INNOVATIVE MODEL OF ECONOMIC BEHAVIOR OF AGENTS IN THE SPHERE OF ENERGY CONSERVATION

Hilorme Tetiana, Oles Honchar Dnipro National University
Nazarenko Inna, Sumy National Agrarian University
Okulicz-Kozaryn Walery, Pedagogical University of Cracow
Getman Olga, Kharkiv National University of Construction and Architecture
Drobyazko Svetlana, Ukrainian State University of Chemical Technology

ABSTRACT

In the article, we considered the communication barriers of group interests of agents during introduction of energy-conservative technologies. The use of agent-oriented modeling for determining the parameters of the state of activity of agents' behavior is proposed. The grouping of agents according to the degree of interest in energy-conservative processes is suggested. Mathematical relation of the transfer of these groups of agents based on the theory of Cellular Automata (CA) is constructed. According to the evolutionary concept of ecosystems of agents, the principles of building a management system for the introduction of energy-conservative technologies are analyzed. The possibility of implementing the agent behavior model on energy-conservative in the context of the "predator-prey" concept, which is determined by the principles of economic efficiency of agent behavior and the available innovative energy-conservative technologies is considered. The model of agents' behavior will allow strengthening the control and influence on the groups of agents, who take managerial decisions on the appropriateness of measures to promote energy-conservative technologies.

Keywords: Energy Conservation, Agent, Cellular Automata, Economic Behavior, Predator-prey system.

JEL Classifications: C6, F37, O31, Q4.

INTRODUCTION

During introduction of energy-conservative technologies, primarily those using alternative energy sources, a special place is occupied by the problem of interaction and mutual relations of people's associations, which is an indication of group interests. Groups of interests arise on the basis of objectively existing problems and people's needs when deciding on the use of alternative energy sources in order to increase the energy conservation of generation, consumption, transportation, redistribution and other technologies. For the formation of groups and effective cooperation it is necessary to explore the wakeup mechanisms of their interaction, expedient activities within the framework of their interests. Interaction of group interests, especially economic behavior, during introduction of energy-conservative technologies for the use of alternative energy sources will improve energy security as a component of the country's national security.

REVIEW OF PREVIOUS STUDIES

When analyzing and evaluating group interests during the implementation of energy-conservative technologies for the use of energy from alternative sources, scientists paid attention to such problems as the identification of the function of social and economic indication of the interests of groups. At the same time prerequisites for the formation of individual needs and requirements of associations of people are created. But there are no clear model of interaction between such groups, which determine the interests of energy producers, their consumers. Also, there are no models for groups, which are the unifying link between the institutions of power and society. That is, it is important to identify such functions of interacting groups as indication of interests, integration, adaptation, etc. Identification of such functions is necessary to eliminate the destructive role in the manifestation of group interests and to reduce the influence of one-sided advantage only, for example, corporate interests of energy generating companies, especially those that form the direction of implementing energy-conservative technologies. Ma Fang (2012) developed a model of consumer behavior based on the cellular automata, it allows for the first time to form the mechanism of introduction of energy-conservative technologies for the use of alternative energy sources, taking into account the "*group interests*" of agents, improving the information analysis of management decisions to achieve socio-economic effect. Thomas (1992) using the Analytic Hierarchy Process (AHP) suggested to consider the future energy system through the prism of a combined process of planning the interaction of various actors (agents). Based on AHP the system of indicators of efficiency of introduction of energy-conservative technologies will allow to provide expediency, relevance, objectivity of administrative decisions. Pyster et al. (2012) formed a scientific toolkit for models of energy-conservative agents' interaction. Further development of the model of the choice of characteristics based on the concepts of stakeholders and the ecosystems agents evolution will make it possible to formulate practical recommendations for increasing communication and centrality (dominance) of congruence the interaction of group interests introducing energy-conservative technologies for the use of alternative energy sources. Thagard (2010) based on the principles of cognitive modeling, developed the cognitive model of consumer interaction, which consists in focusing on specific conditions for the development of the situation in the subject area. The development of an analytical model of the energy system is based on the heuristic establishment of cognitive space parameters, in which modern conscious consumers interact closely. The model of social behavior of economic agents is developed by Kalmykov (2015). Developed model of agents' social behavior is the basis for researching the processes of information distribution on social and economic problems that arise in society in the presence of the problem of energy dependence of economic entities from external traditional energy sources.

DATA AND PRESENTATION

General scientific and specific methods of cognition were used in the process of research. Thus, the formation of economic agent's behavior model on energy conservation was carried out on the basis of the theory of cellular automata. The destructive interaction of these agents was explored on the basis of the concept of the evolution of "*predator-prey*" systems and the interaction of stakeholder interests.

There is a hypothesis that the communication interaction of all groups of agents on energy conservation issues tends to establish balance and stability. The destructive interaction of these groups requires the development of a system of measures to counteract the reduction of effects, leading to the destruction of the country's national security system. This is facilitated by the introduction of new energy-conservative technologies, new energy transportation technologies, devices necessary to create comfortable conditions for a group of consumers, changes in legislation, new tariff setting, etc., accompanied by increased activity of all members of these groups (Nakashydze & Gil'orme, 2015). The proposed model is based on the cellular automata theory (Maksyshko & Glazova, 2016); Lobanov, 2010) and can be used in the preparation and decision-making at the level of energy saving agents. However, this model has a limited scope, and for its use it would be advisable to determine the sources and methods for obtaining quantitative estimates of model parameters, which has not yet been implemented.

The perceptivity or irresponsiveness of civil society to the innovations in the field of energy conservation at the current stage is determined primarily by social factors (if a country has a low level of living standards, the significant part of the population does not sustain to the development of innovations).

METHODS

When implementing the energy conservation model throughout the whole assembly of the formation of consumer value as a manifestation of the resistance barriers considered, groups of interests of energy saving agents arise. For analyzing of these processes, we will consider the mathematical model that stipulate description of the behavior of energy-conservative agents in time and is based on the theory of cellular automata. A cellular automaton (CA) is a collection of identical, in some way interconnected cells, whose behavior is completely determined in terms of local dependencies (Jobstl & Hogg, 2015). At the same time, the state of the energy conservation agent, his behavior as the realization of his interests, depends on two groups of factors: external and internal. On the basis of cognitive modeling of interaction it is possible to construct models of social behavior of agents on the basis of sociability (microenvironment) and the degree of diversity of elements (macro-environment). The parameter characterizing the action of external factors is denoted as $f^{ex} \in [0;1]$. External factors can be analyzed using methods of strategic analysis: SWOT, PEST, etc.: hold the grouping by factors: economic, political, social, technological. For example, external factors include: availability of preferential consumer loans, the period of the "*green" tariff* ", benefits in environmental tax, the formation of apartment building co-owners association, the introduction of Internet technologies (online counters), the increase of tariffs, etc. (Kalmykov, 2015).

Internal factors include the qualities of each individual agent for energy conservation: the ability to communicate, the receptivity to innovation, civic-mindedness, etc. external factors we denoted as a parameter: $f^{in} \in [0;1]$.

A general assessment of the status of each energy-conservative agent (producer, intermediary, and consumer) $A \in U$ at the time *t* we propose to define as follows:

$$F_A = f_A^{ex} \times f_A^{in}, \quad (1)$$

But over time, the effect of external and internal factors varies with a certain probability *p*, respectively varies the general state of the agent, we propose to define analytically:

$$p : F_A(t) \to F_A(t+1) \quad (2)$$

Agents for energy conservation are able to make decisions that affect the state in the future: there is the possibility of self-organization, adaptation. At the same time, it is possible to group agents according to their degree of interest in the processes of energy conservation, scaling: 0-complete indifference to energy conservation; $(0{,}1;0{,}4)$ -low level of interest in energy conservation; $(0{,}4;0{,}7)$ –average level of interest in energy conservation; $(0{,}7;1)$ -high level of interest in energy conservation. The degree of interest of the agents "*indifference to energy conservation"* requires additional analysis of the reasons for this indifference, caused by the level of sociability (inertness, recusancy, level of accommodation/assimilation, etc.). Agents entering the range of interest in energy saving processes (*U*-all capable agents), can be divided into three groups: A-agents with high level of interest in energy conservation, who are ready to the implementation of a new energy conservation model; $\overline{A}$ -agents with average level of interest in energy conservation, additional efforts are needed to incorporate the implementation of a new energy conservation model; $\tilde{A}$-agents with low level of interest in energy conservation, it is necessary active measures to create and develop active behavior of agents, reduce destructural changes in economic behavior to include the implementation of a new energy-conservative model.

Then the assembly of energy-conservative agents displayed analytically:

$$U = A(t) \cup \overline{A}(t) \cup \tilde{A}(t) \tag{3}$$

If measures to create and develop active behavior of energy-conservative agents are effective, positive experience is expanding among the respective groups of agents - conditions are created for a certain probability of transition from group to group: $\tilde{A} \to \overline{A}; \tilde{A} \to A; \overline{A} \to A$. In this case, the probability of changing the state of agents is determined as indicated above, $p_1 : \tilde{A} \to \overline{A}; p_2 : \tilde{A} \to A; p_3 : \overline{A} \to A$. It should also be noted that agents do not exist in a closed system: according to the theory of cellular automata, there is the influence of each agent, group ($A; \overline{A}; \tilde{A}$) on the behavior of everyone, especially in the manifestation of group interests. We propose to determine the impact on the behavior of agents on energy conservation for 3 groups: taking into account the degree of attraction/non-attraction of technical means (the influence of computer social networks, the activity of agents in these social networks, the level of information transparency of technology promotion tools for energy conservation, etc.); level of communication (mentality, receptivity and other psychological factors of personality); the acuteness of the problem of energy conservation (the massive disconnection of energy systems, the increase in the share of energy carriers in the cost of production, services, works, massive "*forced vacations"* in public sector institutions for the heating season, etc.).

RESULTS AND DISCUSSIONS

To evaluate the characteristics of the active economic behavior of energy saving agents, the results of research on V.M. Sazanov's theory of social networks were used, in which the determination of statistical properties that characterize behavior is distinguished as one of the main areas of study of systems with a network structure.

The choice of the characteristics of the interaction of energy saving agents through the characteristics of communication networks is not contrary to studies (Metcalfe & Boggs, 1976), who argued that the communication network value is proportional to the number of links between members of the network, rather than the number of participants as in the classical broadcast network.

To implement the dynamics model of energy saving agents and perform simulation modeling, the multi-agent software simulation environment NetLogo 6.0.4 was used. (Maksyshko & Glazov, 2016). Input parameters of the model are the initial number of participants in energy saving projects in the city of Dnipro (Ukraine) and their activity index *p* (degree of influence on other energy saving agents per time unit).

The output data of the model is the estimation of the number of (agents) belonging to the sets defined above in the dynamics for the given time (weeks, months, etc.) in the form of the "*number-time*" dependency graph.

But when forming an innovative economic model of agents' behavior in the field of energy conservation occurs according to the evolutionary laws of behavior of groups of agents - the third hypothesis of the study. The introduction of the agent behavior model for energy conservation can be considered in the context of the concept of "*predator-prey*", as the most common phenomenon in nature. In this case, the activity of economic entities is considered in the analogy of economic systems with biological ones. If predators feed on those unable to resist species, this leads to another evolutionary result. Those individuals die, which the predator has time to notice. Preys who are less visible or somewhat uncomfortable to capture win. The evolution of species goes towards specialization in these features (Romanov, 2015). For our study, the most interesting are the typical predators in their relationship with the preys and the ecosystem as a whole. If the predator feeds on large, active preys - it leads selection for the improvement of the preys, destroying the sick and the weak (Tetiana et al., 2018). In turn, among the predators there is a selection of strength, agility and endurance, too. A consequence of the evolutionary scale of these relations is the progressive development of both interacting species- both the predator and the prey. In economic systems, this kind of evolution takes place according to similar principles.

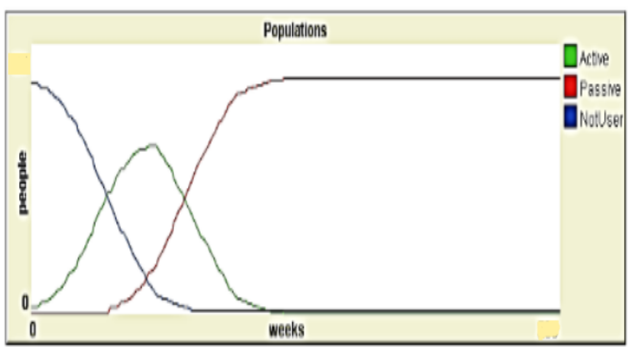

FIGURE 1
AN EXAMPLE OF THE RESULT OF A MODEL BASED ON A CELLULAR AUTOMATON FOR CALCULATION OF THE DYNAMICS OF PROCESSES FOR ENERGY SAVING AGENTS (ACTIVE, PASSIVE)

A new technology, especially that has an energy-conservative component when it appears on the market, enters into a hostile environment and is fighting for survival (international oil and natural gas corporations are blocking projects on alternative energy) (Gil'orme, 2016). This is due to the fact that there are older and stronger technologies on the market, so innovative technologies are either absorbed by the old, or die, without developing to the full. But, if the new technology proves more competitive, then it expels the old one.

CONCLUSIONS

The use of the newly created methods for diagnosing conflicts of group interests will increase the effectiveness of large-scale implementation of energy-conservative technologies, including using alternative energy sources in various sectors. Due to the definition of the mechanism for managing the effectiveness of introducing energy-conservative technologies, management methods (administrative, economic and socio-psychological) will be optimized in the context of taking into account group interests.

The behavior of energy saving agents with regard to the cooperation in the solving of problems is affected by many factors of external and internal nature, among which: the severity of the problem, the agent's sociability, the time, etc. The paper proposes the generalization of the model of dynamics of the processes of the self-organization of the energy saving agents taking into account these factors. The information sources and methods of obtaining quantitative estimates of the model, its parameters and factors are determined and substantiated has been identified and justified. The formalization of the method of estimation of the probabilistic characteristics of self-organization of the energy saving agent, the use of fuzzy mathematics for the evaluation of qualitative characteristics, as well as the evaluation of economic effects allow us to determine the destructive economically active behavior of energy producers of traditional energy sources.

The developed model of agents' behavior in the field of energy conservation is used in the formation of communication support for innovative complex energy supply and air-conditioning systems using solar energy, heat pump, soil heat and air (including ventilation) developed at the Oles Honchar Dnipro National University Research Institute of Energy (Dnipro city, Ukraine).

ACKNOWLEDGMENT

Authors of the paper would like to extend their acknowledgment and gratitude to colleagues for providing vital information in the course of calculations for efficiency of energy-active barriers system project on the basis of implementing alternative energy sources – Useful model patent UA 109070, Ukraine, МПК F24G 2/50, E04B 1/76 Energy-active fencing / L. V. Nakashydze, M.V. Shevchenko, V. O. Habrynets (Ukraine), pub. 01.08.2016. bul №15, apl. 16.02.2016.

REFERENCES

Fang, M., Chao, G., Chen, C., & Luo,Y. (2012). Research on consumer purchase behavior diffusion across market using cellular automata. *International Journal of Marketing Studies*, *4*(5), 108-118.

Saaty, T.L. (1992). *The hierarchon: A dictionary of hierarchies.* Pittsburgh. Pennsylvania: RWS Publications.

Pyster, A., Pyster, A., Olwell, D., Hutchison, N., Enck, S., Anthony, J., Henry, D., & Squires, A. (2012). Guide to the Systems Engineering Body of Knowledge (SEBoK). The Trustees of the Stevens Institute of Technology.

Thagard, P. (2010). *The Brain and the Meaning of Life*. Princeton: University Press.

Lev, K.V., & Kalmykov.V.L. (2015). A Solution to the Biodiversity Paradox by Logical Deterministic Cellular Automata. *Acta Biotheoretica, 63*(2), 1-19.

Jobstl, H.A., & Hogg, J.N. (2015). State of forestry accounting in some european countries. In: Buttoud G., Jobstl H., Merlo M. (eds.), *Accounting and Managerieal Economics for Environmen-tally-friendly Forestry* (pp. 17-40). Economie et Sociologie Rurales, Actes et Communications.

Romanov, V.P., & Akhmadeieva, B.A. (2015). Modeling of the innovation ecosystem based on the "predator-prey model." *Business-informatics*, *1*(31), 7-17.

Gil’orme, T., Ryzhyk, Y., & Yaresko, A. (2016). Formation of the mechanism of energy efficiency management on the basis of ‘predator-prey’concept. Problems of development modern science: Theory and practice: Collection of scientific articles. EDEX, Madrid, España, 107-110.

Tetiana, H., Karpenko, L., Fedoruk, O., Shevchenko, I., & Drobyazko, S. (2018). Innovative methods of performance evaluation of energy efficiency project. *Academy of Strategic Management Journal, 17*(2), 112-110.

Maksishko, N.K., & Glazov, Y.V. (2016). Models of the dynamics of self-organization processes in the territorial community of the city. Kherson State University. *Economic Sciences, 1*(17), 150-154.

Metcalfe, R.M., & Boggs, D.R. (1976). Ethernet: distributed packet switching for loc al computer networks. *ACM Communications, 19*(5), 395-404.

Lobanov, A.I. (2010). Models of cellular automata. *Computer Studies and Modeling, 2*(3), 273-293.

Nakashydze, L., & Gil'orme, T. (2015) Energy security assessment when introducing renewable energy technologies. *Eastern-European Journal of Enterprise Technologies, 4/8*(76), 54-59.