Economic model of power generation enterprise

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Abstract. These days the economic system of any scale faces a challenge not only to best meet the needs of consumers, but also to ensure their comfortable living conditions (especially agricultural), that is, preserve the environment and use natural resources wisely. Power generation enterprises make a significant contribution to the violation of the environmental situation. This is partly due to the alienation of territories that could be used for other human activities, as well as significant emissions into the atmosphere. A power generation enterprise, compared with organizations of other types of activity, is characterized by the method of generating electricity which implies not the impact on the material and raw materials and the production of economic benefits, but the conversion of natural energy into electrical energy. These models are of a general abstract nature and are more applicable to organizations producing tangible economic benefits, rather than the generation of electrical energy, which is the key economic benefit, though, conventionally tangible one. Existing microeconomic models do not show specifics of their functioning – the scale of the enterprise and the conditions for profit maximization. The economic models of a power generation enterprise, the specifics of its functioning and profit-making are presented in the article.

1 Introduction

Economic processes are numerous and diverse. It is extremely difficult to develop their formalized algorithm. The implementation of the process and its results are influenced by a large number of both objective and subjective factors. Processes affect each other and form the economic system.

Depending on the goals of research and analysis and the scale of the system, its economic model is built, which is its abstract, simplified representation. It means that it has all the features of a real system and provides answers to the questions posed (analysis tasks), but still, it is a mental reflection. In the modeling process, various tools are applied that in many respects it depends on the tasks being solved and scaling, that is, the level of economic system [1].

2 Materials and methods

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During the formation of an economic model, a formal mathematical approach is most often used, which makes it possible to describe the economic system and its processes that are closest to the real one. The general economic model of a market system is introduced like follows [2]:

$$\{Y^d\left(R, \frac{W}{P}, \ldots\right) = Y^s\left(\frac{W}{P}, \ldots\right), (-)\ (+)\ (-) \quad (-)\ L^d\left(\frac{W}{P}, \ldots\right) = L^s\left(\frac{W}{P}, \ldots\right), (-) \quad (+)\ (+)\ M^s(R, \ldots) = P \times F(Y, R \ldots), (+) \quad (+)(-) \tag{1}$$

where $Y^d(\frac{W}{P}, \ldots)$ – demand for the commodity;

$Y^s(\frac{W}{P}, \ldots)$ – supply of the commodity;

$L^d(\frac{W}{P}, \ldots)$ – demand for a factor of production – labor;

$L^s(\frac{W}{P}, \ldots)$ – the supply of the factor of production – labor;

$F(Y, R, \ldots)$ – [function] demand for real financial assets;

R – average market interest rate;

W – nominal wages;

P – average market price level.

The application of this model allows us to analyze the cyclical nature of the economic system, which is the result of changes, for example, in production efficiency.

3 Results

For a more detailed analysis of the system, its individual elements (objects / subjects), processes, production resources (production conditions), it is possible to create detailed models. In order to understand and identify the role of energy resources in the economic system, the model is introduced like follows:

$$\{Y^d\left(R, \frac{W}{P}, \ldots\right) = Y^s\left(\frac{W}{P}, \ldots\right), (-)\ (+)\ (-) \quad (-)\ L^d\left(\frac{W}{P}, \ldots\right) = L^s\left(\frac{W}{P}, \ldots\right), (-) \quad (+)\ (+)\ E^d\left(\frac{W^e}{P^e}, \ldots\right) = E^s\left(\frac{W^e}{P^e}, \ldots\right)(-) \quad (+)\ (+)\ M^s(R, \ldots) = P \times F(Y, R \ldots), (+) \quad (+)(-) \tag{2}$$

where E^d – demand for energy resources;

E^s – supply (generation) of energy resources;

W^e – nominal wages in energy industries;

P^e – average market price for energy resources.

The models presented above are the so-called macroeconomic models, which generally give an idea of how the national market and/or the world market functions, how individual industries can affect the market as a whole. But they do not give us an idea of how individual economic agents behave in the market, for example, firms, households, etc. For this, microeconomic models are created which allow us to explain the economic behavior of economic agents. Economic behavior is "a set of actions of agents of the economy, due to their economic goals, budgetary, market and institutional constraints" [3].

When the macroeconomic model allows us to understand the behavior of the economic system as a whole and is based on the fact that the behavior of economic agents is predictable and predictable, the microeconomic model is formed "under given macroeconomic conditions such as total income, price level, interest, etc." [3].

When designing microeconomic models, two approaches to considering the firm are most often applied – (1) – as a production function and (2) the analysis of economic behavior.

Considering the firm as a production function, a connection is established between the production of products and the production resources incurred for the production. The most general function looks like this:

$$Q = f(x_1, x_2, x_3, ..., x_n), \quad (3)$$

where Q – the volume of goods produced;

x_i – production resource costs i, including energy.

This function considers production resources as homogeneous, which are rigidly related to the volume of output. It is recommended that the index denoting the cost of energy resources should come first. Not only output but also other production (technological) resources – the progressiveness of the production of economic goods, for example, automation and robotization of production – depends on energy resources.

Considering aggregated production resources, we get the following model:

$$Q = f(E, L, K), \quad (4)$$

where E – energy costs;

L – labor costs;

K – physical capital costs.

Energy costs can be represented by the following function:

$$E = f\left(e_1, e_2, e_3, ..., e_n\right), \quad (5)$$

where e_i – type of energy resource.

Another approach to microeconomic modeling is to analyze the firm's response to changing economic conditions, both internal and external. Every economic agent is believed to obtain the maximum benefit – profit maximization. Then the function will look like this:

$$R\uparrow = (Q\uparrow - TC\downarrow);$$

or

$$R\uparrow = [Q\uparrow - (FC\uparrow + EC\uparrow + VC\downarrow)\downarrow], \quad (6)$$

where $R\uparrow$ – the profit of the firm, or the benefit of the economic agent, which tends to the maximum;

$Q\uparrow$ – the volume of manufactured (sold) products tends to a maximum;

$TC\downarrow$ – gross (general) production costs tend to a minimum;

$FC\uparrow$ – fixed costs of manufacturing products tend to increase;

$EC\uparrow$ – energy costs tend to increase, including due to the growth of fixed costs;

$VC\downarrow$ – variable costs are reduced due to the growth of fixed and energy costs.

The microeconomic models presented above show the place and use of energy resources in the process of producing economic benefits. Energy generating enterprises have their own characteristics. The low share and role of variable costs are the main features. One should admit that the effectiveness and success of any organization is formed by responsibility, cohesion and mastery of modern competencies by the staff. Energy generating companies are no exception. However, the other part of this type of cost is the

material costs that this enterprise does not bear [1, 4]. The only exception is thermal power plants, where the share of variable costs (these are material and labor costs) is significant [5]. As a material resource for an energy generating enterprise, any natural resource is used, and an organization pays rent for their use [2].

Another important feature is that the entire process of producing an economic good – a unit of electricity – is a process of converting one type of energy into another. Therefore, materials are not the basis for economic good. The process of transformation itself is a natural process without human involvement (or indirect human involvement). Unlike other natural processes that stretch over time (for the creation of some products, the time period can be several years), this process is short and instantaneous in the process of creating a unit of energy [4].

The amount of variable costs depends on the resources they are formed and the volume of production in traditional sectors of the economy. Having reached a certain optimal volume of production, average variable costs tend to increase, which ultimately may affect the financial condition of a business organization – $\underline{VC} = \left(l_1, m_1, e_1\right) = K_{opt} \rightarrow \underline{VC}\uparrow = \left(l_2, m_2, e_2\right) =< K_{opt}$. Fixed costs have a different nature, they depend on prices for elements of fixed costs, as production volumes increase, their average value tends to a minimum – $\downarrow \underline{FC} = \left(p_1, p_2, p_3, ..., p_n\right) = K\uparrow$. Total average cost is the sum of average variable and average fixed costs $\underline{TC} = (\underline{FC} + \underline{VC})$ and have, in fact, the same nature as the average variable costs. On the graph, this dependence can be represented in the following form (Figure 1).

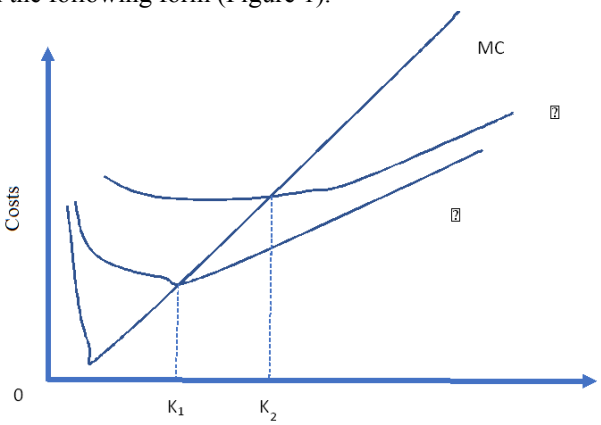

Fig. 1. Interdependence of average variables, average total and marginal costs (MC).

This dependence allows you to determine the optimal volume of production and the amount of maximum profit in the interval $K_1 – K_2$.

All of the above allows us to define two important conditions for the scale of a business organization:

1. Profit maximization (Mr) – the difference between marginal revenue from the sale of an additional unit of output (MR) and marginal cost (MC):

$$Mr = MR - MC.$$

2. Optimum output (Q_{opt}) – unit price (p) equals marginal cost:

$$p = MC.$$

We found out that variable costs do not greatly affect the manufacture of products of energy generating enterprises, and, therefore, the role of marginal costs (MC) is not great, since their value will be more or less constant regardless of the amount of generated energy. The value of the total costs per unit of energy will mainly depend on the costs of creating energy generation capacities, i.e. fixed costs. In the price of a unit of energy, fixed costs will be the "lion's share", and the price itself will be completely dependent on the demand for energy. The power of the energy-generating enterprise and the volume of generated energy will depend on the potential power of the converted energy, in other words, on the natural and geographical conditions of the area where the energy-generating organization is being created [6].

Another factor (factors) that must be taken into account when taking into account the costs per unit of energy, and, consequently, its prices, are the losses that the economy and society may suffer from the withdrawal of the territory on which the energy enterprise is located from economic activity. These can be both direct losses – a shortfall in production (and, consequently, income and profits), and indirect ones, for example, a change in the environmental situation. These losses can be spread over a very long period of time, and are very difficult to account for [5].

Based on the above the economic model of a power generation enterprise can be presented as follows:

$$Q = \{f(x_1, x_2, x_3, \ldots, x_n)\, f(-y_1, -y_2, \ldots, -y_n), \quad (7)$$

where x – costs of production i-resources necessary for energy generation;

y – losses incurred by society and the economy from the withdrawal of the territory from economic circulation.

The above model (7) is a general, abstract idea of the energy enterprise, but it does not show how it implements its goals. The target functional model allows us to reveal the purpose of the organization [7].

4 Discussion

Any business organization achieves its goals through the implementation of linear, basic functions, which are marketing, research and development, production and sales. So an organization generating electricity does. This model will look like this:

$$Q = \{marketing\ RD\ generation\ sale\} \rightarrow r(max). \quad (8)$$

The implementation of these functions and the achievement of goals at an energy enterprise has its own characteristics [8].

1. The marketing function is implemented by a power generation enterprise with the help of energy sales and energy distribution organizations that determine the main consumers, which are individuals (personal consumption) and legal entities (industrial consumption). These organizations calculate the demand for electricity by consumers. It may depend on a larger number of conditions and most often consumers are located in the same territory.
2. The R&D function is implemented by the power generation enterprise indirectly. This is due to the fact that the design of generating capacities is carried out by a third-party organization, which is not directly a division of the energy company, but is part of the

unified energy system. Actually, the implementation of the R&D function by this enterprise is to modernize and maintain the efficiency of generating capacities.

3. Power (electricity) generation function is to convert some kind of natural energy into electrical energy.

4. The sales function is implemented by the enterprise through the processes of concluding supply contracts with energy retailers and energy distribution companies.

5. In addition to maximizing profits, the main objectives of any modern enterprise also include 1) maximum market satisfaction and 2) satisfaction of personal goals and interests of the staff. The implementation of goals by an energy generating enterprise is common; however, it has its own characteristics. The first feature is that the profit received by the power generation enterprise compared with organizations of other types of activity is relatively small, but stable. In addition to three main goals, one more is added which implies the preservation of the environment and the rational use of natural resources.

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