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The balanced scorecard as an adaptive control system

Streszczenie. W artykule przedstawiono jeden z instrumentów zarządzania strategicznego którym jest zrównoważona karta wyników w postaci adaptacyjnego systemu sterowania na przykładzie mapy strategii dla elektrociepłowni. Przedstawiony system adaptacyjny w zadowalający sposób opisuje wewnętrzne środowisko przedsiębiorstwa w trybie ciągłego dostosowywania się do warunków zewnętrznych.

*Abstract. The paper describes a balanced scorecard as an adaptive control system built on the basis of a strategic map of a heat-supply plant. The proposed adaptive system in the form of a tracking system adequately describes the processes of transformation of the enterprise internal environment in the mode of constant adaptation to the changes in the external environment. (**Zrównoważona karta wyników jako adaptacyjny system sterowania**).*

Słowa kluczowe: zrównoważona karta wyników, zarzadzanie adaptacyjne, system organizacyjny, elektrociepłownia.
Keywords: balanced scorecard, adaptive management, organizational system, thermal-electric power station.

Introduction

An important criterion for any production pattern is proper management of the company as well as human resources. The choice of managerial decisions should be mainly aimed at reducing the overall cost of production, improving its observability and controllability, qualitative and quantitative characteristics, as well as reliability. Under market economy, enterprises interested in the development and economic growth must constantly review their actions in order to achieve the best results in comparison with their competitors.

The carried out analysis of the published data shows that the traditional systems of strategy construction in most cases were based solely on financial indicators of enterprises; as a result enterprises could not identify and integrate all the factors that were crucial for improving the enterprise performance [1-6].

BSC as a tool for achievement of the main goals of the company

At present the Balanced Scorecard (BSC) established by David Norton and Robert Kaplan became widespread among the generated approaches towards building strategies [7].

On the basis of generalization of numerous studies, the Balanced Scorecard developers offered to operate using four major perspectives: "Finance", "Customers", "Internal Business Processes" and "Learning and Growth."

A BSC is used by a company as a tool of management according to the hierarchical levels including all the resources, as well as staff, through a system of incentives closely engaged with the key performance indicators which are aimed at a common purpose.

Balanced consideration of the mentioned perspectives in developing strategies of a company (enterprise) allows developing a balanced system of objectives (Figure 1 and Figure 2).
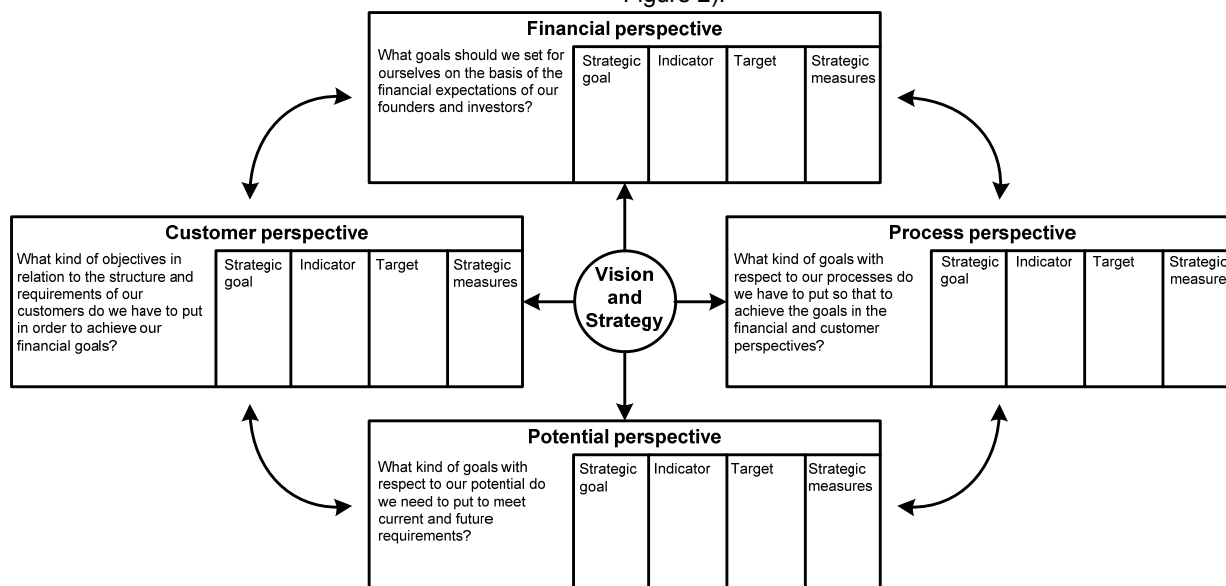

Fig.1. The Balanced Scorecard

After determining the main objectives, it is necessary to concentrate the efforts of the team on them. Therefore, the following problem arises: bringing the targets to subordinate units, as well as developing a system of incentives to encourage the achievement of these objectives and direct the efforts of numerous sub-divisions in order to achieve the major goal of the company [8].

In order to make it easier to achieve the goals, it is necessary to assign all the objectives, indicators, targets and measures to specific employees and departments, that is to decompose the card according to the units [9].
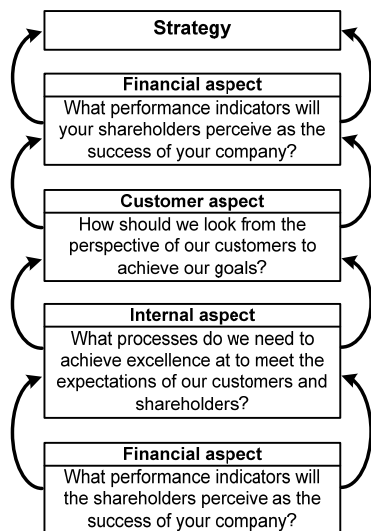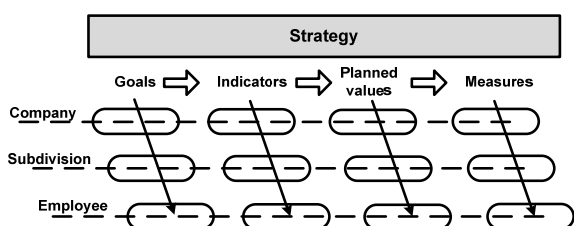
Fig.2. The BSC strategy development model

Fig.3. Goal decomposition

The basic principles of successful formation of a BSC are: sufficiency of informative indicators; consistency, i.e. consistent detailed elaboration and the formation of the tree of interrelated indicators reflecting the real cause-and-effect relationships; feedback – ongoing analysis of information content and adjustment of the structure and the composition of indicators.

At present balance scorecards integrate with a variety of current information technologies, particularly in the process of indicator and performance modeling in most cases the theory of fuzzy sets and expert evaluation is used. There are examples of application of fuzzy cognitive maps (FCMS) imitating strategies, this approach is called the active balanced scorecard methodology (proactive balanced scorecard methodology - PBSCM) [10]. A so-called BSC-DEA system (balanced scorecard and data envelopment analysis) also has been used; it is the system of balanced indices along with the analysis of the operational environment, where the grouping of these systems enables multi-criteria evaluation of R&D projects [11-13].

The paper proposes an adaptive control system using the balanced scorecard which takes into account the dynamics of the process of resolving disagreements between the planned data and the results obtained.

A BSC as an adaptive control system

A thermal-electric power station is a complex, multi-dimensional and multilinked system. Managing such a system would be possible if we apply the principle of adaptability.

One of the advantages of multi-dimensional organizational structures that best meet the requirements of adaptability is that this type of organization eliminates the need for ongoing restructuring, which is replaced by resources redistribution. Replacing restructuring with the procedure of rational allocation of resources can significantly improve the speed of the adaptation process.

The properties that characterize the principles of modeling adaptive organizational structures should be supplemented by the principle of stochastic (probabilistic) modeling. The optimality criterion presents the minimum of some functional which characterizes the degree of discrepancy between the organization parameters and the requirements of the external environment in the steady state [14].

Substantively this criterion means striving for such management adaptation which will provide the minimum of the systematic and random components of the discrepancy.

The process of adapting an organization to the changing conditions of the external environment can be represented by the following generalized scheme:
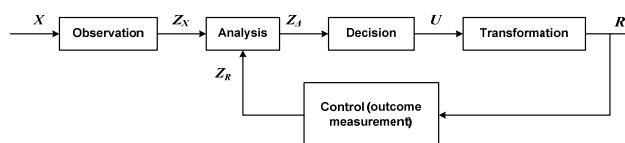

Fig.4. The process of adaptation of the company internal environment to the external environmental changes

The diagram uses the following notations:

X – the variables of the external environment the change of which requires immediate company response;

Z_X - observation of X variables taking into account possible information uncertainty;

R – the results of adaptive transformations of the company internal environment;

Z_R – monitoring the results of adaptive transformations of the company internal environment;

Z_A - the results of analysis of the company deviation from the requirements dictated by the changes in the external environment;

U – the managerial decision which requires implementation of adequate transformations in the company internal environment.

The proposed model of organization in the form of a tracking system adequately describes the processes of change in the internal environment of a company in the mode of constant adaptation to the changes in the external environment.

The implementation of the adaptive model for the strategic map based BSC of a thermal supply complex (Figure 5) is as follows.

The strategic map is a four-level system (finance, customers, internal business processes, learning and development), which describes the objectives and indicators. The lower-level goals are indicators of the higher-level objectives.

The highest level of a strategic plan is finances. That is the targets of this level are priority-oriented. At this level there are three goals: increase in profits, tariff consumption and reducing consumer debt. The main goal is to increase profits.

The BSC analysis showed the need for building an adaptive system and the transformation of the strategic map presented in the classic version (shown in Figure 5) in the following manner, which is a more convenient form of construction of adaptive systems (Figure 6).
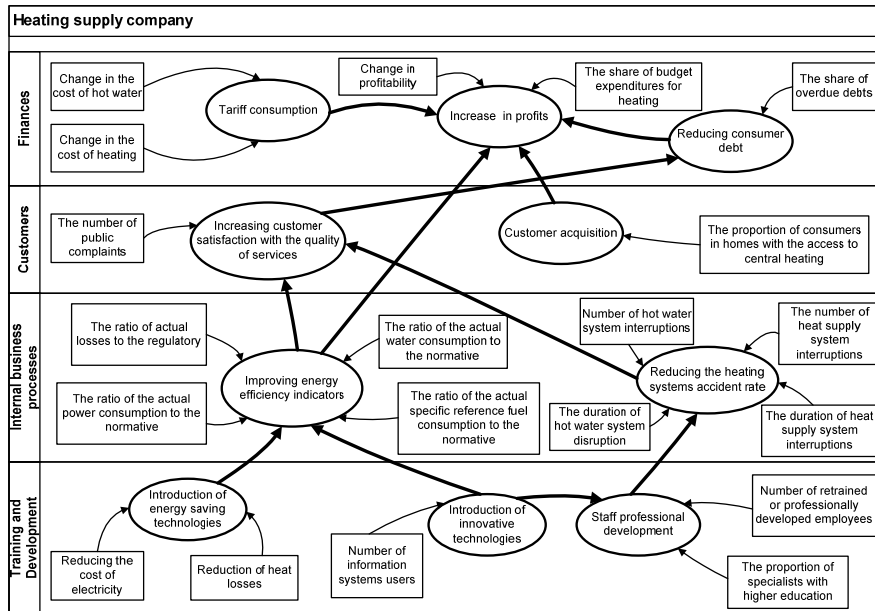
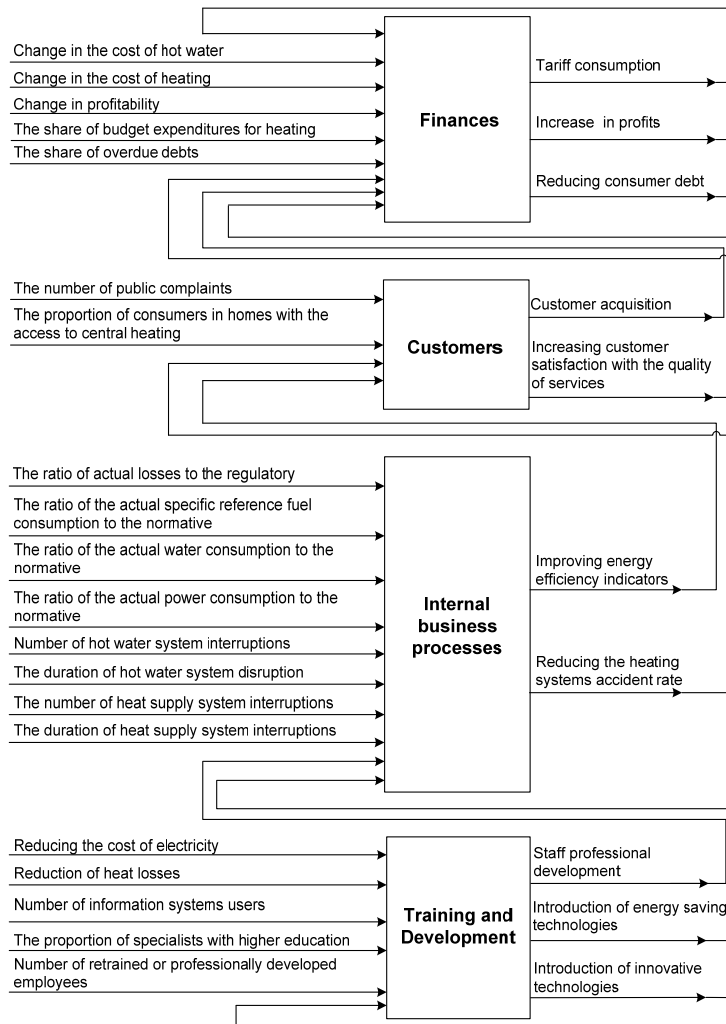Fig. 5. Strategic mapping of a heating supply company

Fig. 6. The transformed strategic map of a heating supply company

The adaptive model is built in the multidimensional case, where m and n denotes number of inputs and outputs, respectively.

Such an adaptation model was proposed by P.A. Mikhnenko [17]. The scheme is based according to the strategic map of a thermal power station, whose output is the ultimate goal of increasing profits (Figure 8).

Having constructed an adaptive model aimed at the increase of profits we derive the conclusion on the need for using feedback, that would take into account the output value of the upper level in the lower stages of the

hierarchical structure of the strategic map. The feedback in the proposed scheme characterizes the discrepancy of the current value from the planned one, which is denoted by ε. The lower level of the adaptation system is presented in Figure 9.
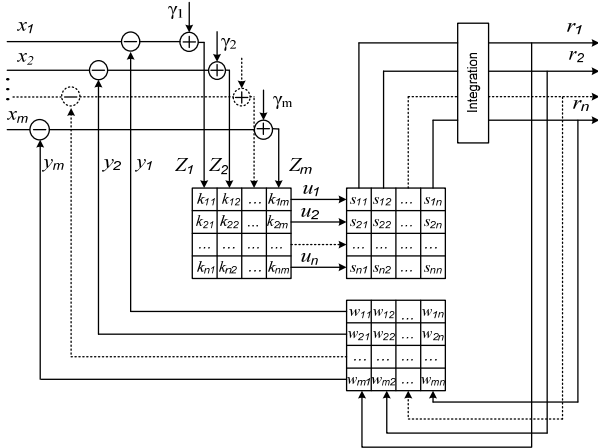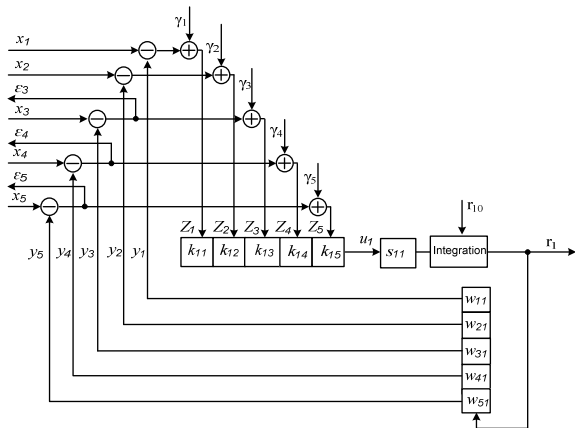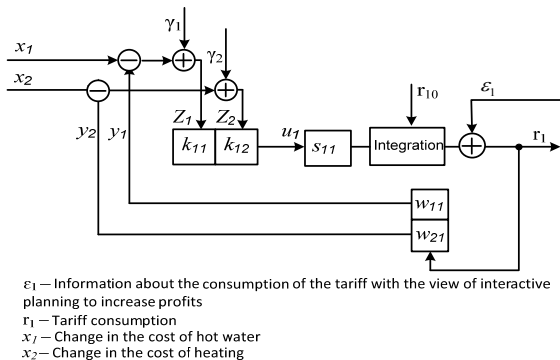

Fig. 7. Stochastic multidimensional adaptive control system

ε_3 – Information about the consumption of the tariff with the view of interactive planning to increase profits
ε_4 – Information about reducing consumer debt with the view of interactive planning to increase profits
ε_5 – Information about the customer acquisition with the view of interactive planning to increase profits
r_1 – Increase in profits
x_1 – Change in profitability
x_2 – The share of budget expenditures for heating
x_3 – Tariff consumption
x_4 – Reducing consumer debt
x_5 – Customer acquisition

Fig. 8. The adaptive system of control of the increase in profits

ε_1 – Information about the consumption of the tariff with the view of interactive planning to increase profits
r_1 – Tariff consumption
x_1 – Change in the cost of hot water
x_2 – Change in the cost of heating

Fig.9. An adaptive system of controlling tariff consumption with the account of profit increase indicators

All the strategic map targets are constructed in a similar, adaptive way. The adaptation process starts from the top level to the lower ones. As a consequence, it can be pointed out that any response to external perturbations helps solving a given problem at all the control levels when a feedback path is applied.

Conclusions

W matrix in Figure 7 denotes compatibility matrix which prescribes the adaptation target system by establishing relationship and the required quantitative level of transformation. K is a matrix of resources allocated for the implementation of transformations of each factor of the internal organization environment whereas S matrix describes the organization structure applied to organizational interaction of the structural units of an organization. In the future a detailed description of these matrices and provide their stochastic model in the form of a tracking system that would adequately describe the processes of transformation in the internal environment of a company in the mode of constant adaptation to changes in the external environment. It would make possible to developing an adaptive control algorithm over the management strategy of a thermal-electric power station.

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