy contamination, as indicators of qualitative estimation.

In economics energy efficiency is often considered as inverse measure of energy intensity. Energy intensity can be measured by indicators of energy intensity of GDP, which is energy consumption per unit of GDP, or energy efficiency per capita, on the sectoral level it is the consumption of primary energy per unit of output [10, p.3].

The concept of energy intensity as the main factor of energy efficiency is also being rethought. In the 19-20th centuries the increase in production volumes according to the formula of energy intensity compensated for the increase in energy consumption and energy efficiency was considered as similar to economic efficiency by meaning. In the 21st century the natural capital has become an important restricting factor, especially with respect to using the renewables and useful energy consumption is brought to the fore [11, p. 90].

Therefore, disaggregating the formula of energy efficiency into two components: 1) energy intensity based on useful energy consumption and 2) coefficient of useful energy efficiency; we can receive the equation of energy efficiency, which has the form of formula (1.1):

$$\text{Energy efficiency} = \frac{\text{coefficient of useful}}{\text{energy consumption}} : \frac{\text{energy intensity of}}{\text{output}} =$$

$$= \frac{\text{useful energy consumption}}{\text{total energy consumption}} : \frac{\text{useful energy consumption}}{\text{value of output}} . \qquad (1.1)$$

This equation represents the classic formula of the efficiency as the ratio of the results to cost (in the above case – energy consumption), incurred in connection with this result. However, this vision provides the opportunity to manage the energy efficiency in accordance with current challenges in energy sector. The system of technical and economical indicators for management of energy efficiency at the industrial enterprise is developed on its basis (Fig. 1.8).

Represented by one target indicator of energy efficiency, the system of energy efficiency indicatorsofthe industrial enterprise has bilateral coverage: economic part is in “energy intensity” block and technical part of production is in the “useful energy consumption” block. The aggregation of indicators is conducted by formal logical scheme,combining technical and economic indicators related to the energy efficiency. Thus, influencing on any one of them, it is possible to change the level of energy efficiency at the enterprise and vise versa while planning it is possible to base on desired level of energy efficiency.

The proposed system of energy efficiency indicators has following advantages:

- Consolidation of different indicators in the compact scheme with the identification of linkages between indicators;
- Versatility in the estimation of energy efficiency of the industrial enterprise;

- It can be used in the internal and external analysis, as well as in planning and control;
- It demonstrates the influence of separate indicators on the target indicator of energy efficiency;
- The indicators are balanced.

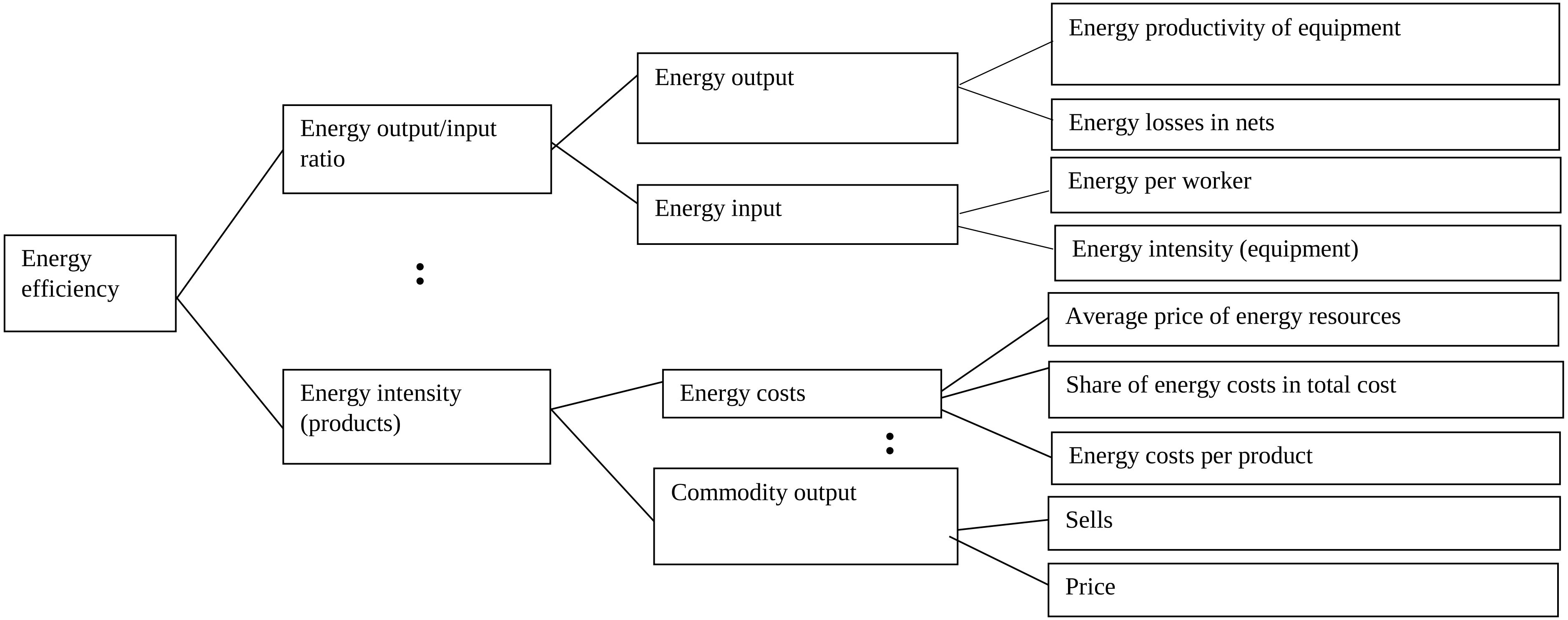



Fig. 1.8 – System of energy efficiency indicators at an industrial enterprise

If it is necessary to compare the levels of energy efficiency between countries, branches of industry, enterprises, there are a number of peculiarities, which should be taken into account. International Energy Agency (IEA) developed the method of decomposition of the final consumption by sectors and industries of economy, which separates the main factors determining energy consumption: economic activity, structure of economy and energy intensity of production that allows to receive more precise estimations of energy efficiency compared to the standards [12, p. 6]. According to the research conducted in 2014 using the methods of IEA, the comparative level of energy efficiency in Ukrainian machine-building industry is 22.5 % of the average European level in this industry, which is the lowest result of Ukrainian industries. [12, p. 12]. This means that the domestic machine-building is well behind the EU standards of energy efficiency, which creates one more risk factor for the enterprises of this industry, especially when prices and tariffs on energy resources are growing inevitably.

Table 1.2 – Comparable energy efficiency for Ukrainian branches of industry, %

| Industries | Year | | |
|---|---|---|---|
| | 2012 | 2013 | 2014 |
| Extractive industry | 41.3 | 41.2 | 37.1 |
| Processing industry | 58.1 | 63.6 | 60.6 |
| including<br>- food | 59.8 | 47.5 | 62.5 |
| - textile and leather | 58.5 | 74.0 | 74.5 |
| - wood | 45.8 | 39.9 | 45.3 |
| - pulp and paper | 112.9 | 127.8 | 125.5 |
| - chemical | 18.0 | 38.0 | 51.5 |
| - non-metal mineral production | 47.2 | 51.5 | 59.0 |
| - metallurgy | 66.0 | 70.2 | 61.7 |
| - machine-building | 17.1 | 23.5 | 22.5 |
| In general industry | 57.1 | 62.1 | 59.0 |

Source: based on [12, p. 12]

This could lead to the conclusion that among all Ukrainian industries the enterprises of machine-building industry require special attention with respect to the development of measures and programs on energy efficiency as well as to the studies on the opportunities to improve or development of the internal energy strategy, implementation of new approaches to enterprise energy management, for example, controlling.

# 2. ENERGY CONTROLLING CHALLENGES

## 2.1. Energy controlling vs energy management

High energy intensity of output is characteristic of the most Ukrainian industrial enterprises that does not contribute to the competitiveness of the domestic producers in the internal and external markets. Earlier, in the years when the cost of energy resources was relatively low and energy share in the cost of output in money terms was insignificant even though the energy consumption was high, producers were not interested in putting money in the investment projects related to the energy savings and energy efficiency as these investment could not be returned quickly and were not related to significant profits.

In recent years the conditions of Ukrainian energy market are changing gradually and the increase in prices and tariffs on primary and secondary energy has become sustained trend and the most tangible result of these changes for the domestic producers. This caused the increase in demand for energy efficient technologies, energy saving technologies and renewable energy technologies. The same applies to the traditional attitude towards the processes of management of energy resources consumption and production, as well as the processes related to the maintenance of basic technological equipment and the system of providing energy in the organization that means technical activity of energy department as it does not meet new economic and social challenges. As a result of the above mentioned transformations, the need for energy management and energy controlling at industrial and non-industrial enterprises became necessary.

Modern energy management is an instrument that can provide the economy through the sound energy policy of using energy resources for business objects [16, p. 7]. For its implementation and functioning the international standard ISO 50001:2011 «Energy management systems – Requirements with guidance for use» is used [76, ISO]. There are Ukrainian state standards in energy management: DSTU 4472-2005 "Energy saving. Energy management system. General requirements", DSTU 4715:2007 "Energy saving. Energy management systems of the industrial enterprises. Structure and content of the activities at the stages of the development and implementation", DSTU 5077:2008 "Energy saving. Energy management systems of the industrial enterprises. Verification and control of effective functioning" [15]. As their names and numbering imply, they had been developed before ISO 50001:2011 and focused on energy saving that limit their scope of application. That is why we will consider the management in accordance with ISO standard as modern European energy management, which has prospective benefits while its application at Ukrainian industrial enterprises.

Apart from the standard ISO 50001:2011, which is applied by some Ukrainian industrial enterprises, there are other lines of standards ISO in energy management: ISO 50002:2014, ISO 50003:2014, ISO 50004:2014, ISO 50006:2014, ISO 50015:2014. They are also important as they are related to appropriate energy audit; organizations, which carry out energy audit and certification of energy management systems; implementation, support and improvement of energy management systems; evaluating the comparable energy effect; and evaluation and verification of energy effect/success of organization. However, according to the authors of standards of 2014, they are additional to the basic standard ISO 50001:2011 [16, p. 419].

Management of energy resources according to the standard ISO 50001:2011 focuses on constant increase in the energy efficiency level. It does not contain the absolute requirements to the energy efficiency level – the organization establishes the requirements to itself, recording them in their own energy policy, and certainly meets the legal requirements or other obligations. That means that two organizations, which operete on a similar basis but with different levels of energy efficiency, can meet the requirements of the standard. The stages of energy management system realization according to the standard ISO 50001:2011 in general terms is shown in Fig. 2.1.

Step-by-step explanation of every stage, which is presented in Fig. 2.1 and which the organization should implement according to the standard requirements, as well as the explanation of the terms used, are the essence of the document, which is the international standard ISO 50001:2011 «Energy management systems – Requirements with guidance for use».

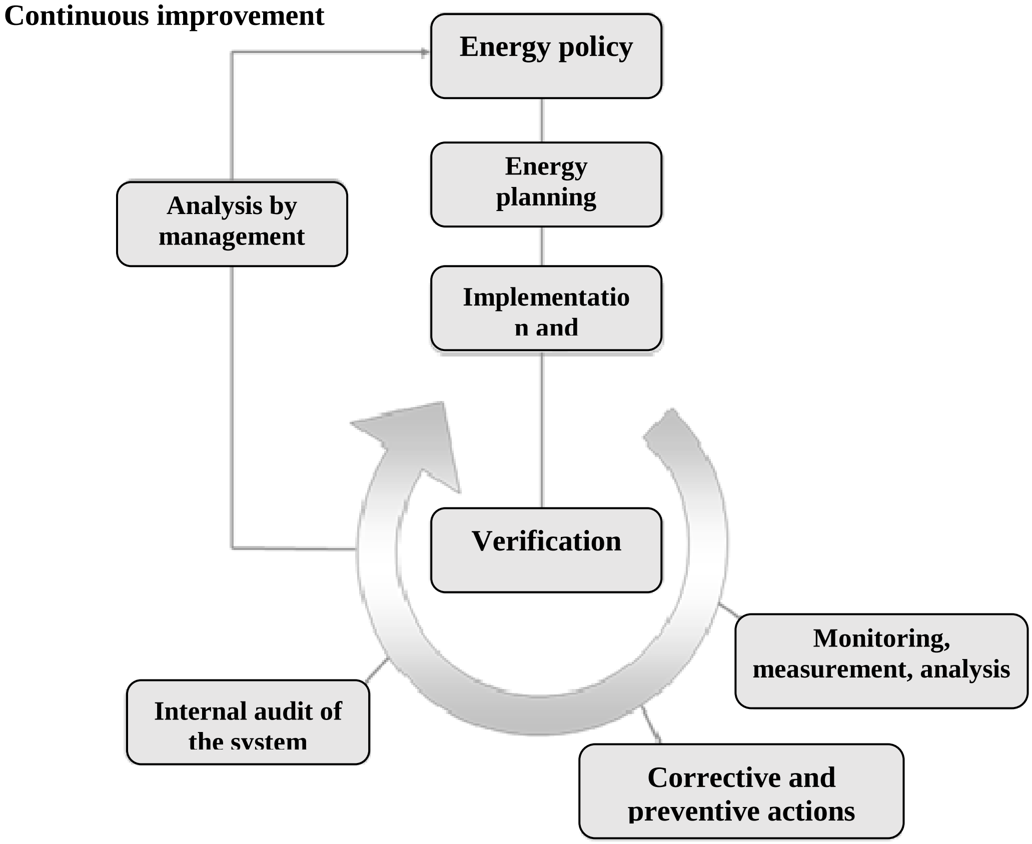



Fig. 2.1 – Model of energy management system in the standard ISO 50001:2011
*Source*: based on [13, p.12 ;14]

Energy policy-making is the first and the significant step to the establishment of the energy management system. According to the international standard, the issues of energy policy refer only to the area of responsibility of the top management of the organization. At large enterprises it is possible to delegate responsibilities and tasks to the representative of the management or the group of energy management but according to ISO 50001:2011 the top management is responsible for the energy management system implementation. The main requirements to the document are: constant improvement of energy efficiency, compliance with the laws and obligations to a third party, relation to the energy objectives and tasks, regular updating, etc. It worth mentioning that energy policy does not have to include detailed key values, for which the organization should aimed, in money terms, units of volume or in percentage. In the authors' of standard view, the very existence of an approved and transparent document on energy policy at the enterprise should be an impetus for the management of the organizational policy and stimulation of workers to more responsible use of the energy resources.

Standard ISO 50001:2011 uses concepts of energy policy, energy objectives, energy tasks, as well as energy base line and groups of actions (for instance, preventive, corrective), not as instruments for planning goals achievement, but as peculiar hierarchy of objectives, presented in Fig. 2.2.

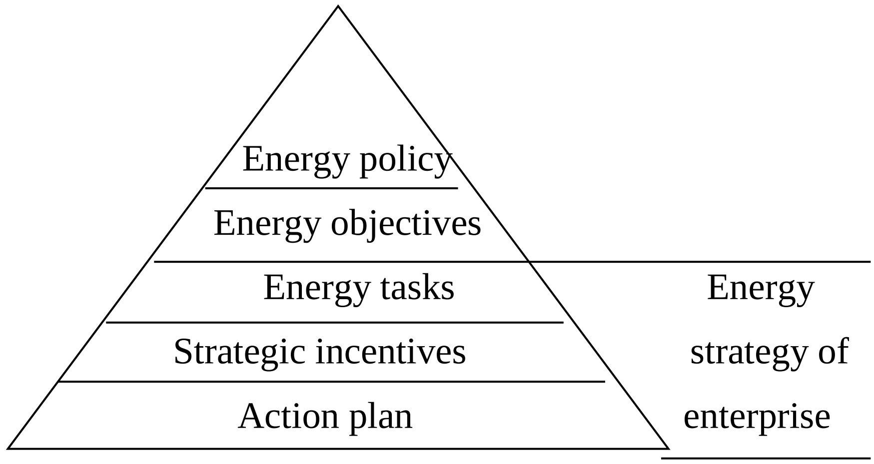



Fig. 2.2 – Hierarchy of objectives according to the standard ISO 50001:2011
*Source:* developed by the author based on [14;16, p. 820]

As indicated in Fig. 2.2, planning of actions should take place in accordance with the energy policy, energy objectives and tasks with the use of the appropriate methods. The standard does not specify which actions should be planned and which methods should be used for this.

The standard ISO 50001:2011 proposes to use methods of extrapolation and factor analysis for the **energy planning**. It is proposed to use the identified indicators of energy efficiency level, which are selected by the organization itself represented by the responsible energy manager and with approval of the top management, as planned indicators. The standard does not address the question which specific indicators should be calculated and planned. It only interprets conceptually the definition of “energy efficiency level”, which includes: energy consumption; energy use; energy intensity; energy efficiency and other. Downstream of the planning stage it is expected to identify energy objectives, energy tasks and plans of actions to improve the level of energy efficiency.

The stage of **using and functioning** includes the implementation of the results of the developed energy policy and energy planning to the daily production activities and business operations of the enterprise. It includes the organization of document circulation system on the key elements of the energy management system and their interaction, as well as competencies of workers, who work using a significant energy use.

**Verification,** as the above figure presents, has three components. **Monitoring, measurement and analysis** provide information about factual state of the implementation of the plans, which had been developed at the stage of energy planning. The organization identifies on its own the means and methods for the measurement of energy resources, which were consumed during the analyzed period. If the differences from planed values were revealed, then it is necessary to study the reasons of such variations and to carry out the **corrective and preventive actions**. This is management by exception, which is innate to the controlling [17, p. 188-192]. This means that the corrective and preventive actions should be implemented according to the criterion of the exception relevance after the analysis procedure in accordance with the classification of the revealed exceptions and in case of authority to eliminate the reasons of their occurrence.

**The internal audit** of the energy management system can be implemented by the organization on its own, as well by the invited consultants. It should not be identified with energy audit and the energy evaluation. The internal audit of the energy management system should be done on schedule for the independent evaluation of the existing energy management system in the organization. It addresses the questions: whether it meets the requirements of the standard, whether it promotes the achievement of goals declared in the energy policy, and whether it is in working condition. All the actions of the internal audit should be documented. Recording or even "records management" is an important part of the demonstration of the correspondence of the energy management system with the requirements of the standard ISO 50001:2011 and the achieved level of energy efficiency.

Engagement of the company's top management to the energy management system might be called the main requirement of the analyzed standard. This is due to the fact that the energy management system should involve the whole enterprise and not just its energy system. Moreover, meeting the ambitious goals of the energy efficiency and implementation of the energy policy can be done with commitment of the top management or company's owner. The recorded stage of the analysis **by the management** is the quintessence of the ISO 50001:2011authors' desire to connect precisely the energy management system to the company's top management. It is expected that the manager will check the implementation of every stage, their documenting, will make adjustments and recommendations about the improvement of energy management system functioning, as well as the level of energy efficiency.

A highlight of the energy management in the standard ISO is the repeating PDCA-cycle (cycle of Shewhart-Deming). Cycling nature of Plan-Do-Control-Act allows to improve the energy management system in the organization and provide the continuous improvement in terms of envisaged steps are taken [3, p. 74-75].

Therefore, the standard of energy management system ISO 50001:2011 does not answer the question concerning the necessary level of energy efficiency, energy saving, energy security, etc. It also establishes the system contour, in which the organization should find the solutions, follow them, and thereby increase the awareness and improve attitude of workers towards energy issues day by day, as well as quantitatively measured indicators in the energy sphere. Supporting management decisions in the energy sphere should be provided by the energy controlling.

As the very concept of controlling, the energy controlling first appeared in the practice of western companies. At the end of the last century European companies used the controlling instruments not only in their own energy systems but also implemented the energy controller position. Because the qualitative changes at the enterprises in energy consumption, level of energy saving, etc. depend not only on existence of appropriate modern technologies but on the subjective influence and its value as the result of managerial decision making. The appearance of energy controlling became the sign of attention to the energy sphere in enterprise activities, awareness of the reserves of cost reduction and consequently the increase in the competitiveness by means of energy efficiency measures, as well as the response to the modern socio-economic challenges in the industrially developed countries, which do not have large reserves of carbons.

It is worth mentioning that the energy management and the energy controlling do not duplicate and do not substitute each other and have own characteristics and the sphere of action. They can complement each other, providing thereby the synergetic effect to the activities in the enterprise energy sphere. Table 2.1 presents the results of the research and the comparison of the main characteristics of the energy management and the energy controlling.

Taking into account the theory and practice of using the energy management and energy controlling, the conducted comparative analysis demonstrates that their mission and tasks, as well as their functions are not identical, though they are applied in the unified space. A shift of emphasis provides the greater economic influence on the processes, which occur in the enterprise energy sphere, as well as on the decision-making at the enterprise level, taking into account the state of the energy system and energy market as a whole, intensification of information and control and analytical work concerning energy issues, etc.

Introduction in the domestic enterprises' practice of the energy management by international standards, as well as the energy controlling are aimed on the organization of energy sector activity in a new way. That is not necessarily connected with the increased attention at the top management level to the issues in enterprise energy sphere. Energy controlling widens in this context the opportunities for the managerial influence, as it presents effective instruments for the management of energy efficiency levels, energy security and thereby facilitates the transition to the international standard on the energy management. Moreover, as mentioned earlier, energy controlling is the guarantee of the transparency, systematic in the managerial decision-making and manageability in the enterprise energy sphere.

Table 2.1 – Comparative analysis of energy management and energy controlling

| Characteristics | Energy management | Energy controlling |
|---|---|---|
| Mission | Energy manager runs energy department and provide the achievement of the target levels of energy saving | Controller focuses on the achievement of the energy objectives, which were set in the organization; provides the relative information and support the processes of making and implementation of management decisions on the energy issues. |
| Aims and tasks | Providing effective ways of realization of economic entity's energy policy<br>- control over energy consumption;<br>- increase in the level of energy efficiency;<br>- minimization of energy resources consumption per unit of output. | Providing of cost-effectiveness and feasibility of actions in enterprise energy system:<br>- increase in the level of energy efficiency, energy saving and energy security;<br>- informational and analytical support of the management decisions. |
| Object | Industrial enterprise as a whole, its separate departments, fuel- and energy-consuming equipment. | Industrial enterprise and its environment in the energy market. |
| Time coverage | - strategic,<br>- operational. | - strategic,<br>- operational. |
| Functions | PDCA-cycle:<br>Plan-Do-Check-Act. | Planning, informational support, analysis/control, coordination, consulting. |
| Standardization in Ukraine | ISO 50001;<br>Standard DSTU 4472-2005, 4715-2007, 5077:2008 in the State Certification System of Ukraine. | Does not exist |

Source: developed by the author based on [13; 15; 16; 19; 21]

## 2.2. Development and implementation of energy controlling tools

Functional content of controlling is determined by the objectives set for the organization and includes such types of activities, which provide achievement of these goals. One of the main reasons of the appearance and development of the controlling concept is the necessity of the system integration of different aspects of financial and economic activity. Controlling provides methodical and instrumental basis for the support of managerial functions: planning, control, organization, motivation and evaluation of the current situation for managerial decision-making. However, controlling is also a modern concept of enterprise management, which is aimed at combining their functions. The traditional square of controlling, which outlines its main functions – planning, informational support, analysis and control, coordination and regulation [22, p. 2 and others] – is being replaced by a pentagon supplemented by the consulting function.

Fig. 2.3 shows functional pentagon of energy controlling, which includes not only controlling functions but also two levels of management (strategic and operational). It is rather flexible and has dynamic components for the further development. Such functional structure of energy controlling allows to cover all aspects of the management of enterprise energy sphere and due to the instruments of coordination and the ability to develop allows better integration at the enterprise.

The planning function turns into energy planning and supports the formulation of enterprise energy strategy and the development on its basis detailed plans and programs. A starting point of energy planning are, on the one hand, long-term objectives, which were set in the energy policy framework and was more detailed in the process of strategic planning, and, on the other hand, energy analysis of enterprise's current state. Moreover, energy controlling is indispensible in project planning on the energy efficiency issues and related actions and helps with investment decision making in the enterprise energy sphere.

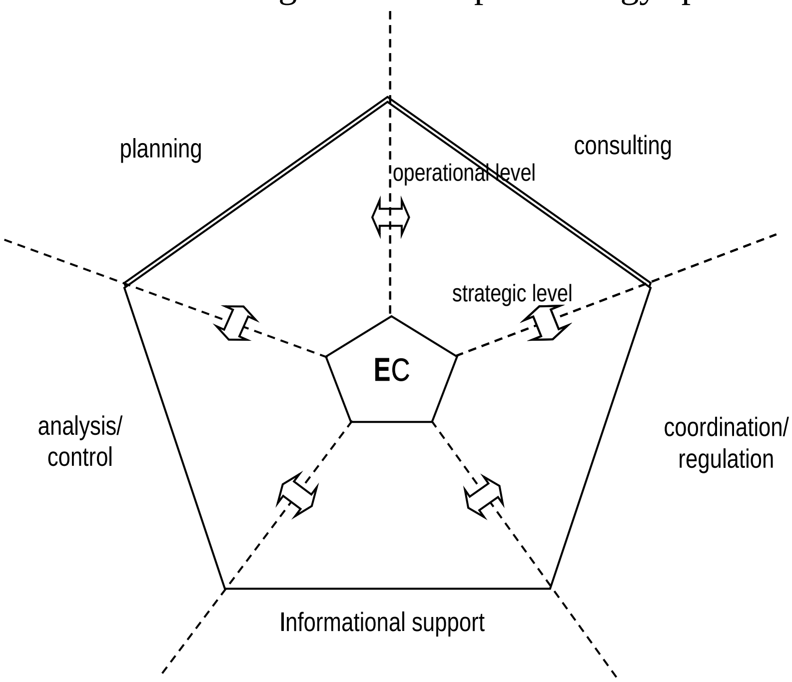



Fig. 2.3 – The functional pentagon of energy controlling

*The function of coordination* in controlling brings together planning, realization and control over implementation of managerial decisions. Energy controlling is not an exception, hence the same applies to the measures on energy efficiency, energy saving, etc. In the framework of coordination function energy controlling initiates constantly and supports internal reconciling production processes, ensures the necessary information support of engaged managers or departments on issues of managerial decision making and, if it is possible, removes existing barriers. Moreover, coordination function means the support of specific actions or energy efficiency programs in form of constant recording of their progress according to the project, as well as monitoring timelines of intermediate results.

*Information function* of energy controlling includes the creation and further support of energy information system at an enterprise. It also includes providing the system access to the primary information (for example, energy accounting, calculation of energy costs, as well as energy reporting) [23, p. 72].

In the information society and in conditions of rapid development of the information technologies this function of controlling is becoming increasingly important. It is not limited today by monitoring and providing information, but should also connect enterprise to information technologies. This means that it should include implementation of the computerized information and analytical processes, application of latest software in the managerial activities for hardware and software data transformation into processed and systematic information, and then into knowledge for business decision-making.

*Control function,* which is typically considered as synonym of controlling, is mostly associated with regular analysis of differences between planed and actual values, that is “between energy status-quo and outlined strategic and operational energy objectives” [23, p. 73]. In current conditions the control function should develop not only in the direction of control over the end or intermediate results but over the processes themselves. In the energy controlling this function has its peculiarities as it related not only to the control/analysis of exceptions but also to the elements of control over the energy equipment functioning through the implementation of the indicators system, which includes technical indicators, development of check-lists for workers, which work with or use the energy equipment. Therefore, in the energy sphere control is necessary, on the one hand, for uninterrupted equipment operation and, on the other hand, for the achievement of energy objectives related to energy efficiency, energy saving, energy conservation, etc.

Consulting function transformed the traditional square of the controlling activities into the functional pentagon, as it shown in Fig. 2.3. The scientists for quite some time have been insisting on the integration of consulting in the spheres of controlling activities [24, p. 257]. The first western researches on energy controlling showed a clear need for consulting in the energy sphere: only some of them include it in the functions of energy controlling [23, p. 73], while others – to its tasks [16, p. 452]. Within this function the support of managerial decisions at the enterprise on energy issues is carried out. The German researchers R. Gleich and M. Schulze in the function of energy consulting pay attention to the cooperation in developing energy supply strategy and in financial transactions with suppliers; to the consideration and financial evaluation of proposals on rationalization of production energy system, as well as to the analysis of their cost effectiveness and bottlenecks [23, p. 73]. Particular aspect of the internal consulting services is the justifying the investment in the energy sphere of enterprise.

In order to execute its functions, energy controlling need appropriate instruments. The selection and classification of the instruments for each function was conducted among several traditional financial and economic controlling instruments and some control and technical instruments of energy management.

*1. Enterprise energy balance* refers to technical and economic instruments of energy controlling, is widely used in energy management. It makes it possible to estimate the state of enterprise energy system and is starting point of energy planning. Usually energy balance is prepared after energy flows visualization at the enterprise and is based on the first law of thermodynamics, it is calculated for the enterprise, enterprise's facilities or group of equipment taking into account their need for the energy, energy loss in the grid and a degree of influence while energy transformation. But in order to achieve the goal of constant improvement according to the international standard ISO 50001:2011, to this instrument the system of motivation of energy saving over the norms and other additional options should be added.

*2. Energy flow diagram* is fundamental basis of active energy management , which shows the directions of energy resources, points of its transformation and consumption but does not address the question how many energy flows within the enterprise. For the energy controlling objectives it is not enough, it also requires visualization of points of energy resources consumption by types of resources, demand for them and points of their transformation, processes or equipment, to which the energy resources delivered directly or in transformed form, the opportunities to use energy resources, which have been remained after processes implementation or consumption by equipment, possibilities of transformed or created energy resources sale (if the enterprise uses renewable). That is why for planning function implementation as energy flow diagram, Sankey Diagram should be used. It is a visual instrument, which shows also energy flow volumes. The benefit of Sankey Diagram is its simplicity and graphic representation of complex interrelations in enterprise energy system.

*3. Energy load schedule* shows the regime of energy consumption in time. It serves as a basis of energy balance compilation, calculation of required capacity of energy resources and optimal regime of the equipment operation, development of recommendations on regulation and determination of work conditions of energy grid and intersystem relations.

This scheduling is necessary for both planning and energy load management. Energy load management is able to reduce costs of consumed energy, while the economic leverages application is as capable as technical measures. Within the planning function of energy controlling the schedules allow optimal usage of tariffs differentiated by time periods, justification of decentralized generation use, particularly in the peak periods, etc. Through this, the effect of consumed energy cost reduction is achieved, as well as declining accidents in energy systems, decreasing natural resources loss at generating companies, and as a result the energy security enhancement in industry and in the country as a whole.

*4. Portfolio analysis* is wide spread in the controlling for strategic planning and analysis of long-term strategies. Enterprise energy portfolio can consists of "consumption portfolio", portfolio of energy investment projects, portfolio of strategic energy units, etc. Portfolio analysis in energy controlling will allow to improve both quality of long-term managerial decisions on energy strategy implementation and general strategic planning at the enterprise. The existing matrix models of portfolio analysis (BCG, McKinsey, ADL, etc.) can be adapted successfully for the needs of energy planning and analysis.

*5. Energy market analysis* is crucial for energy planning as it provides a sense of interaction between market players, dynamics of prices on energy resources, regulation policy in the country and abroad, etc. Energy controlling uses the results of conducted analysis when preparing energy balance, own energy portfolio, searching for suppliers, energy efficient equipment and technologies, development of own energy strategy.

*6. Benchmarking* has been widespread recently in Ukraine for comparison and application of the best practices of other enterprises or leading departments within own enterprise. It is an area of scientific and practical interest, as it can help obtain the measurable result with lowest costs in energy sphere. Benchmarking is an instrument of strategic controlling and its ultimate goal in energy controlling is improvement of energy efficiency at the enterprise. The subject of improvement is specific values of energy costs or direct energy efficiency indicators, as well as individual energy processes, energy resources use, energy strategies or whole energy management system at the enterprise.

*7. Analysis and risk management* has its conceptual interpretation, as well as is applied in practice of energy planning function. Certain indeterminacy, which accompanies every managerial decision and rises with broadening the planning horizon, is typical for the energy issues. Moreover, the western researchers identify two groups of risks, which distinguish in economic essence and in approaches to their management: 1) investment risks [16, p. 467] and 2) production risks [25, p. 134]. But both groups need analysis and actions for their mitigation. This means that at the planning stage, on the one hand, the risk of non-fulfillment of the results should be taken into account, and, on the other hand, the steps to prevent unfavorable situations should be foreseen.

*8. Investment calculations* and investment decisions justification are traditionally related to the planning function of strategic controlling. The peculiarities of investment calculations in energy sphere are associated with:

- estimation of the investment projects efficiency from the perspective of future energy costs and expected energy saving;
- lack of information and experience of investing in modern energy technologies, as there are constant technological changes and rise of socio-economic awareness of the society in the energy sphere;
- long-term character of investment projects and problems in integration to the process of operational planning, depreciation calculations, etc.

*9. Method of morphological analysis*, which was suggested by Swiss astronomer Fritz Zwicky (1898–1974), helps to consider different possible decisions of a problem, breaking down it into separate attributes and combining their possible realizations. In economics morphological analysis is applied for making those managerial decisions, which are characterized by generating the large number of alternatives, for further systematization of selected options and their analysis.

Within the realization of energy controlling planning function the morphological analysis is applied in the development of energy strategy. Morphological matrixes can be built for analysis of the strategic factors (for example, marketing segment, chosen competitive strategy, organizational structure of the enterprise, risk preferences, etc.), or for analysis of main parameters of energy strategy (for example, energy supply, energy efficiency level, etc.) or energy potential [16, p. 785, 790; 26, p. 193, 204].

*10. Gantt chart* is widespread in the project management. It was suggested in 1910 by the American scientist Henry Lawrence Gantt during ships construction. It was presented as a graphic for the management of engineers and their tasks, which had to be fulfilled during certain time with the use of certain resources. In energy controlling Gantt chart is used for the regulation and optimization of enterprise energy processes.

*11. Management by exceptions* is a controlling instrument for identification and analysis of diversions from the plan, as well as for intermediate coordination of implementation of projects, works, production processes. Within the coordination function of energy controlling, emphasis is placed on milestone analysis and preparation of intermediate reports, which illustrate level of achievement of set *milestones.* «Milestone» is considered as kind of gates, through which it is possible to transfer to the next work phase [16, p. 249] and, therefore, with use of intermediate reports the realization of task not fully implemented is coordinated.

*12.* The simplest *analysis of energy costs dynamics* is comparison of current costs with their previous values. Collected data are presented in convenient form of graphs or tables. More advanced analysis is the analysis of energy costs trends. Analysis of energy costs dynamics can be long-term or short-term. This means that, on the one hand, it should be focused on the future, as its results can be used for goals set and strategic planning. On the other hand, it should be focused on coordination of achieved results in enterprise departments aimed on energy efficiency.

*13. Energy accounting* includes collection of the quantitative information on energy consumption and its further processing, compilation and evaluation of collected information (for example, by energy resources, over a certain period, by enterprise department, by individual consumers). In its essence it is similar to the monitoring but has only informational content without technical, control and analytical components. That is why the form, content and amount of data reflected in energy accounting are set depending on its informational requirements.

*14. Calculation of energy costs* is conducted at the enterprise by the fixed models of costs calculation based on the data of energy accounting. In energy controlling apart from the determination of energy costs, this instrument helps identification of ineffective energy elements in the organization. Calculation of energy costs is a necessary component of energy efficiency level determination, is used during the justification of investment decisions and is an informational basis for technical and economic researches. Taking into account the significant informational content of the calculation of energy costs, it is logical to categorize it to informational function of energy controlling.

*15. Internal production energy calculation* is related directly to the energy cost calculation. In this case the whole primary energy, which is supplied to the enterprise, and all types of secondary energy are recalculated by each enterprise department in money and/or physical terms. In calculations the departments are considered as internal energy consumers. Internal production energy calculation is included in informational functions of energy controlling, as its results provide information for cost management (particularly, on types of costs and points of costs), are integrated into general enterprise informational base and, if it is necessary, they form separate energy informational base.

*16. Activity-Based-Costing* is related to a process approach, that is why for the description of business processes it is recommended to use software products. Energy costs are frequently included to the overhead expenses and hence the internal economic calculation of energy consumption is get complicated, and energy costs are reflected incorrectly in the final product cost. Activity-based-costing provides reliable information on energy cost drivers, energy cost centers, etc.

17. Energy reports are considered by the most researchers of controlling concept as one of its key purpose [22, p. 107; 24, p. 224]. Moreover, according to the international standard ISO 50001:2011 the documentation of achievements, records management and reporting on energy efficiency is the requirement of certified energy management. That is why *energy reports* is an element of informational function of energy controlling. Controlling report on general state of enterprise energy activity is a standard document, which presents the results of analytical work, conclusions and recommendations on consumption or own energy production, for instance, from renewable, energy saving, energy efficiency and energy security. It is one of the main sources of relevant information for managerial decision-making in energy sphere. Apart from the report on general state, the standard, referential reports and reports on deviations of actual data from planned can be prepared. The quality of internal reporting system should be focused on the relevant reaction of information users. Therefore, energy reports form the informational base of controlling and further managerial decisions in energy sphere.

*18. Special software products* in enterprise energy sphere are developed for: 1) current monitoring; 2) database operating; 3) business intelligence. Their purpose is collection, systematization and processing information. For the multi-level informational support of managerial decisions in energy sphere, the independent groups of scientists propose to transform the instrument «Management Cockpit» for the architecture of energy controlling goals [23, p. 73; 27, p. 498]. They called this innovative instrument «Energiecockpit» («Green Cockpit»). In its essence it is a complex informational and analytical instrument of energy controlling, which consists of hardware and software and is based on the methods of collection, processing, presentation and storage of information. In the future it is expected that systems Energiecockpit (Green Cockpit) will replace energy reports or reduce it.

19. *Variance analysis* generally precedes management by exception. In control function the emphasis is on revealing and analysis of variations of actual values from planned. This means that it is not enough to record, for example, overexpenditure of energy resources, it is necessary to find its original cause to prevent repetition of this situation.

20. *Energy indicators* are used primarily for determination of quantitative goals in energy resources use and then for the control and analysis of their implementation. In general, the sphere of application of controlling indicators are wide enough, as it brings into life its motto "if something cannot be measured, it cannot be managed", The international standard ISO 50001:2011 requires using energy efficiency indicators, which can be presented indicators or complex economic and mathematical model as chosen by the enterprise. Examples of energy indicators are: amount of consumed energy in certain period of time, energy intensity, energy efficiency, energy per unit of production, energy per worker, etc.

21. Systems of indicators are considered as more advanced and universal controlling instrument compared to individual indicators application. *System of energy indicators* should meet the requirements of enterprise informational system, they can be used in order to optimize energy resources consumption in short- or long-term period, to support planning and control at the enterprise. There is a view today that systems of energy indicators should be developed individually for each enterprise [28, p.50]. In their creation it is proposed to use similar approaches to the well-known production systems of indicators, namely, to choose the target indicator and other energy indicators, to identify their interrelations.

22. *Checklist* is a template, which standardizes the process of tasks implementation and goals achievement. Checklists are widely used in time management for avoiding mistakes and force majeure situations, self-assessment, etc. The higher price for the mistake, the more effective checklists using. In energy controlling checklists are aimed on the improvement of energy efficiency at different energy facilities. They consist of the list of specific activities/options in energy saving, use of energy efficient equipment, etc. that will lead to the higher level of energy efficiency at the enterprise. With passing through the list, the focus is shifted to unfulfilled options.

Checklists can be used while planning the actions of energy efficiency, besides checklists allow most effectively to conduct technical and economic control independently at the different stages of managerial processes – both in planning and managerial decision implementation. Moreover, checklists can be spread among workers, for example, the requirements of standards on energy management and energy efficiency and then the control over the adequacy of standard requirements will be conducted.

23. *Due diligence* implies thorough economic and legislative preparation of company to the transformations, transaction, etc. Controlling is increasingly included in Due diligence procedure. This is demonstrated in the financial sphere but it has great potential in energy issues. Energy Due diligence is actively used in practice of western companies. Its using is most frequently related to the projects of transition towards the renewable but for other investment projects in energy sphere the background check of the partners and the very project should be done. Due diligence procedure should consists of five main blocks of work, for each of them the objective conclusion should be done: commercial or market, tax, legal, technical and ecological.

It is obvious that a new perspective on the energy issues requires considerable transformations that is why Due diligence should be considered in energy controlling as its consulting function.

24. In practice of every enterprise there are some tasks, which solution requires a specific approach that cannot be applied for the other tasks. The diversity of such situational approaches is combined in the world practice within the instrument *ad-hoc analysis* that means *solution of specific tasks*. Typically the controlling department is involved in solution of such tasks and obviously this activity should be referred to the consulting function.

25. *Simulation modeling* relates to the logic and mathematical methods of cognition of complex systems. In economics simulation modeling is usually used for the analysis of possible consequences of one of another decision. Among western researchers of energy controlling functionality there is no common view on application of simulation modeling within its specific function [16, p. 453; 23, p. 73]. At the modern domestic enterprises the application of logic and mathematical methods in the energy sphere look complicated according to the necessity of prove and convince managers in the usefulness of investment and spending time of researchers on creation of the simulation models, their verification. That is why the simulation modeling should be categorized as consulting function of the energy controlling.

The results of the research, which has been conducted at the wire and cable industry enterprises of the South of Ukraine, on using analyzed instruments of energy controlling are shown in the Table. The research revealed a lack of application of energy controlling instruments for the management of production energy systems. This means that there are significant reserves in the improvement of their energy efficiency through the mentioned functional and instrumental aspects. The table shows that the economic practice of production energy systems management usually the functions of control and information support are used. However, there are some instruments of controlling, which are able to improve these functions implementation.

Analysis of the table proves that despite the scientists' insistence, entrepreneurs do not usually use consulting instruments of controlling. A small number of projects (investment or internal production) in the energy sphere almost ignore coordination function. The specialists of energy department are not always involved in planning.

Table 2.3 - Instruments of energy controlling used by enterprises of the wire and cable industry of the Southern region of Ukraine, on the state of 2018

| Controlling function | Instruments of energy controlling | Enterprise A | Enterprise B | Enterprise C |
|---|---|---|---|---|
| Planning | Energy balance | + | + | + |
| | Energy flow diagram / Sankey diagram | - | + | - |
| | Energy load schedule | + | + | + |
| | Portfolio analysis | - | + | - |
| | Analysis of energy market | - | - | - |
| | Benchmarking | - | - | - |
| | Risks analysis | - | - | - |
| | Investment calculations | - | +/- | - |
| | Morphological analysis | - | +/- | - |
| Coordination | Plans of projects implementation / Gantt chart | - | - | - |
| | Management by exception | - | + | - |
| | Analysis of the energy costs dynamics | - | + | - |
| Informational support | Energy accounting | + | + | + |
| | Calculation of energy costs | + | + | - |
| | Internal production energy calculation | +/- | + | - |
| | Cost calculations on processes | +/- | + | - |
| | Energy reports | + | + | + |
| | Special software products | + | +/- | - |
| Control | Variance analysis | +/- | + | +/- |
| | Energy indicators | +/- | + | + |
| | System of energy indicators | +/- | + | - |
| | Check-lists | - | - | - |
| Consulting | Due diligence | - | - | - |
| | Solution of the specific tasks / Ad-hoc analysis | - | - | - |
| | Simulation modeling | - | - | - |

«+» is used
«-» is not used
«+/-» is partially used

Thus, modern challenges of the production energy systems efficiency require the extension of the controlling conceptual basis, particularly concerning its functional and instrumental content, which can affect energy resources consumption, energy efficiency, etc. The conducted research showed, on the one hand, the economic entities' interest to the innovative instruments of energy system management and, on the other hand, using of limited instruments of energy controlling. The suggested classification by controlling functions of instruments, which are known and unknown to practicing specialists in the energy sphere, is based on specific needs of entrepreneurs and promotes interdisciplinary frameworks of the application of technical and economic actions in order to increase the efficiency of enterprise energy department efficiency.

# 3. PRACTICAL CHALLENGES OF ENERGY EFFICIENCY AND SUSTAINABILITY / IMPLEMENTATION OF ENERGY CONTROLLING

## 3.1. Energy sustainability as an objective of implementation of energy controlling.

3.1.1. Determination of the sustainability level in energy systems of educational organizations. Case of Rozdilna district in Odessa region, Ukraine.

While studying the state of energy system of non-profit organizations, it is necessary to place increased emphasis on their social and environmental efficiency, and not just cost-effectiveness. In this case, cost-saving efforts in energy management are more likely limiting factors, than target. Thus, the energy efficiency for non-profit organizations changes the context of the discussion.

The primary aim of enterprise energy management is to measure its effectiveness. In this case, it is necessary to measure indicators, which describe the efficiency of energy management, taking into account its complexity, versatility and focus on three components of the sustainable development (social, ecological and economic).

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." [29, p. 41].

In our opinion, sustainable development cannot be seen in isolation from enterprises' activity. At the same time it is possible to deal with sustainability of energy system of enterprise, since energy is crucial to ensuring economic development.

Output of energy sector activity is energy services that are provided to meet clients' need (social component). Energy processes, in turn, are accompanied by emission and waste, which impact the environment (ecological component), and financial expenditures (economic component). Enterprise energy management system should guarantee optimal balance between these components that is its sustainability.

Therefore, enterprise energy system sustainability is its ability to meet the enterprise's need for energy services at the lowest costs and emissions to the environment.

Level of sustainability is a latent indicator. It can be reflected with indicators that characterize the impact of energy system on each of the sustainable development components (social, ecological and economic).

Determination of the level of energy system sustainability will provide the opportunity for financing organizations to choose those areas of improvement of energy sectors, which are most needed.

Energy system of a school is a complex of technological equipment, which is used for continued provision of all energy services. Its functioning is essential for achieving the goals of the sustainable development at the local level, since there is a challenge of striking a balance between addressing the needs for energy and the impact of its use on natural resources. Moreover, proper energy services are a key element of maintaining the conditions of education quality, and therefore energy use is of a social nature.

That's why introducing the energy efficient measures and transition towards environmentally friendly technologies are inevitable in the moving towards the sustainable development. In this case local authorities should take measures to create efficient, socially acceptable and environmentally-friendly energy systems. Taking into account a significant number of socially valued objects, it is first and foremost to take these measures for the worst objects, which means the lowest level of energy efficiency.

Practice of energy systems can be characterized by means of qualitative and quantitative indicators. For that reason studying of only one indicator cannot provide reliable information on its state and efficiency of work. Therefore in order to identify the efficiency it is necessary to study these indicators in conjunction.

Given that schools as energy consumers has certain homogeneity, their selection as objects, to which energy efficient measures are applied, should be conducted based on their sustainability level. In order to increase this level, we propose to carry out this selection in favor of the schools with the lowest level of sustainability. It means that firstly it is necessary to rank the schools according to their sustainability level, to determine "outsiders", which have the lowest level of sustainability, and in the first place to take steps to improve their energy efficiency.

Mathematical problem of determination of the energy system sustainability is to reduce raw data on the energy resources consumption. As a result illustrative and concise data will be provided, presented in a lower-dimensional space. This task can be solved by means of multidimensional statistical analysis, in particular, factor analysis. Its results make it possible to concentrate multidimensional information in the lower number of broader internal characteristics. These characteristics are at the same time more determining.

The principal components method plays a leading role among the factor analysis methods. Technically, this method is one of the component analysis methods; however, has much in common with factor analysis method, namely, resemblance of algorithm of calculation.

The tasks of the principal components method are following:

1. Data reduction.
2. To reveal the structure of interrelations between symptom-factors, to quantify them and to provide economic interpretation.
3. To range the researched objects and classify them by revealed latent indicators.

As analyzing sustainability of school energy system based on available data, we identified indicators, which reflect the components of the sustainable development and are connected with schools' energy sector activity:

$X_1$ – heat of combustion of fuel, MJ;
$X_2$ – useful heat of combustion of fuel, MJ;
$X_3$ – number of pupils;
$X_4$ – amount of ash waste, kg;
$X_5$ – amount of sulphur waste, kg;
$X_6$ – amount of carbon emissions, kg;
$X_7$ – amount of money spent on fuel, thousands of hryvnas;
$X_8$ – size of the school building, $m^2$;
$X_9$ – fuel consumption, in physical terms depending on fuel type.

Indicators $X_1$, $X_2$, $X_3$ describe the social component of the sustainable development (level of energy services provided to school pupils); $X_4$, $X_5$, $X_6$ describe the ecological component (level of emission); $X_7$, $X_8$, $X_9$ describe the economic component of the sustainable development.

These indicators were chosen as they characterize each of the components and at the same time are the characteristics of energy system sustainability. Each of the components of the sustainable development and sustainability indicator could be classified as latent components.

The estimation of schools' energy system sustainability was conducted in two stages. The scheme of the algorithm is presented in Figure 3.1.

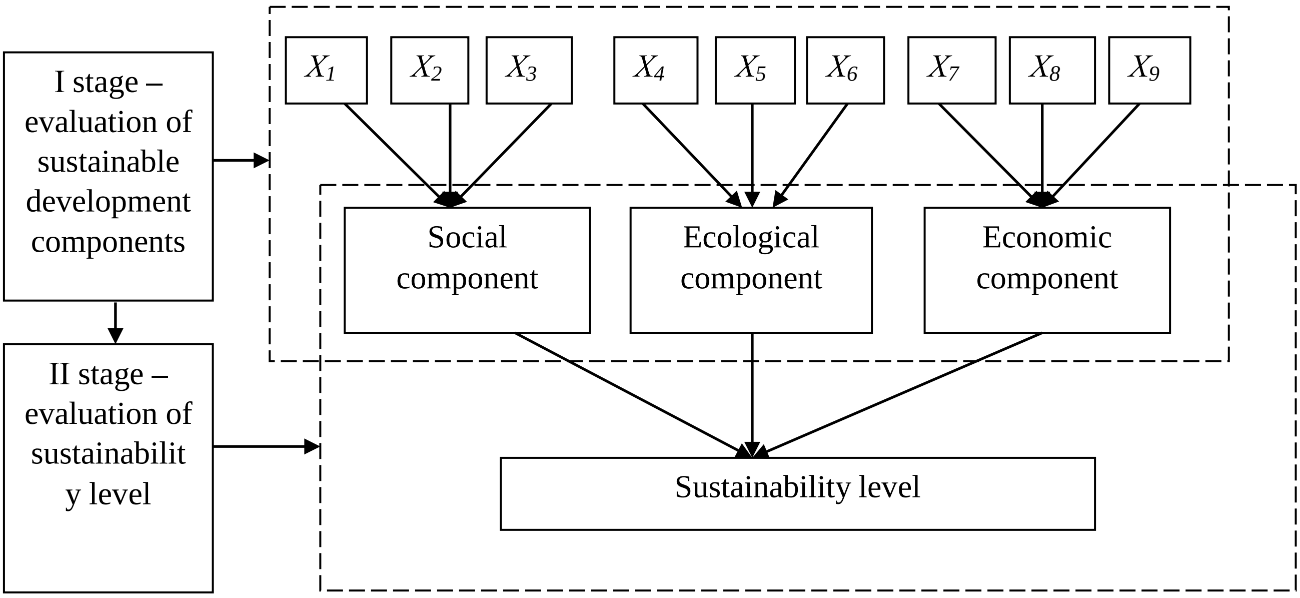



Fig. 3.1 – Two-stage algorithm of latent indicator evaluation (energy system sustainability) and its components

As previously mentioned, statistical population must be homogeneous to be used for principal components method. Since schools are heated by different types of fuel (coal and natural gas), it is necessary to evaluate the economic components for the schools, which are heated by coal, and for schools, which are heated by natural gas, separately.

The methodology of sustainability level determination was applied for schools of Rozdilna district (Odessa region, Ukraine). Heating is the main direction of energy consumption of the schools in Odessa region. Heating season starts since October, 15th and continues during 6 months (till April, 15th). During the extended period, certainly, the significant amount of fuel is being consumed that causes economic cost as well as social and ecological development of the region. This enables to talk about the necessity of sustainability level determination, which is related to energy resources use in schools.

Let us illustrate the application of the algorithm of sustainable development and its components studying as applied for 28 schools of Rozdilna district in 2012. The mathematical calculations related to principal components method were conducted by means of STATISTICA software (ver 5.5. A), modules «Factor Analysis» and «Cluster Analysis».

The social component of sustainability was researched in the first stage. The matrix of the weights of separate principal components obtained for each researched school is given in Table 3.1.

Table 3.1 – Principal components in the research of social component of the sustainable development of energy system

| Factor Scores (NEW.sta) | | | |
|---|---|---|---|
| Rotation: Unrotated | | | |
| Extraction: Principal components | | | |
| | Factor | Factor | Factor |
| | 1 | 2 | 3 |
| 1 | -0,0039 | 0,660838 | -0,89059 |
| 2 | 0,080627 | 0,918262 | -0,69452 |
| 3 | -0,32059 | 0,671675 | -1,1854 |
| 4 | 0,175302 | 0,22987 | -0,91533 |
| 5 | -0,76892 | 1,338311 | -1,30908 |
| 6 | -0,77941 | 1,976183 | -1,03139 |
| 7 | 0,265016 | 0,441238 | -0,73512 |
| 8 | -0,49658 | 0,023205 | -1,64433 |
| 9 | 0,315946 | 1,120466 | -0,38066 |
| 10 | 0,518326 | 0,992455 | -0,24686 |
| 11 | 1,540994 | -0,3807 | 0,101769 |
| 12 | 0,141988 | -1,34131 | -1,6553 |
| 13 | 1,321108 | -0,73803 | 0,197188 |
| 14 | 0,756464 | -0,16241 | 0,733287 |
| 15 | 1,129624 | -0,39129 | 0,49679 |
| 16 | -1,23437 | -0,2067 | 1,011264 |
| 17 | -0,26299 | 1,141622 | 1,90703 |
| 18 | -0,40623 | 0,696 | 1,583077 |
| 19 | -1,61987 | 1,143 | 2,12103 |
| 20 | -0,18967 | -0,67062 | 0,486672 |
| 21 | -0,66338 | -0,35902 | 0,803246 |
| 22 | -2,16567 | -1,80779 | -0,08729 |

| | | | |
|---|---|---|---|
| 23 | -1,81429 | -2,16583 | -0,42078 |
| 24 | 0,924442 | -1,13599 | -0,04994 |
| 25 | -0,35337 | -1,02398 | 0,237655 |
| 26 | 1,391287 | -0,25608 | 0,560842 |
| 27 | 1,435565 | -0,55971 | 0,317855 |
| 28 | 1,082542 | -0,15369 | 0,688897 |

Principal components in Table 3.1 are standardized and uncorrelated that makes it possible to use them for further research of sustainability level. Moreover, this matrix can be used for ranging and clustering researched schools by selected principal components.

Let us give the economic interpretation to the results received. Firstly, it is necessary to identify how many principal components should be used in the further research. The first two of the three principal components satisfy the criteria $d_L \geq 10\%$, and the share of variation of the input indicators, which are explained by these components, is 97.6 %. However, the second principal component does not contain high factor loads that makes it possible to interpret it qualitatively.

Let us give the economic interpretation to the first principal component, which describes 78.6% of the overall dispersion of the researched symptom-indicators. The first principal component is closely related to all three factors $X_1$, $X_2$, $X_3$ ($a_{11}$=-0,90594, $a_{12}$=-0,96951, $a_{13}$=-0,77285). This means that they “load” the first principal component with their meaning. Let us remember the economic content of these indicators: $X_1$ – heat of combustion of fuel, MJ; $X_2$ – useful heat of combustion of fuel, MJ; $X_3$ – number of pupils. The negative values of factor loads show that the principal component varies inversely with these indicators, that means it is increasing while they are reducing. By connecting named symptoms-factors into the single one, it can be argued that for the researched schools the principal component reflects the latent economic indicator “social effect”, which is the characteristic of the social component of the sustainable development.

The ecological component of the sustainable development can be analyzed similar to the social component. The symptom-factors for this component are above mentioned indicators of energy system activity, namely, amount of ash waste, kg; amount of sulphur waste, kg; amount of carbon emissions, kg. Principal components matrix for the researched schools are given in Table 3.2.

Table 3.2 - Principal components in the research of ecological component of the sustainable development of energy system

| Factor Scores (NEW.sta) | | |
|---|---|---|
| Rotation: Unrotated | | |
| Extraction: Principal components | | |
| | Factor | Factor |
| | 1 | 2 |
| 1 | 1,03011 | 0,410731 |
| 2 | 1,021562 | 0,414859 |
| 3 | 1,3578 | 0,252462 |

| | | |
|---|---|---|
| 4 | 0,71589 | 0,562493 |
| 5 | 2,019139 | -0,06695 |
| 6 | 2,223265 | -0,16554 |
| 7 | 0,688069 | 0,575931 |
| 8 | 1,341481 | 0,260344 |
| 9 | 0,841812 | 0,501676 |
| 10 | 0,595694 | 0,620546 |
| 11 | -0,86816 | 1,327562 |
| 12 | 0,273703 | 0,776062 |
| 13 | -1,07506 | 1,071335 |
| 14 | -0,8873 | 0,359064 |
| 15 | -0,99993 | 0,78633 |
| 16 | -0,38208 | -1,55751 |
| 17 | -0,52829 | -1,00286 |
| 18 | -0,52538 | -1,01387 |
| 19 | -0,18156 | -2,31818 |
| 20 | -0,68402 | -0,41206 |
| 21 | -0,53945 | -0,96049 |
| 22 | -0,26522 | -2,00082 |
| 23 | -0,38205 | -1,55762 |
| 24 | -1,00381 | 0,801069 |
| 25 | -0,66892 | -0,46935 |
| 26 | -1,05655 | 1,001124 |
| 27 | -1,09082 | 1,131111 |
| 28 | -0,96994 | 0,672558 |

The first principal component, which describes 76.21 % of the overall dispersion of the input symptom-factors, has the following interpretation. The first principal component is related closely to two factors $X_4$, $X_5$ ($a_{11}$=0,9670, $a_{12}$=0,9670). This means that they "load" the first principal component with their meaning. By connecting two symptoms-factors into the single one, it can be argued that for the researched schools the principal component reflects the latent economic indicator "ecological effect", which is the characteristic of environmental pollution from solid waste, that is the ecological component of the sustainable development.

For this indicator let us calculate the coefficient of interpretation, which is the ratio of the sum of the squares of the maximum factor loads for this factor to its overall sum of the squares of its factor loads [30, p. 108].

$$\frac{0{,}9670^2 + 0{,}9670^2}{0{,}9670^2 + 0{,}9670^2 + 0{,}6453^2} = 0{,}8179\,. \quad (3.1)$$

Therefore, variables $X_4$, $X_5$ interpret the latent indicator (identify its name) by 81.8 %.

Then we analyze the economic component of the sustainability. The algorithm was applied twice as above mentioned 28 schools were divided into two groups depending on the type of fuel used for their heating. Thus there are 12 schools in the first group, which consume coal (let us identify them Group A), and 16 schools (Group B) consuming natural gas.

Three symptom-factors of the economic component were identified: amount of money spent on fuel, size of the school building, fuel consumption.

The values of principal components are shown in Table 3.3 (Group A) and Table 3.4 (Group B).

Table 3.3 - Principal components in the research of economic component of the sustainable development of energy system (group A)

| | | | |
|---|---|---|---|
| Factor Scores (NEW.sta) | | | |
| Rotation: Unrotated | | | |
| Extraction: Principal components | | | |
| | Factor | Factor | Factor |
| | 1 | 2 | 3 |
| 1 | 0,465037 | 1,483123 | 1,41208 |
| 2 | 0,087035 | -0,11922 | -0,27659 |
| 3 | 0,880652 | 1,371844 | 0,723797 |
| 4 | -0,1977 | 0,067816 | -2,01208 |
| 5 | 0,934887 | -1,60537 | 0,961796 |
| 6 | 1,26878 | -1,42859 | 0,244954 |
| 7 | -0,4358 | -0,43114 | 0,04872 |
| 8 | 0,897149 | 1,289088 | -1,02236 |
| 9 | -0,09605 | -0,00237 | -0,78398 |
| 10 | -0,53539 | -0,46485 | -0,78027 |
| 11 | -2,28437 | 0,239925 | 0,747489 |
| 12 | -0,98423 | -0,40026 | 0,736446 |

Table 3.4 - Principal components in the research of economic component of the sustainable development of energy system (group B)

| | | | |
|---|---|---|---|
| Factor Scores (NEW.sta) | | | |
| Rotation: Unrotated | | | |
| Extraction: Principal components | | | |
| | Factor | Factor | Factor |
| | 1 | 2 | 3 |
| 1 | -1,20651 | 0,010519 | -0,10071 |
| 2 | -0,54478 | 0,352578 | -0,54106 |
| 3 | -0,87065 | 0,628728 | 0,042739 |
| 4 | 1,203071 | 1,087531 | -0,20501 |
| 5 | 0,317279 | -1,65443 | 0,003715 |
| 6 | 0,580894 | -0,00065 | -1,96691 |
| 7 | 1,330319 | -2,41245 | -0,5855 |
| 8 | 0,241093 | 1,210271 | 0,07854 |
| 9 | 0,419176 | -0,67175 | 2,808775 |
| 10 | 1,619921 | 1,333674 | -0,48128 |
| 11 | 1,151015 | 0,77384 | 1,381453 |
| 12 | -0,94886 | 0,188735 | -0,05575 |
| 13 | 0,034383 | -0,50966 | -0,53938 |
| 14 | -1,13353 | 0,102813 | 0,170877 |

| | | | |
|---|---|---|---|
| 15 | -1,27082 | -0,07101 | 0,198425 |
| 16 | -0,922 | -0,36873 | -0,20893 |

Thus, the was identified the number of the principal components, which will be used in the further research. In the Group A for the first two characteristic roots the condition $d_L \geq 10\%$ is met and the share of variation of the three input symptom-indicators, which is interpret with first two components, is 99.9%. However, the second principal component does not contain high factor loadings that makes it possible to interpret it qualitatively.

In the Group B the condition $d_L \geq 10\%$ is met only for the first principal component, and the share of variation of the three input symptom-indicators, which is interpret with it, is 95.1 %. In this case, in the further calculations we will use only two first principal components $F_1$ for both groups of schools.

Let us give the economic interpretation to the first principal components. For the Group A the first component describes 84.7 % of the overall dispersion of the studied symptom-indicators; for the Group B it describes 95.1 %. In both cases the first principal component is related closely to all three variables $X_7$, $X_8$, $X_9$ ($a_{11}$=0,9722, $a_{12}$=0,8144, $a_{13}$=0,9661 for the Group A and $a_{11}$=0,9878, $a_{12}$=0,9486, $a_{13}$=0,9890 for the Group B). This means that they "load" the first principal component with their meaning. Let us remember the economic content of these indicators: $X_7$ – amount of money spent on fuel; $X_8$ – size of the school building; $X_9$ – fuel consumption. By connecting named symptoms-factors into the single one, it can be argued that for the researched schools the principal component reflects the latent economic indicator "economic effect", which is the characteristic of the economic component of the sustainable development.

Therefore, we have identified quantitatively each of the three components of the sustainable development, namely, social, ecological and economic. Then we can move to the second stage of the evaluation of sustainability level of school energy system (Fig. 3.5). The input variables are the values of the identified first principal components, given in the tables 3.2-3.4. It is possible to use data received in the previous stage due to the fact that these data are standardized and uncorrelated. The results of calculations of principal components matrix for each researched school are given in the Table 3.5.

Table 3.5 – Principal components in the research of sustainability level of energy system

| Factor Scores (NEW.sta) | | | |
|---|---|---|---|
| Rotation: Unrotated | | | |
| Extraction: Principal components | | | |
| | Factor | Factor | Factor |
| | 1 | 2 | 3 |
| 1 | 0,512605 | -0,95868 | 0,910553 |
| 2 | 0,308266 | -1,09146 | -0,0342 |
| 3 | 0,924579 | -1,0406 | 1,144667 |
| 4 | 0,052642 | -0,89115 | -0,50005 |

| | | | |
|---|---|---|---|
| 5 | 1,330798 | -1,50759 | -0,30925 |
| 6 | 1,543045 | -1,62816 | 0,60449 |
| 7 | -0,09786 | -0,96865 | -0,97949 |
| 8 | 0,999997 | -0,93455 | 0,704112 |
| 9 | 0,076539 | -1,06406 | 0,154115 |
| 10 | -0,27427 | -1,01956 | -0,52311 |
| 11 | -1,90455 | -0,43665 | -2,34637 |
| 12 | -0,41178 | -0,62 | -2,83809 |
| 13 | -1,39932 | 0,175429 | 0,529483 |
| 14 | -0,8175 | 0,425787 | 0,906024 |
| 15 | -1,14945 | 0,278111 | 1,00201 |
| 16 | 0,929191 | 1,316923 | 0,473691 |
| 17 | 0,092175 | 0,767631 | 0,528051 |
| 18 | 0,26873 | 0,903899 | 0,948512 |
| 19 | 1,204742 | 1,324756 | -0,32895 |
| 20 | -0,01808 | 0,876098 | 0,57897 |
| 21 | 0,299865 | 0,998804 | -0,28534 |
| 22 | 1,534014 | 1,752321 | -0,92731 |
| 23 | 1,146754 | 1,581217 | -1,34142 |
| 24 | -1,1 | 0,359713 | 0,173635 |
| 25 | -0,03689 | 0,883383 | -0,5458 |
| 26 | -1,39074 | 0,141802 | 0,949309 |
| 27 | -1,47984 | 0,119887 | 0,661257 |
| 28 | -1,14367 | 0,255359 | 0,690502 |

Let us give the economic interpretation to the first principal components, which describes 74.5 % of the overall dispersion of the studied symptom-indicators. The first principal component is related closely to variables, which characterize the social and economic components of the sustainable development ($a_{11}$=-0.9267, $a_{13}$=0.9672). This means that they “load” the first principal component with their meaning. The negative value of the factor loading $a_{11}$ shows that the principal component varies inversely with this indicator. As the factor loading of the ecological component is also high enough ($a_{12}$= 0.6634), it can be argued that for the studied schools the first principal component reflects the latent economic indicator “sustainability level”, which is the characteristic of the combined social, ecological and economic effects of the sustainable development.

Let us calculate the coefficient of interpretation for this indicator:

$$\frac{(-0{,}9267)^2 + 0{,}9672^2}{(-0{,}9267)^2 + 0{,}6634^2 + 0{,}9672^2} = 0{,}8030. \quad (3.2)$$

Therefore, the components of the sustainable development interpret the latent indicator (determine its name) by 80.3 %.

It is possible to range studied schools by the value of the latent indicator “sustainability level”. For this purpose the principal components matrix was used (Table 3.6). Each school was given a rank corresponding to the values of the first principal component (Table 3.6).

Table 3.6 – Ranking of the schools of Rozdilna district by the energy system sustainability level (2012)

| No | Name of school | Value of the first principal component | Rank |
|---|---|---|---|
| *1* | *2* | *3* | *4* |
| 1 | School of Bolharka | 0,512605 | 9 |
| 2 | School of Butsenivka | 0,308266 | 10 |
| 3 | School of Vynohradar | 0,924579 | 8 |
| 4 | School of Kamyanka | 0,052642 | 15 |
| 5 | School of Kalantayivka | 1,330798 | 3 |
| 6 | School of Novoukrayinka | 1,543045 | 1 |
| 7 | School of Slobidka | -0,09786 | 18 |
| 8 | School of Stepanivka | 0,999997 | 6 |
| 9 | School of Betsylove | 0,076539 | 14 |
| 10 | School of Novoselivka | -0,27427 | 19 |
| 11 | School of Pavlivka | -1,90455 | 28 |
| 12 | Educational complex Stepanivka | -0,41178 | 20 |
| 13 | School of Burdivka | -1,39932 | 26 |
| 14 | School of Yehorivka | -0,8175 | 21 |
| 15 | School of Yeremiyivka | -1,14945 | 24 |
| 16 | School of Kuchurhany | 0,929191 | 7 |
| 17 | School of Poniativka | 0,092175 | 13 |
| 18 | School of Shcherbanka | 0,26873 | 12 |
| 19 | School of Yakovlivka | 1,204742 | 4 |
| 20 | School No. 1of Lymanske | -0,01808 | 16 |
| 21 | School No. 2 of Lymanske | 0,299865 | 11 |
| 22 | School No. 1of Rozdilna | 1,534014 | 2 |
| 23 | School No. 2of Rozdilna | 1,146754 | 5 |
| 24 | School No. 3of Rozdilna | -1,1 | 22 |
| 25 | School No. 4of Rozdilna | -0,03689 | 17 |
| 26 | School of Hayivka | -1,39074 | 25 |
| 27 | School of Markivka | -1,47984 | 27 |
| 28 | School of Starostyne | -1,14367 | 23 |

According to the fourth column of Table 3.6, the school of Novoukrayinka has the highest level of sustainability related to its energy use (rank 1). The obvious outsider in energy services is the school of Pavlivka (rank 28). It, indeed, has the low number of pupils, uses coal for heating, which is more expensive and leads to excessive emissions to air.

The others schools have the intermediary position between the above mentioned ones. Moreover you can see their differentiation by the values of the first principal component. The schools with numbers 1, 2, 3, 4, 5, 8, 9, 16, 17, 18, 19, 21, 22, 23 have the positive value of the principal components and can be included in the group of leaders. The schools with numbers 7, 10, 12, 13, 14, 15, 20, 24, 25, 26, 27, 28 have the negative value of the first principal component and form the group of outsiders by the sustainability level.

Therefore, researched schools were ranked by the value of the latent indicator "sustainability level". Based on the given ranks the groups of leaders and outsiders were formed.

The similar analysis was conducted applying to the schools of Rozdilna districts for the years 2010 and 2011. The results received show that during that three-year period the groups of leaders and outsiders remained almost constant. Only schools, for which the values of the principal component are close to zero, could be included to the group of leaders, as well as to the group of outsiders from year to year.

It can be argued that the key actions in energy management should be aimed to the very schools, which were included to the group of outsiders, in order to increase their sustainability level.

Therefore, the principal component method give the opportunity to take into consideration the interrelations between indicators characterizing the sustainable development of school energy systems, to quantify this latent indicator and to interpret received results in economic terms.

Conducted analysis made it possible to identify leaders and outsiders among researched schools. It was also identified which symptom-factors impact the researched indicator, sustainability level of energy sector. All this enables to develop activities in enterprise energy management in order to increase their energy efficiency.

### 3.1.2. Organization of energy controlling in district management structure

Decentralization reform is continuing in Ukraine since 2014. It includes the extending the powers of local authorities and transfer of more financial resources to local executive committees. One of the main purposes of this reform is to provide every inhabitant with high-quality social services, among which the high level of education. In the accordance with the decentralization process the territory communities are being established, as well as educational districts and supporting schools. These schools will be able to provide all the children with quality education and to use resources more efficient.

In January 2019 there were 34 supporting schools in Odessa region, but none in Rozdilna district. Nevertheless, the problem of increasing the sustainability level and efficient energy management is one of the most important for ensuring the quality of education for the local inhabitants. Increasing the efficiency of energy resources use can be achieved through the improvement of enterprise energy management. The main reserves of energy efficiency increase are concentrated in energy management system, since it is related to solving the problems of planning, analysis, control, coordination and regulation, as well as information support of managerial decisions.

District management believes that controlling as system concept of management can create an efficient methodological and instrumental basis for the successful implementation of these tasks.

Today different departments perform the functions of energy management: accounts department (bookkeeping and accounting), department of planning and economics, HR (motivation of staff) etc. However, it is necessary to establish internal links for their effective performance. Controlling concept examines an enterprise as an integrated system, where information flows play the important role. That is why the decision of controlling implementation at the enterprise, in any case, will lead to organizational changes. It will be necessary to form the organization structure, in which departments will not duplicate functions, but to fulfill all the tasks faced by the enterprise.

The choice of organizational structure should be done taking into account the specific nature of the particular enterprise. However, there are common features for the budget organizations.

Figure 3.2 presents the organizational structure of Rozdilna district state administration in accordance with the division of responsibilities between the head of administration and his deputies.

It is shown that the line of command runs by the functional principle. That means that finance administrator and factual manager is the department of education represented by the school director, but the workers of energy sphere are subordinated to the department of housing and commune services of administration.

This allows managing each school with competence without transfer of functions to the specialized departments of the district state administration. However, it is commonly seen that there is no coherence of orders from administration that leads to reduction in the efficiency of energy management.

District administration today may change the management organizational structure in order to provide controlling implementation in the energy management. In according with this it is possible to create Board of the district administration, which will be able to take responsibility for controlling functions. The boards of district administrations are consulting and advising bodies, which are created to provide recommendations for district administrations in the main tasks implementation.

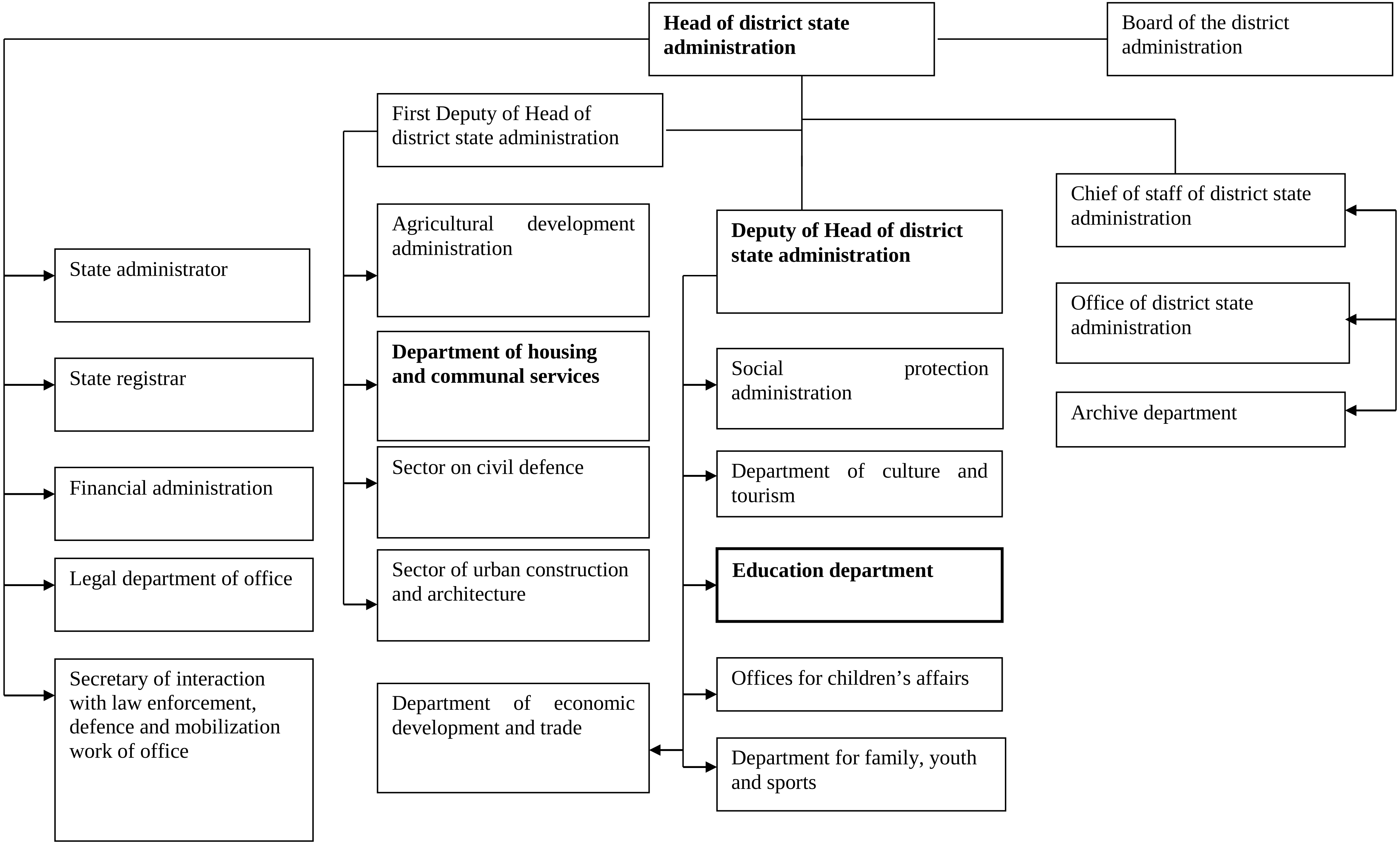



Fig. 3.2 – Structure of state administration in Rozdilna district

Today these boards consist of heads of district state administration, first deputies and deputies of heads, chiefs of staff, chiefs of other departments, etc. Boards' work is periodic in the form of meetings, decisions are made by vote.

However this situation does not reflects the main mission of these bodies. They should be organized as separate departments (project groups), which will monitor the implementation of tasks and decisions, as well as manage by exception in district state administration activity, promote improvement of socio-economic development of each district.

Controllers from among personnel of each department of district state administration will work in this department; harmonize conflicts, which arise between different departments in the issues of financing, budgeting, personnel administration in district state administration, its departments, administrations of towns and villages, enterprises and organizations, which are subordinated to them.

Board meetings should be devoted to the issues of prioritizing for action, selection of further work directions of district state administration, as well as alternatives for their implementation. Therefore, organization of controlling system in the structure of district state administration (illustrated by Rozdilna district) is presented in Fig. 3.3.

Controlling system without expansion of managerial staff should operate as project group and focus on the result. On the one hand, this will enable to increase efficiency of district state administration. On the other hand, this will not increase management cost.

Such an organization of controlling in organizational structure will allow integrating functional relations between departments whilst their specialization in key spheres of competence, including energy management. Controlling department will be formed from several workers (controllers), whose responsibilities include decision making in energy management.

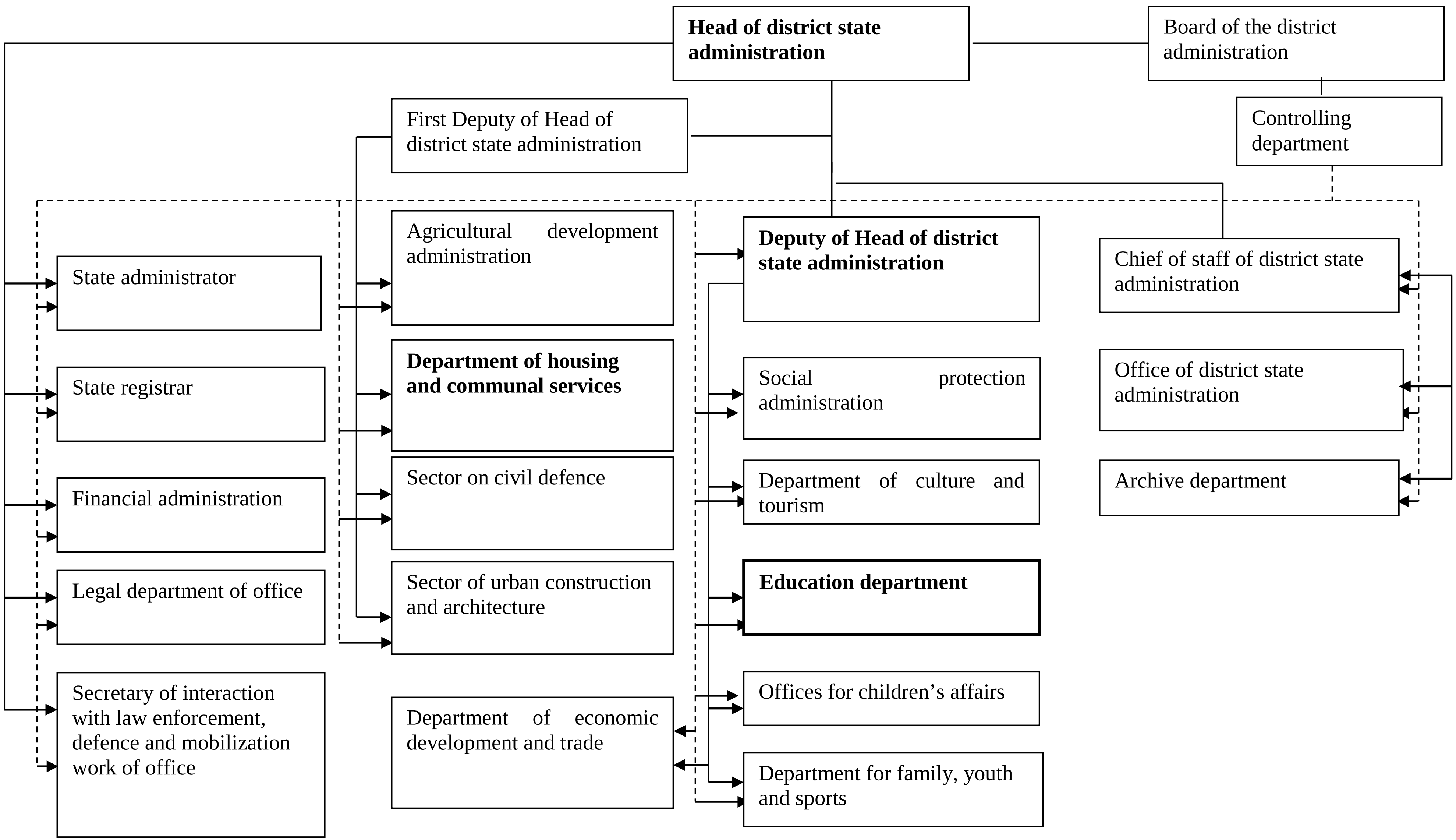



Fig. 3.3 - Organization of controlling system inside state administration of Rozdilna district

While organizing controlling system in management of commercial and non-profit organizations, its management rationalization takes place that is addressing all challenges, enterprises facing. It is achieved through the adaptation to the common goal. Controlling include all the enterprise activities through its functions implementation (planning, information support, analysis and control, coordination and regulation. It can be applied to the energy system activities. Table 3.7 illustrates the main controlling functions, specified for enterprise energy system.

Table 3.7 – Functions of energy controlling

| ***Controlling functions*** | ***Controlling functions in energy management*** |
|---|---|
| Planning | Development of alternative plans for energy consumption taking into account the results of energy energy-saving actions and assessment of the possibilities of their implementation; coordination of plans for energy saving with other enterprise plans |
| Information support | Formation of communication links between responsibility centers, places of cost creation, management and external environment of enterprise; processing information on indicators of energy efficiency; providing the management with full and reliable data on the state of energy system development |
| Analysis and control | Account and control of processes of energy generation and consumption, as well as costs, influence on environment and level of social development related to the energy consumption; comparison of actual and planed values of indicators; identification of anomalies, analysis of these anomalies reasons; actions development for their elimination; monitoring the results of these actions |
| Coordination and regulation | Alignment of objectives of energy management with enterprise's mission and strategy; identification of influence of energy system results on the results of the enterprise as a whole (including financial results), on the degree of achievement of enterprise general results. |

Implementation of controlling in the enterprise management system is certainly is complex and long process, which needs managerial support at the every stage of its formation. It imposes high standards to the workers, which will put this concept into enterprise's practice. However, as a result, the achievement of higher level of development enterprise as a whole and its energy system will be ensured.

### 3.1.3. Measures to improve the sustainability level of energy system

The researched organizations, as well as all others energy consumers, focus on reducing costs in their energy systems, increasing the level of consumed energy services. In order to achieve this, the management of enterprises and their energy departments should develop low-cost actions, which have high energy efficiency, as almost every energy system of enterprise has the reserves of cost reduction. Revealing and using of them will allow to increase the efficiency of enterprise energy system.

Successful implementation of these actions into practice should be done in a way that enterprise management can monitor trends in energy system development and to adapt promptly to them, using the discovered opportunities and preventing emerging threats. This can be executed through the implementation of controlling concept to the energy management.

One of the main ways to effective management is internal reserves mobilization that means unused opportunities to reduce cost of energy system functioning for the given level of economic development.

Harmonization of enterprise activity with energy efficiency increase according to the world trends of energy sector development require reserves activation, modernization of internal production and energy consumption processes, energy system re-focusing on more sustainable way. It will lead to increase of efficiency of energy resources use, reduce the dependence on traditional energy resources and will allow enterprise to take additional advantages in the form of money savings from energy system maintenance. Taking this into account, management is considering the possibility of implementation of certain actions to increase the level of sustainability of energy system of enterprises-outsiders from the perspective of each group of internal factors.

It is worth emphasizing that all the actions, which are oriented on the improvement of energy system operation, should be implemented simultaneously and systematically in order to provide best results in the short time.

One of the challenges for enterprises, which implement actions in energy efficiency, is limited financing. However in the current circumstances this problem can be overcome.

Firstly, all suggested actions have short payback period. That means that using own money for improvement of energy system, enterprise receives additional benefits in the form of financial savings from saved energy resources.

Secondly, implementation of energy saving programs can be financed with money obtained from special micro financing programs, among which Ukrainian Program in energy efficiency improvement (UKEEP), which is financed by the European Bank for Reconstruction and Development. These programs are extremely beneficial mechanism for enterprises that allow to reduce cost on energy consumption. As a results, there is an increase in revenues, risk reduction, related to energy consumption, positive impact on the environment. For non-profit organizations the important source of financing are grants to conduct energy efficient actions. Moreover, financing energy efficient projects can be made from state and local budget.

Thus, the main actions directed to the improvement of enterprise energy system from the perspective of each group of internal factors should be following.

1. Material and technical factors.

First action, which should be carried out by enterprise, is energy audit, which includes primary energy examination, certification and development of energy saving program. Energy audit is complex and time-consuming process. Its implementation can be conducted by involving specialists of outside organizations (outsorcing). Indicative cost of this action is UAH 50,000. This measure will allow to identify primary actions for energy system modernization and to calculate their payback periods. Moreover, energy audit is the first step on the way of energy management implementation at the enterprise. Energy audit can also reveal the hidden reserves of improvement of efficiency of energy system that cannot be seen by enterprise reporting and that are related to improvement of technologies.

The next step for the enterprises-outsiders should be reconstruction or replacement of ineffective boilers.

Today boilers, which use renewable fuels (pellets or granules from sawdust, straw, sunflower husks) have increasing energy efficiency. For heating of non-profit organizations it is advisable to use boiler AKO-200. Its advantages are low share of harmful substances in the produced smoke, high effectiveness (87 %), high safety and simple operation.  Cost of the boiler is UAH 97,500. Using of cheaper energy resources in comparison with natural gas and coal can save money for enterprise. According to preliminary calculations, the cost of heating can be reduced by 51.61 %.

The third way to improve efficiency of enterprise energy system is installation of decentralized direct-flow ventilation system (recuperator) "Prana-200C" (half-industrial. This re-equipment will cost UAH 5,000. Nominal working life is 10 years. Effectiveness is 67 %. Electricity consumption is from 12 to 54 watt-hours depending on mode of operation.

Taking into account high technological effectiveness of this ventilation system, its use will allow to reduce energy consumption by 3992.4 KWatt-hours over the heating period, which is 0.81 % for the enterprise-outsider.

2. Social factors.

One of the major impediment to the successful implementation of advanced technologies in enterprise energy sectors is the lack of information, which is essential for enterprise workers at the different level of the energy chain. As a result, the vast majority of workers, including managerial staff, do not know which actions will lead to overuse of energy and even to its loss. That is why enterprise managers face the challenge to create awareness of energy use issues, to improve of educational level in and popularization of advantages of energy saving, as well as to create interest in fulfillment of enterprise energy program. Awareness of functionaries about economic, ecological and social issues of energy saving should become the priority, which is related to human resources development in energy management.

Moreover, energy system in its direct work should base on scientific developments. That means that science and practice should be related closely and latest energy saving processes and technologies should be implemented in enterprise activities based on the complex of scientific researches.

In order to improve energy system work on social factors, following recommendations can be developed for specific enterprise:

1) Identification of awareness level of enterprise personnel on issues related to energy consumption. This task can be completed through a survey among workers

of energy system (development of questionnaires and results interpretation) and HR (conducting the survey). If it is necessary, the consulting services on issues of energy saving can be used. Based on the results the expert in energy saving issues should instruct workers, eliminating gap in workers' knowledge.

2) Material and moral motivation of enterprise workers. The success of energy saving actions is related closely to willingness of personnel to implement them into enterprise activity. Thus enterprise management needs to introduce system of material and moral motivation of workers for energy saving. Material incentives are systems of bonuses accordingly to energy saving objectives. The material motivation system can be developed by HR department with the support of experts of energy department. Moral motivation is also an integral part of working with staff. It uses commendations, honor roll, as well as participation in seminars and workshops on energy saving issues, etc.

3) Cooperation between enterprises and special educational institutions. Agreements with high educational institutions to conduct researches on specific topics, related to enterprises and their energy systems activities, will make it possible to create scientific basis for practice. Moreover, collective creation of educational programs and requests for the specialists will allow to direct future enterprise workers on real practice.

2. Organizational factors.

Improvement of enterprise energy system on the organizational factors can be implemented in the following areas:

1) Improvement of production and labor organization;
2) Improvement of economic mechanism (systems of management, planning and forecasting, improvement of innovative and investment processes, financing, personnel motivation, etc.).

As a part of the first area it is proposed to hire staff of boiler-house under fixed-term labor contract, as their work depends on the natural and climate conditions and is carried out only during heating period. This contract can be concluded since 1st of October (include time of preparation for heating season) to the end of the heating season, that means that contract is concluded for 6-7 months. This action allows to reduce labor cost by 40 %.

The second action is the development of preventing maintenance system of energy equipment and taking actions of monitoring, services, renovation of energy equipment. It is worth mentioning that major repairs and modernization can be done by the workers of energy department with appropriate qualification, as well as by outsourcing services.

The above mentioned actions can be implemented in the activities of commercial and non-profit organizations, as, on the one hand, it will lead to economies even while energy services are increasing, on the other hand, and there is a positive ecological effect through use of renewables and through reducing use of energy resources, which is the main goal of social enterprises. Moreover, it is possible as energy systems of commercial and non-profit organizations are similar in the functioning. However, the approaches to their management are different.

### 3.2. Usage of energy controlling tools in industrial enterprise. Case of “ODESKABEL“ PJSC

“ODESKABEL“ PJSC is one of the largest manufacturers of cable and wire products in Central and Eastern Europe. It focuses on production of cables for the telecommunications market and the energy sector. Main products are copper and aluminum power cables and wires, copper LAN-cables, fiber-optic cables, telephone cables, coaxial cables, fire safety cables, video surveillance cables, industrial interface cables, heating cables, heated floors, structured cable system OK-net.

The history of ODESKABEL begins in the USSR in 1949. Now ODESKABEL is a private company with modern production. ODESKABEL product range totals more than 10 000 wire and cables types. The high quality of ODESKABEL products has been confirmed by testing in international laboratories and by deployment of the following international standards:

- ISO 9001:2015 (TÜV CERT) – quality management system;
- ISO 14001 – environment management system;
- OHSAS 18001 and SA 8000 – industrial safety and social responsibility management systems.

The management is planning to implement the requirements of the Energy Management Standard ISO 50001:2011 in the future and now is working on definition of enterprise energy strategy and implementation of the western experience on energy management. However the existing energy strategy requires documented definition and energy management requires relevant instruments, particularly organizational and economic ones. The next step should be the transformation of the department of the chief power engineer into the department of energy management, which will pay more attention to managerial work that is planning, organization, motivation, control and coordination. That is why from a scientific and practical perspective a synergy of energy controlling and energy management is advisable from the very beginning of their implementation at the enterprise.

The energy services in ODESKABEL involve 48 persons. The structure of energy department is demonstrated on Figure 3.4:

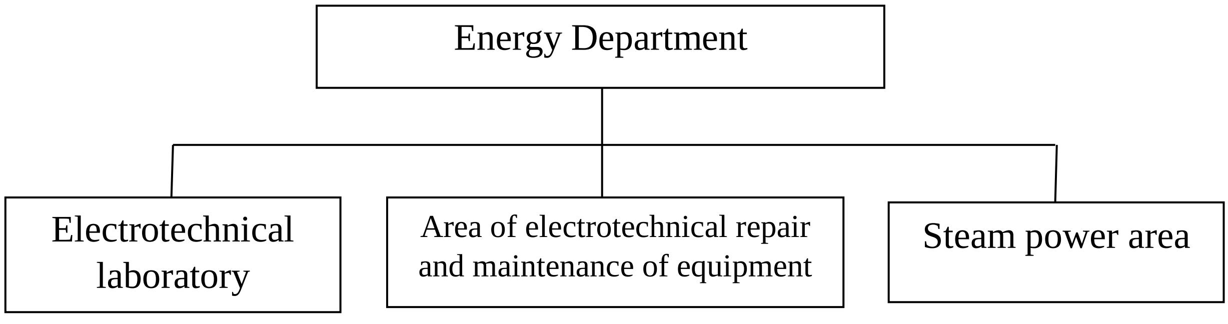



Figure 3.4 – Structure of energy department

The energy department partially uses energy controlling tools for planning, control, and information services but it has nothing to do with consulting activities. Despite the fact that this is sufficient for its coordinated and effective work, enterprise management requires constantly the improvement of efficiency of all departments, reduction of costs, including through the improvement of total energy efficiency.

Existing energy department at the enterprise deals with mostly operational planning in the energy sphere. Its main task while fulfilling this function is providing the availability of energy resources and smooth functioning of energy equipment for sustainable enterprise activity with minimum allowable cost. In planning the controlling instruments are used, but often in non-formalized or transformed form.

For instance, there is no energy balance in its pure form at the enterprise. Instead, the forms of the state statistical observation No 11-mtp "Report on the results of using the fuel, heat energy and electricity" and No 4-mtp "Report on the using and reserves of the fuel" are prepared and used in the planning and analytical work.

For internal use the document, which reflects in details the consumption of energy resources and water by the enterprise departments, equipment, energy points, etc., is developed based on the above mentioned forms of statistical observation. The calculation is conducted through the actual consumption or calculated planning requirements for energy resources of specific department / equipment / workplace. Losses in the power grid are identified depending upon whether high or low voltage cables are used in the grid. Also it is important whether old or new type of transformers is used for powering of different appliances.

For visualization of energy flows, which also contributes to the energy planning, the enterprise uses:

1) heat and mechanical scheme of boiler house;
2) schemes of implementation of automatic electricity accounting system (AEAS) – electricity supply, powering own needs (see Figure 3.5), etc.

Each of the schemes is intended to illustrate heating energy or electricity flows at the enterprise. The specific volumes of energy consumption are recorded separately by indicators of meters.

ODESKABEL works 24 hours a day in three shifts. The discrete nature of its production can be seen at weekends and holidays. Thus during the working week energy voltage is more or less equal and voltage management through the equalization of its weekly schedule is not advisable and feasible. Figure 3.5 demonstrates weekly electrical load with a 2-hour breakdown.

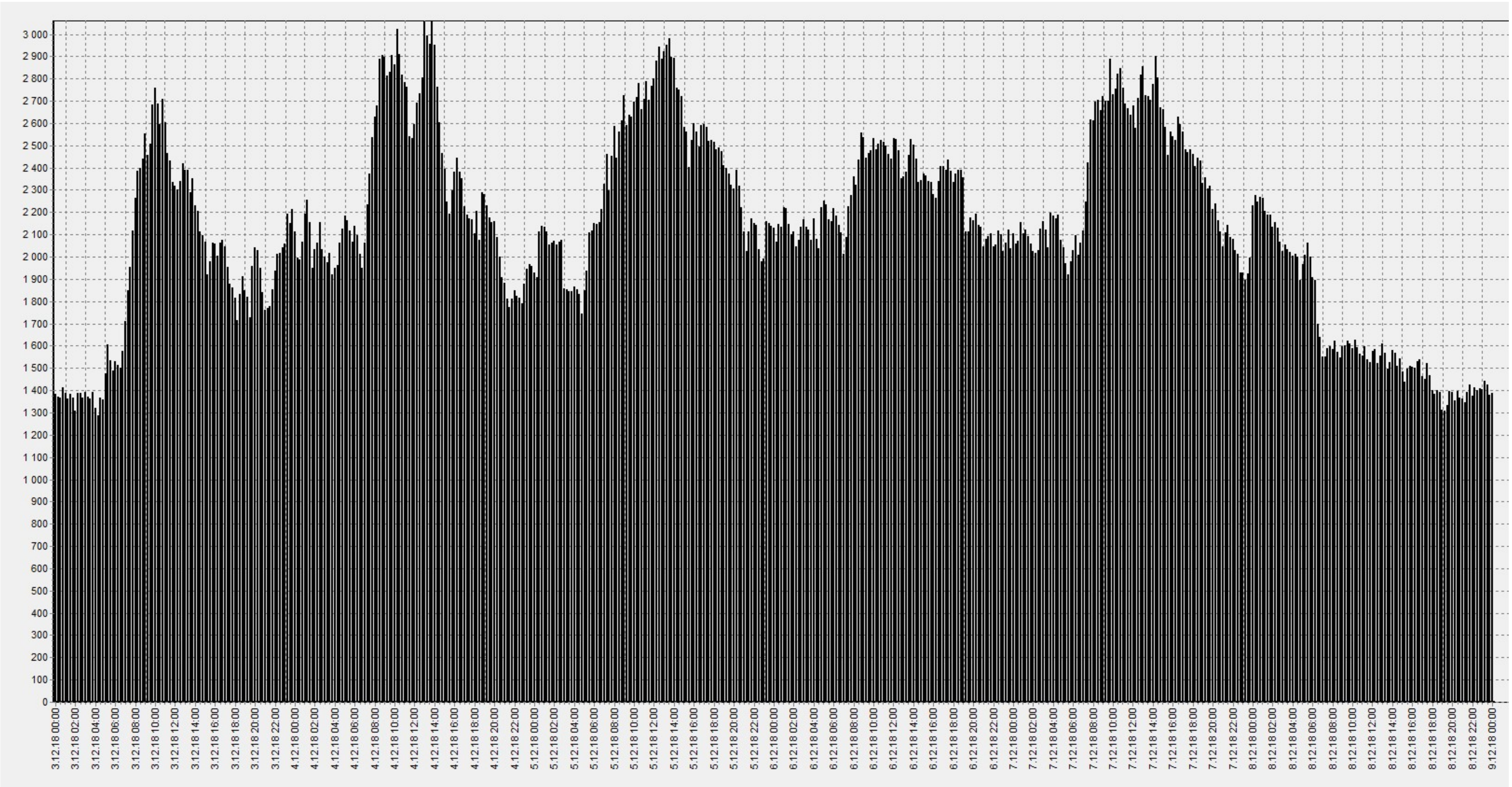


Figure 3.5 – Weekly electrical load with a 2-hour breakdown by monitoring of  AEAS (extract)

The peak loads of hot water utilization are observed on Friday evening and on Monday morning. The enterprise has own boilers for heating water, which are turned out after the peak load on Friday and are turned on in advance on Sunday before Monday's peak load. Starting their heating on Saturday is inappropriate.

The analysis of energy market is of interest to the enterprise from the point of view of energy resources suppliers. Since 2017 ODESKABEL has not been consuming the natural gas in its production and business activity. Before that the natural gas was used only for space-heating and water heating purposes. The decision about replacement of the gas boilers with the pellet boilers was made by the enterprise management according to the unstable situation in the market. Thus, analysis of the energy market that is conducted at the enterprise is focused on the selection of the electricity suppliers and producer of pellets.

On 13th April 2017 the Verkhovna Rada of Ukraine adopted the Law of Ukraine "On Electrical Energy Market". Thus, the state monopoly in the electrical energy market, in which the functions of "single seller-buyer" were carried out by the State-Owned Enterprise "Enerhorynok" and the prices were regulated by National Energy and Utilities Regulatory Commission, should be replaced by the competitive liberalized model, which is required by EU Third Energy Package. Since 11th December 2018 in implementation of this law National Energy Company "Ukrenergo", which carries out function of the administrator of the commercial accounting and transactions between the market participants began test operations of buying and selling the electricity in the test platform of the balancing market and market of supplementary services Market Management System [31]. That is why ODESKABEL does not have a wide choice of electricity suppliers but it is worth mentioning that in general the enterprise is fully satisfied with the quality of services and price level of the existing monopolist in the electricity market.

Table 1 shows results of survey among experts of ODESKABEL concerning its risks in the energy sector. They consider energy risks as low level and with small influence on manufacturing activity. The exceptions are technical risks, which although have a low probability of occurrence due to the harmonized work of the energy department, however, in case of their ignoring the enterprise finds itself in a critical state. That is why the risk management in the energy department is directed to the technical risks prevention through the constant monitoring of energy equipment, searching of the alternative ways of energy production, accumulation of energy resources reserves, etc.

Table 3.8 – Matrix of energy risks on ODESKABEL

| Risks | Probability of occurrence | Possible consequences for the organization | | | |
|---|---|---|---|---|---|
| | | Shutdown of the enterprise | Critical state | Difficult situation | Insignificant |
| Investment | High | | | | |
| | Average | | | | √ |
| | Low | | | | |
| Technological | High | | | | |
| | Average | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | Low | | √ | | |
| Procurement | High | | | | |
| | Average | | | | |
| | Low | | | √ | |
| Ecological | High | | | | |
| | Average | | | | |
| | Low | | | | √ |

Latest conditions of business activity require the higher level of energy efficiency and the measures on energy efficiency require certain investment. ODESKABEL implements the investment projects including projects in the energy sphere, particularly using its own financial resources and calculates thoroughly investment-related costs, as well as the further supporting the investment projects.

According to table 2 investment projects in the energy sphere are passing through the whole PDCA-cycle at the enterprise and are supported by the relevant departments. The interaction of the controlling department and the department of chief power engineer is the characteristics of the beginning of energy controlling formation that was caused by the objective reality of the business activity. According to the standard ISO 50001:2011 the engagement of management in the investment activity in the energy sphere and in general energy issues is extremely important.

Table 3.9 – PDCA-cycle in the investment activity of ODESKABEL

| Stages of PDCA-cycle | Energy controlling tasks | Executive department |
|---|---|---|
| Plan | Specification of the investment goals and the requirements to the investment projects in the energy sphere of organization<br>Development of the measures for energy efficiency, energy saving, etc.<br>Analysis of the alternatives<br>Investment calculations and risk assessment<br>Investment budgeting | Chief power engineer<br>Controlling department |
| Do | Due diligence<br>Detail evaluation of investment projects realization<br>Integration into production processes<br>Recording the purchase price, investment guarantees, insurance, etc. | -<br>Chief power engineer<br>- |
| Check | Control over achievement of targets set (qualitative and quantitative)<br>Managerial monitoring of the equipment during the life-cycle<br>Tracking of physical and moral obsolescence, depreciation of established equipment<br>Work on errors, training | Chief power engineer |
| Act | Investment budgeting and cost budgeting<br>Consideration of the investment project alternatives (freezing, reinvestment, expansion) | Enterprise management |

| | | |
|---|---|---|
| | Regulation of implementing investment projects over time<br>Real option assessment | |

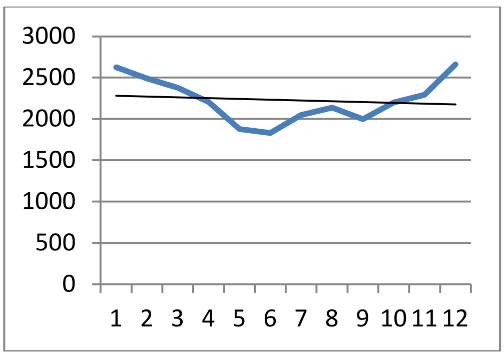
Morphological matrix of energy strategy parameters has never been used before at ODESKABEL but the enterprise has already been working on own energy strategy. The suggested pattern made significant contribution to determine the quantity of energy strategy parameters, which should be documented.

According to table 3.10 the enterprise in its energy strategy indicates a general consistency in possible reduction of energy costs. In order to do this the different energy supply channels, gradual transition towards the less energy-intensive technologies and processes, diversification of energy resources are used.

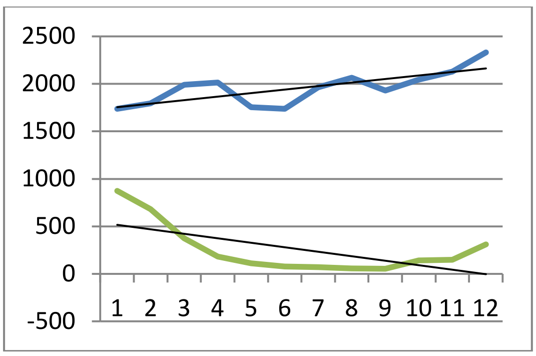
Table 3.10 – Definitions of enterprise energy strategy parameters according to the morphological matrix pattern

| Energy strategy parameters | Alternatives of strategic goals | | | |
|---|---|---|---|---|
| Supply | Centralized supply | Building up the suppliers portfolio √ | Suppliers portfolio and own production | Supply management (smart grid) |
| Efficiency | Cost minimization √ | Optimization of technologies and processes √ | Implementation of new technologies and processes | Product update |
| Quality | Reactive behaviour | Active internal prevention of risks of disconnection from the grid | Active internal and external prevention of risks of disconnection from the grid | |
| Harmful emission | «Green energy» | Traditional energy resources | Combining energy resources √ | |
| Energy flows management | Own production | Procurement from outside √ | Combining production and procurement | |

According to the above mentioned energy strategy the enterprise energy department monitors carefully the energy costs dynamics, analyses them thoroughly in order to reduce the total costs and costs on energy resources, as well as seeks opportunities for energy saving and alternatives of energy production. The example of making the managerial decision to stop natural gas consumption based on the energy consumption analysis is the situation, which arose at the enterprise in 2015 (Figure 3.6).




A) general energy costs



B) costs by the main energy resources

Fig. 3.6 – Energy costs in 2015

The enterprise had a stable enough trend of general costs (figure 3a). However, costs by the main energy resources (electricity and natural gas) had opposite dynamics. Through a significant reduction of the natural gas consumption, particularly during the warmer months there was a decreasing trend in the costs on natural gas (figure 3b). That is why the management decided that the refusal of gas consumption and replacement of gas boilers by alternative boilers (on pellets) will not cause significant harm but has the ability to reduce specific energy consumption, as well as to increase enterprise energy safety in those conditions. As time goes on, the enterprise is more and more satisfied with the decision made related to the transition towards the alternative energy resources, as a significant increase in tariffs on natural gas in the next years would become real trial by fire.

In the current activities of the enterprise the reports of the energy department are aimed for the state statistical observation, for managers' awareness and for own control and analytical observation. Most of the records and calculations for internal use are recorded in spreadsheets and then are used for the control and analytical work and for compilation of the reports for the management and state statistical bodies.

Taking into account the commitment of the enterprise management to applying the international standards on energy management, it is advisable to compare the existing energy reporting with reporting required by the standard ISO 50001:2011 in table 3.11. Such a comparison is extremely important for reloading of energy department, as the availability of certain energy reporting is crucial to the creation of systematic energy management and the key element for ISO certification.

Table 3.11 – Comparison of the elements of internal energy reporting of ODESKABEL and the list of required reports of standard ISO 50001:2011

| The list of required reports according to the international standard of energy management ISO 50001:2011 | The list of existing at the enterprise energy reports |
|---|---|
| From management | |
| 1. energy policy;<br>2. results of the analysis of the energy management system | 1. energy policy / strategy |
| From responsible energy manager | |
| 1. report on the level of energy efficiency;<br>2. report on the functioning the energy management system; | 1. report on water and electricity consumption;<br>2. energy passport of the enterprise |

| | |
|---|---|
| 3. report on the internal audit | |

Therefore, not taking into account individual records, which are proposed to use in energy management by the standard ISO 50001:2011 and which were named in previous chapter, it may be concluded that the enterprise does not have enough reports on energy efficiency level and energy management system functioning , which are still being developed by energy department and chief power engineer.

Application of special software in energy sphere of enterprise is still limited by using AEAS. This situation is typical enough for energy systems of domestic enterprises. The point is that in its orders the National Electricity Regulatory Commission has long demanded from enterprises to establish local equipment of data collection and processing or automated system of commercial registration of consumer's electricity in order to organize transactions with electricity transmitting organization [32]. Since 2017 in Ukraine there is a Law of Ukraine "On electrical energy market", which implements the requirements of legal and regulatory acts of the Energy Community. For example, according to the law the Code of commercial registration determines "the main statements of organization of electricity commercial registration in the electrical energy market, rights and duties of market participants, suppliers of commercial registration services and administrator of the commercial registration of providing the electricity commercial registration, receiving accurate and reliable data of commercial registration and their aggregation (consolidation), procedure of registration of commercial registration services, points of commercial registration and registration of automated systems, which are used for commercial registration of electricity". [33]. This means that the implementation of the systems similar to AEAS at Ukrainian industrial enterprises is approved at the legislative level.

Nevertheless, domestic producers of AEAS try to increase the abilities of own automated system, which are proposed by them in the market, and not be limited to the recording the consumed energy according to meters. The functional and informational abilities of AEAS as the software for energy sphere of industrial enterprise will be considered in details in the next chapter.

The AEAS for ODESKABEL was developed by LLC «Elektroservis-Pivden" bases on technical means of LLC "Telekart-Prylad" in 2003. It is based on the relational system of database management SQL-server and has following purposes:

- data storage and processing;
- measurement in real time and data transmission from the measuring devices (electricity meter) through the server to work stations;
- entering and obtaining data through the calculation, which are not the results of measurements (financial, economic and other information);
- providing the necessary information to the specialists of energy department taking into account rights to access to information and its confidentiality.

The workers of energy department are quite content of work of installed AEAS. It can also record the anomalies in the work of equipment, in energy consumption, etc. The anomalies, which are caused by technical reasons, are analyzed first of all and their consequences are eliminated immediately.

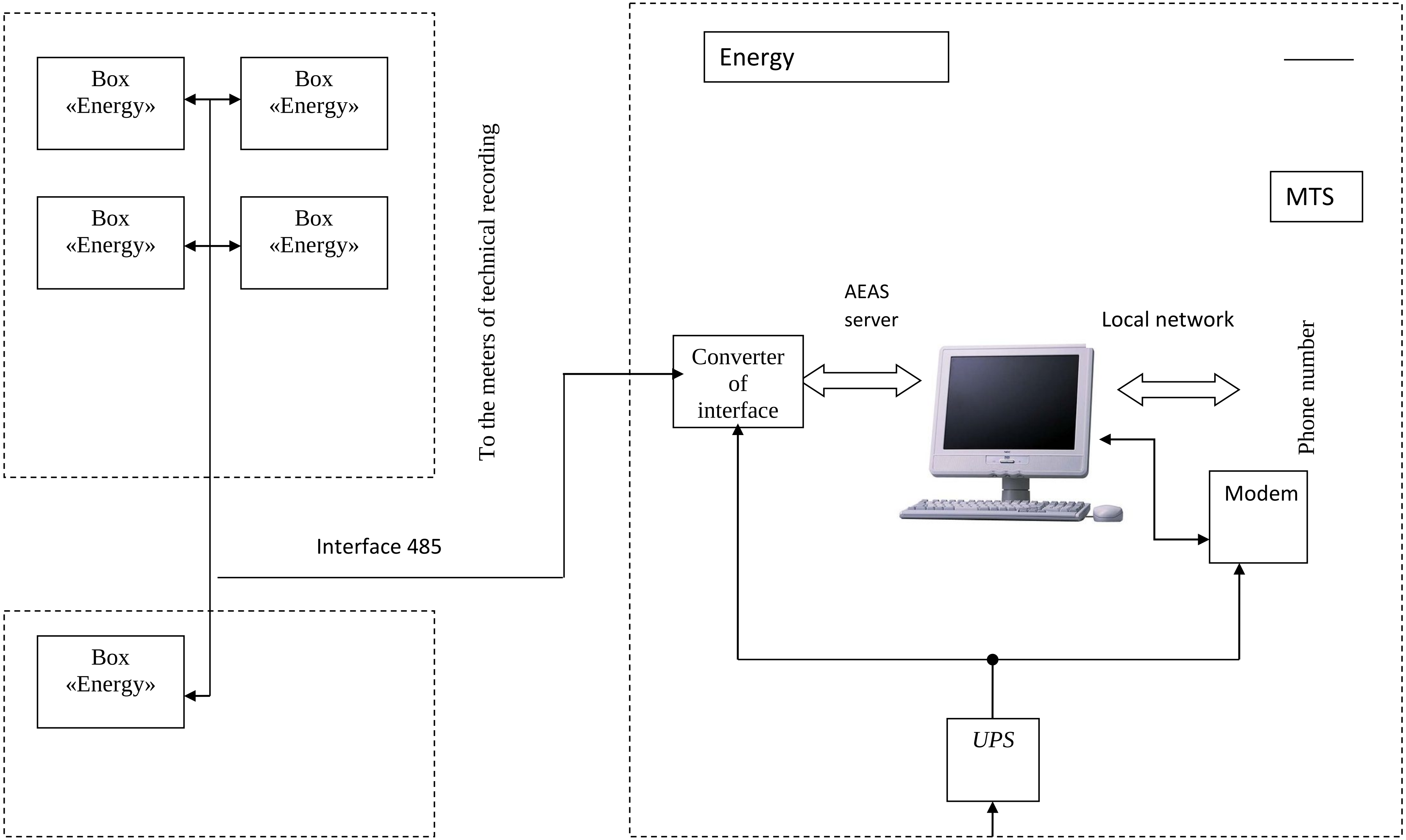



Figure 3.7 – General structural scheme of AEAS ODESCABEL

The energy department uses and follows the dynamics of two main energy indexes (table 3.12):

- energy intensity of output and
- energy per one worker.

Table 3.12 – Dynamics of the main energy indicators, which are used in the analytical work of enterprise energy department

| Indicators | Years | | | | |
|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2016 | 2017 |
| Energy consumption, thsd. UAH | 18271 | 11418 | 18871 | 31218 | 30422 |
| Production volume, thsd. UAH | 492839 | 484793 | 741618 | 958296 | 1299244 |
| Average annual number of workers, pers. | 921 | 810 | 804 | 817 | 879 |
| Energy intencity, % | 3.7 | 2.4 | 2.5 | 3.2 | 2.3 |
| Energy per one worker, thsd.UAH / pers. | 19.84 | 14.1 | 23.47 | 38.21 | 34.61 |

In economics the energy intensity indicator is inverse measure of the energy efficiency indicator. This leads to the conclusion that the level and dynamics of energy efficiency are monitored at the enterprise, however there are no reports. The period, which is analyzed in Fig. 3.7, covers hard time for the enterprise as well as for the country. Energy sector is also was unstable. If in 2013 the enterprise could afford the highest level of energy intensity in 5 years and it was not necessary to look for ways of its reduction, the shocks in the domestic energy market, which occurred in the following years, made the enterprise focus on its energy efficiency. In general, the enterprise copes with the task of reduction of energy intensity of output. The years, which omitted from the general dynamics, are characterized by the significant external influence and the processes of energy system transformation. Thus, the rapid decline in 2014 resulted from production reduction and the increase in 2016 is caused by tariff policy of National Energy and Utilities Regulatory Commission and simultaneous use of gas and pellet boilers. Table 3.12 shows that the dynamics of indicator of energy per worker is influenced by unstable prices on energy resources.

Thus, energy department of ODESKABEL mostly prefers technical tools in its activity. The technical approach to energy services is traditional for Ukrainian industrial enterprises. However, the required improvements can be related to the organizational and economic actions. That is why there are some reserves of energy efficiency improvement and the systemic implementation of energy controlling should remove barriers of path dependence in the enterprise energy sector and demonstrate own capacity of optimization of using energy resources and, most importantly, diversify the ways of energy efficiency improvement at the enterprise.

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