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Making Management Decisions Based on Value Criteria When Developing Programs for Energy-Intensive Enterprises

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Abstract*: The paper presents the solution of an actual scientific and applied problem related to ensuring the efficiency of management decision making when developing programs of energy-intensive enterprises and solving the contradiction when the projects results are estimated by the interested parties, taking into account the limited resources of the enterprise. The purpose of this article is to develop project practices on improving the feasibility of management decisions when implementing a program of energy-intensive enterprises, taking into account the use of value criteria from the point of view of the interested parties as compared to the expected results of projects, resource limits. However, it is necessary to measure how a certain project contributes to achieving a program goal. Therefore, in the article the list of project value criteria was transformed into an absolute measurement scale. This allowed estimating each alternative project when developing a program to minimize the consumption of the fuel and energy resources required for the production (provision of services) of definite quality, taking into account the satisfaction of the interested parties and limited resources of the enterprise, and risk factors. Within the existing production, as a rule, mixed design decisions on investments in various production areas of the enterprise are made. During the study, the following research methods were applied: questioning, system analysis, and theory of sets. The study has resulted in revealing that most problems when implementing the energy saving strategy are associated with a low estimation of customer satisfaction (values from the point of view of the interested parties). This estimation ranges from 57.81 to 66.41, which, in turn, is a prerequisite for using value-based management when developing programs of energy-intensive enterprises.

Index Terms*: project management, program development, management decision making, value criteria.

I. INTRODUCTION

In the modern conditions, the system of enterprise strategic management should formulate certain and measurable tasks based on an efficient system of developing projects and programs, coordinated current, medium-term and long-term plans, timely adjusting plans and goals, as a response to external and internal changes of the enterprise. Taking this into account, it is necessary to form value criteria when implementing an enterprise strategy in various areas and their possible development, investment needs, sources of funding, expected results, taking into account the satisfaction of the interested parties and the limited resources of the enterprise. In the framework of the current production, as a rule, mixed project decisions on investments in any production area of the enterprise are made. The instruments that ensure the efficient projects and programs management are quite specific and are characterized by their focus, details, and record the relevant certain project practices used at this enterprise.

The strategy development at energy-intensive enterprises provides for an integration process of approaching optimality through a comparative analysis of the efficiency of various options for project alternatives. In this case, the optimality criterion is the energy efficiency of new modern technologies at the enterprise as a result of developing and implementing the enterprise’s development programs (energy saving, ecology, quality) [1]. The main value criterion is the minimization of consuming fuel and energy resources required for the production of the relevant quality, taking into account the satisfaction of the interested parties and the limited resources of the enterprise. Nowadays most energy-intensive enterprises objectively need to develop a strategy based on values, aimed at the rational consumption of fuel and energy resources, improving the enterprise’s products quality and taking into account wishes of the interested parties. The enterprise’s strategy is implemented mainly through a certain program that is developed at almost every enterprise. However, it is necessary to note that in most cases certain techniques (project practices) for its implementation, taking into account understanding of “a value” for the interested parties, are fragmentary. In turn, these techniques and the way they are used depend on the enterprise maturity in project management. The international energy management standards at enterprises ISO 500001 [2], Energy StarTM [3], and Superior Energy Performance (SEP) [4] primarily define energy management as the energy policy, which implies long-term vision and improvement of environmental performance. An energy strategy involves a systematic approach, including the development of a roadmap to achieve goals of the energy policy. However, the standards do not state clear recommendations for the implementation of an energy strategy or policy at enterprises [5].

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There is a need for systematic energy asset management [6, 7] by reducing carbon emissions, as well as improving safety [7-10].

Today, it is possible to obtain cheap electric and thermal energy due to using energy-efficient solutions based on distributed generation technologies [11]. To systematically improve the energy efficiency, enterprises need to combine their vision of an energy management strategy developed according to the standards with their own organizational structure [8]. At the same time, the development of processes, strategies and structures of the enterprise should be modified taking into account innovative approaches and the interested parties [12, 13].

Project management by the interested parties is a complex process from understanding the environment to management actions [14]. Competent management by the interested parties will not cause conflicts. That is why it is necessary to pay enough attention to the problems associated with projects management by the interested parties [15]. When introducing innovations, the interested parties contribute to the development of business by promoting them, where the management structure pursues a contribution to the enterprise of partner networks that can work on the basis of synergy and achieve common goals [16-18].

A vision and methodological approach to corporate energy policy and strategy to support the energy management system was formulated for the energy-intensive multinational production [19]. The transition of demanded industries to a continuous innovation process will enable the production to move to a qualitatively new level [20]. The methodological approach to quantifying the efficiency of changes based on the value criteria when developing programs for energy-intensive enterprises under resource limits and risk factors, which is currently relevant to many post-Soviet enterprises, was formed [21].

The North China Electric Power University in Beijing analyzed management in energy-intensive industries in the Beijing-Tianjin-Hebei (Jing-Ching-Ji) regions. It revealed that due to the introduction of innovations and the technological changes, Tianjin had the highest total coefficient of average energy efficiency when producing raw chemical materials and chemical products, as well as heating and processing ferrous metals [22].

After studying energy management with the participation of major Italian and Swedish manufacturing companies, an innovative model for estimating the energy management based on a new characteristic of energy management practices was developed. The model makes it possible to identify strong and critical areas in the energy management of an industrial organization, thereby to determine the value and vision for the further improvement of activities [23].

The article formulates a study hypothesis that assumes that the use of value criteria when developing programs of energy-intensive enterprises from the point of view of the interested parties in relation to expected results of projects, resource limits, and risk factors will improve the feasibility of management decisions and the efficiency of the program, in general.

II. METHODS

A. Block Diagram

In the course of its existence, any system undergoes a number of changes related to external and internal factors. Today, the success of the strategy chosen by an enterprise is determined by the extent to which its implementation corresponds to the rapidly changing environmental conditions (consumers' wishes).

The program within the strategy as a special form to implement changes assumes that these changes must be implemented within certain limitations in terms, cost, quality and value from the point of view of the enterprise and consumers. These limitations impose special requirements on the methods of project and program management, in particular, the requirement on focusing powers and responsibility for the efficient implementation of the program, both for managers and project teams. At the same time, the program becomes the center of costs and profits of the enterprise, which requires special attention to accounting for human, material and financial resources and forming a system of motivation based on the results of certain projects.

As noted above, the strategy is implemented at the enterprise through the program. That is why this activity can be definitely considered program-oriented. At the same time, the program approach in management can be considered as a full-fledged methodological and organizational instrument.

When estimating the efficiency of programs, it is often necessary to perform a number of operational tasks within stationary technological processes (in particular, norming and accounting for energy consumption at each production stage).

In this work the goal of the program within the energy saving strategy is considered to be a set of interrelated projects, whose implementation will make it possible to reduce the consumption of fuel and energy resources or to improve the efficiency of their use. Figure 1 shows the study stages.

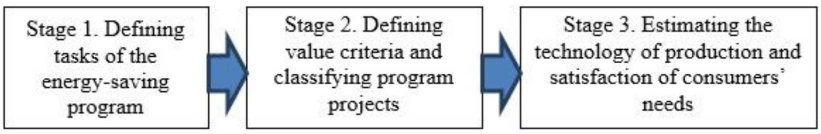

Fig. 2: Study Stages.

B. Algorithm

Energy saving, quality and ecology programs are particularly relevant for energy-intensive enterprises within their energy saving strategy.

In particular, energy saving programs within the enterprise's strategy considerably differ in terms of scale, duration, complexity, cost, etc. The practice proves that it is possible to successfully implement programs within the defined budget in accordance with the technical requirements of quality only within a formalized environment and is supported by the project and program methodology. It is offered to consider the program management system as such environment. This is a mechanism for developing and implementing value-oriented solutions at all levels of project and program management at the enterprise. This mechanism will provide the efficiency of management and coordination of the energy saving program based on unified methodology.

At the first stage of the study, 36 top managers of the *Dneprodzerzhinsk Heat and Power Plant* OJSC (DHPP) and its branches, Dneprodzerzhinsk, Ukraine (a typical representative of energy-intensive enterprises) were surveyed.

The survey is aimed at identifying objectives of the energy saving program.

The following approaches combining the process and project activities of the enterprise have been identified at the energy-intensive enterprises under study. They imply the following:

a) Structuring the operating activities of the enterprise. This stage aims at formal description of the organizational and functional structure of business processes. It results in defining the process owner. This is the person who is responsible for the result of the entire process as a whole, and will make a decision on the form of implementing this process.

b) Creating mechanisms to implement processes by using software-based management. This stage aims at adapting the enterprise management system to the implementation of projects and programs, forming regulations for the interaction of process owners and project managers.

When making changes at the enterprise, it is an important strategic issue to change the organizational structure of the enterprise mainly focused on transferring to the basics of program-oriented management.

In due time, the enterprises under study created certain subdivisions "Project Office" that were powered to manage energy saving, quality, and ecology programs.

At the second stage, a system view of the energy saving program was formed, the value criteria were determined, and the projects of the energy saving program were classified.

In order to form a system view on managing energy saving programs and to formalize the rules for implementing projects at the enterprise, it is necessary to have clear criteria and features to classify these projects.

The most important criteria for the future project value are organizational ones: a study of energy saving reserves, employee motivation, organization of a project and program management system, as well as technological criteria: repair, replacement of equipment with a new one, construction and installation of systems (heating and ventilation, water supply), installation of additional equipment, and installation of alternative energy sources.

The projects were classified in two ways by the way of achieving energy savings: reducing energy consumption and improving the utilization rate of fuel and energy resources.

According to the type and composition of the planned economic effect, the program has been divided into projects that:

– Do not influence the production process (the implementation effect can be achieved by reducing energy losses and the costs of production, transmission and distribution of energy in the heat and power plants and boilers),

– Influence the production process (the effect is achieved by reducing the cost of production),

– Do not influence the technological process (the effect is achieved by reducing operating costs in the auxiliary production),

– Influence the technological process (the effect is achieved by saving energy and reducing operating costs in the main production), and

– Improve the reliability of technological units (the effect is defined on preventing losses from poor quality power supply).

The following objectives of the energy saving program were defined: to reduce heat carrier losses in the networks, to reduce heat losses in the networks, and to control consequences of loss of heat carrier and heat in the networks. The study resulted in revealing the tasks related to the objectives of the program: to test networks, to liquidate breakthroughs, to bypass heating mains, to inspect heat chambers, to pump out water, to control a heat carrier, to pump a heat carrier into the system, to condition water, to monitor the contamination of systems in residential buildings, to wash in-house heating systems, to purge in-house heating systems, to control heating devices, to replace heating equipment, to breakthrough mixers, to carry out revision of stop valves, to replace stop valves, to control the amount of heat, to control the heat loss in the network, to replace worn insulation, to control worn insulation, to carry out thermal insulation of network grids, to control pipe diameter for networks, to partially replace main networks with pipes of appropriate diameter, to completely replace the main networks with pipes of appropriate diameter, to control soaking of the insulation coating, to restore the insulation coating, to install drainage device, to control the availability of narrowing gaps in residential buildings, to control recycling, to recover recycling, and to install nozzles according to hydraulic calculations.

At the third stage, in order to analyze the estimation of the services value, taking into account consumers' (parties' in interest) wishes, it has been set that

$X = \{x_1, x_2 \ldots x_n\}$ is the variety of energy saving projects,

$Y = \{y_1, y_2 \ldots y_p\}$ is the variety of the product (service) characteristics, and

$Z = \{z_1, z_2 \dots z_m\}$ is the variety of consumers' requirements to the product (service).

Then $F_R: X \times Y \rightarrow [0,1]$ is the membership function of the fuzzy binary relation (in the matrix form – $\|F_R(x,y)\|$).

For all $x \epsilon X$ and all $y \epsilon Y$ the function $F_R(x,y)$ is the degree of importance to perform a certain work for the implementation of the relevant characteristics of the project product.

Let $\pi: Y \times Z \rightarrow [0,1]$ be the membership function of a fuzzy binary relation *S*. For all $y \epsilon Y$ and all $z \epsilon Z$ the function $\pi_S(y,z)$ is the measure of the membership or degree of compatibility of the product characteristics with consumer requirements to this product.

In the matrix form, this ratio is as follows: $\|\pi_S(y,z)\|$.

Now there is the ratio: $T: X \times Z \rightarrow [0,1]$, whose elements are determined by the following membership function $\mu_{Ai}(x,z_i) = sup_{y \epsilon Y}\{F_R(x,y) \times \pi_S(y,z_i)\}$ for all $x \epsilon X$, all $y \epsilon Y$, and all $z \epsilon Z$.

In the matrix form, this ratio is as follows: $\|\mu_A(x,z)\|$.

Thus, the ratio $\frac{\sum \mu_A(x,z)}{\sum \mu_A(x,y)_{reference}} \times 100\%$ determines the enterprise's ability to meet the consumers' expectations (get value) of a given product for a consumer $\sum \mu_{Ai}(x,z)_{reference}$, whose elements are defined by the following membership function

$$\sum \mu_{Ai}(x,z_i)_{reference} = sup_{y \epsilon Y}\{F_R(x,y)_{reference} \times \pi_S(y,z_i)_{reference}\}$$

for all $x \epsilon X$, all $y \epsilon Y$, and all $z \epsilon Z$, where the values are $F_R(x,y) = max$ and $\pi_S(y,z) = max$.

The above estimation allows obtaining two components of the estimation: the estimation of the production technology and the estimation of the consumers' needs satisfaction. For this, it is necessary to calculate two ratios.

The first ratio – "Estimation of the production technology" – looks as follows:

$$\left(\sum \mu_{Ai}(x,z_i) / \sum sup_{y \epsilon Y}\{F_R(x,y)_{reference} \cdot \pi_S(y,z_i)\}\right) \times 100\%, \quad (1)$$

The second ratio – "Estimation of the consumers' needs satisfaction" – looks as follows:

$$\left(\sum \mu_{Ai}(x,z_i) / \sum sup_{y \epsilon Y}\{F_R(x,y) \cdot \pi_S(y,z_i)_{reference}\}\right) \times 100\%, \quad (2)$$

for all $x \epsilon X$, all $y \epsilon Y$, and all $z \epsilon Z$

III. RESULTS

At the first stage of the value-oriented methodology (project practice), the following was formed:

Variety of the projects related to the energy saving programs in the "Reducing heat carrier losses in networks" area (*X*): testing networks, liquidating breakthroughs, bypassing heating mains, inspecting thermal chambers, pumping out water, controlling a heat carrier, pumping a heat carrier into the system, water conditioning, monitoring the system pollution in residential buildings, washing of in-house systems, purging of in-house systems, control over heating devices, replacement of heating devices, breakthroughs of mixers, revision of stop valves, and replacement of stop valves.

Variety of the projects related to the energy saving program in the "Reducing heat loss in networks" area (*Y*): controlling the amount of heat, heat loss in networks, replacing worn insulation, monitoring worn insulation, insulating network pipelines, monitoring pipe diameter for networks, partial replacement of main networks with pipes of relevant diameter, complete replacement of the main networks with pipes of the relevant diameter, control over soaking of the insulation material, restoration of the insulation coating, installing of drainage device, control over the availability of narrowing gaps in residential buildings, installation of nozzles according to the hydraulic calculation, and recovery of recirculation.

Variety of the projects related to the energy saving program in the "Control over consequences of heat carrier and heat loss in networks" area (*Z*): bypassing heating mains, inspecting thermal chambers, controlling a heat carrier, monitoring the contamination of systems in residential buildings, monitoring heating devices, revising the existing fixture valves, control over the amount of heat, control over the worn insulation, control over the diameter of pipes for networks, control over soaking of insulating material, control over the availability of narrowing gaps in residential buildings, and control over the circulation.

Besides, a variety of characteristics of the DHPP product (heat supply service) was determined by the following properties: temperature at the consumer's site, gas consumption for heating the heat carrier, water consumption, energy consumption for the delivery to the consumer.

At the second stage, $F_R: X \times Y \rightarrow [0,1]$ was formed.

This is the membership function of the fuzzy binary ratio *R* (in the matrix form – $\|F_R(x,y)\|$) for the three selected areas of the energy saving program.

For all $x \epsilon X$ and all $y \epsilon Y$, the function $F_R(x,y)$ is the degree of importance of energy saving projects for the implementation of the relevant product characteristics in the "Reducing heat carrier loss in networks" area (Table 1).

Table 1. Importance of the Project to Implement the Relevant Characteristics of the Product in Terms of "Reduction of Heat Carrier Loss in Networks"

Program projects	Variety of characteristics of the DHPP product (heat supply service)			
	Temperature at the customer's site	Gas consumption to heat the heat carrier	Water consumption	Power used for delivery to consumer
Testing networks	0	0	1	0
Liquidating breakthroughs	0.15	0.2	1	0.7
Bypassing heating mains	0	0.2	0.2	0.2
Inspecting thermal chambers	0.5	0.8	0	0
Pumping out water	0.5	0.5	0	0
Controlling a heat carrier	0.8	1	0	0
Pumping a heat carrier into the system	0.5	1	1	0
Water conditioning	1	1	0	0
Monitoring the system pollution in residential buildings	0.3	0.3	0	0.5
Washing of in-house systems	1	1	0	0
Purging of in-house systems	0.7	0	0	0
Control over heating devices	0.8	1	0	0
Replacement of heating devices	1	1	0	0
Breakthroughs of mixers	0.5	0	0.5	0
Revision of stop valves	0.3	0.5	1	0.8
Replacement of stop valves	0.5	0.3	1	0.8

Similar ratios will be obtained for the remaining areas of the energy saving strategy: reduction of heat losses in the networks and control according to the results of a heat carrier and heat loss in the networks.

Next, the ratio $\pi: Y \times Z \rightarrow [0,1]$ was formed. This is the membership function of the fuzzy binary relation S. For all $y \in Y$ and all $z \in Z$, the function $\pi_S(y,z)$ is the membership measure or the degree of compatibility of product characteristics with the consumers' requirements to this product (the data for the table are filled in with the help of experts). In the matrix form, this ratio is as follows: $\|\pi_S(y,z)\|$ (Table 2).

Table 2. Compatibility of Product Characteristics and the Consumers' Requirements (Value from Consumers)

Variety of characteristics of the DHPP product (heat supply service)	Variety of value criteria for the planned project results					
	Payback period	Decrease in the accounts receivable	Decrease in the water consumption by RUB 1 of the product	Improving the management accounting system	Compliance with the technological mode	Decrease in resource costs by RUB 1 of the product
Temperature at the consumer's site	0.5	1	0.5	0.8	0.8	0.2
Gas consumption for heating the heat carrier	1	0.5	0	0.8	0.6	0.6
Water consumption	1	0.5	1	0.5	1	0
Consumption of power to deliver to the consumer	1	0.5	0	0.5	0.8	1

At the third stage, the ratio for the chosen area of the "Reduction of heat carrier losses in the networks" strategy was obtained (Table 3).

The ratio $T: X \times Z \rightarrow [0,1]$ is obtained. Its elements are determined by the following membership function $\mu_{Ai}(x, z_i) = sup_{y \epsilon Y}\{F_R(x, y) \times \pi_S(y, z_i)\}$ for all $x \epsilon X$, all $y \epsilon Y$, and all $z \epsilon Z$. In the matrix form, this ratio is as follows: $\|\mu_A(x, z)\|$.

Table 3. Importance of the Project for the Energy Saving Strategy in the Direction "Reduction of Heat Carrier Losses in Networks"

Variety of projects of the program	Variety of value criteria for the planned project results					
	Payback period	Decrease in the accounts receivable	Decrease in water consumption by RUB 1 of the product	Improving the management accounting system	Compliance with the technological mode	Decrease in resource costs by RUB 1 of the product
Testing networks	1	0.5	1	0.5	1	0
Liquidating breakthroughs	1.975	1.1	1.075	1.13	1.8	0.85
Bypassing heating mains	0.6	0.3	0.2	0.36	0.48	0.32
Inspecting thermal chambers	1.05	0.9	0.25	1.04	0.88	0.58
Pumping out water	0.75	0.75	0.25	0.8	0.7	0.4
Controlling a heat carrier	1.4	1.3	0.4	1.44	1.24	0.76
Pumping a heat carrier into the system	2.25	1.5	1.25	1.7	2	0.7
Water conditioning	1.5	1.5	0.5	1.6	1.4	0.8
Monitoring the system pollution in residential buildings	0.95	0.7	0.15	0.73	0.82	0.74
Washing of in-house systems	1.5	1.5	0.5	1.6	1.4	0.8
Purging of in-house systems	0.35	0.7	0.35	0.56	0.56	0.14
Control over heating devices	1.4	1.3	0.4	1.44	1.24	0.76
Replacement of heating devices	1.5	1.5	0.5	1.6	1.4	0.8
Breakthroughs of mixers	0.75	0.75	0.75	0.65	0.9	0.1
Revision of stop valves	2.45	1.45	1.15	1.54	2.18	1.16
Replacement of stop valves	2.35	1.55	1.25	1.54	2.22	1.08

Similar ratios will be obtained for the remaining areas of the energy saving strategy: reduction of heat losses in the networks and control over the results of heat carrier and heat loss in the networks.

As a result of the study at the final stage, using formulas 1 and 2, the data on the ratio of service quality estimation in terms of value to the interested parties were obtained (Table 4). It is necessary to note that the maximum estimation of the satisfaction of the interested parties can reach 100.

Table 4. Ratio of Service Quality Estimation in Terms of Value for the interested parties

Ser. No.	Program	Value criteria	
		Estimation of the production technology	Estimation of satisfaction of the interested parties
1	Reduction of heat carrier losses in networks	69.71	66.41

2	Reduction of heat losses in networks	70.39	65.29
3	Control over consequences of losing heat carrier and heat in networks	70.75	57.81

IV. DISCUSSION

The offered project practice enables the project manager not only to monitor (analyze the status as on the "current date"), but also to control the program progress (to make more feasible management decisions when including projects in the program).

However, it is necessary to measure how a certain project contributes to achieving the program goal. Therefore, the list of project value criteria was transformed into an absolute measurement scale. This allowed estimating each alternative project when developing a program to minimize the consumption of fuel and energy resources required for the production (provision of services) of definite quality, taking into account the satisfaction of the interested parties, limited resources of the enterprise, and risk factors.

V. CONCLUSION

As a result of the study, it has been revealed that most problems in the implementation of the energy saving strategy are associated with low assessment of customer satisfaction. This assessment ranges from 57.81 to 66.41 (Table 4), which, in turn, is a prerequisite for the use of value-based management when developing programs.

Based on the results obtained, it is possible to conclude that the efficiency of the management decision made by a project manager is based on his ability to respond to the problems arising during the implementation of projects and programs, and the need to constantly take steps to satisfy all the interested parties of the program. The comparison of project alternatives and value criteria for their results, as well as the ratio of service quality estimations help the project manager to improve the feasibility of management decisions and improve the program efficiency, in general. Therefore, it is possible to use the development of approaches to more efficient estimation of value criteria from the consumer's point of view at the pre-project stage (initiation stage) of the project as prospects for the further study.

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