STRATEGIC DSS FOR ROBUST ENERGY PRODUCTION AND STORAGE INVESTMENTS AND OPERATION PLANNING INVOLVING VARIABLE RENEWABLE ENERGY SOURCES: A TWO-STAGE STOCHASTIC OPTIMIZATION MODEL WITH STOPPING TIME AND ROLLING TIME HORIZON

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Аннотация. *The paper presents a strategic Decision Support System (DSS) for energy-efficient technology investments planning, including energy production and storage capacities expansion and operation policies. The DSS enables the analysis of robust decisions against inherent uncertainties and risks, in particular, systemic risks due to introduction of stochastic renewable energy sources, price volatility, demands uncertainties, weather variability, resource availability. The DSS is based on a new two-stage, dynamic stochastic optimization model with rolling random time horizons bounded by stopping time moments.*

In this paper we present stochastic methodologies for energy-efficient technology investments planning, which can provide robust decisions against inherent uncertainties for optimal energy and storage capacity expansion and operation policies involving stochastic renewable energy sources. The approach for the robust decision support relies on a new two-stage, dynamic stochastic optimization model with moving random time horizons bounded by stopping time moments [1-2].This allows to analyze and model systemic impacts of potential extreme events and structural changes emerging from experts and stakeholders' dialogues [6-7], which may occur at any moment of the decision-making process. In this way, the DSS provides an environment that can guide the necessary experts and stakeholders' dialogues and negotiations with the DSS and among the stakeholders themselves, possibly with different conflicting motivations and goals. The dialogues/negotiations can enable endogenous and exogenous feedbacks into the decision-making process. Since the decision-making can be considered as an iterative process, the DSS-experts/stakeholder outcomes provide feedback and revisions of the DSS and the energy system structure through stopping time moments and moving time horizons [3].

The DSS allows the representation of all relevant energy subsystems components (e.g. traditional and renewable) and their interactions, dealing with both strategic and operational decisions planning, and including technological and financial-oriented decisions. Energy storages are represented and modeled in a rather general way. For example, the excess electricity can be used for hydrogen and fertilizer production or "exported".

The stopping time moments induce endogenous risk aversion in strategic decisions in a form of dynamic VaR-type systemic risk measures dependent on the system's structure [2-4]. Unlike the static nature of deterministic models, the proposed stochastic model and the DSS deliver solutions that are responsive to revealed information about systemic uncertainties and risks such as related to stochastic supply, demand, prices, weather variability, technological change, in order to adjust local or regional energy structure and management policies in a cost-effective and risk hedging manner [3-5].

Integration of the operational and strategic models under the umbrella of the two-stage stochastic optimization provides an effective way to make real-time decisions consistent with long-term strategic goals of energy system planners to guarantee secure energy provision in all uncertainty scenarios [3-5]. The solution of the problem involves adjusting operational decisions to hit long-term targets if additional information about prices, subsidies, demand, weather, new technologies can become available in the future.

Литература.

1. Ermoliev Y., Wets R. (Eds.). Numerical techniques of stochastic optimization. Computational Mathematics. Springer Verlag, 1988.
2. Ermoliev, Y., Hordijk, L.: Global changes: Facets of robust decisions. In: Marti, K., Ermoliev, Y., Makowski, M., Pug, G. (Eds.). Coping with uncertainty: Modeling and policy issue. Springer Verlag, Berlin, Germany, 2003.
3. Ermoliev Y, Ermolieva T, Fischer G, Makowski M. Extreme events, discounting and stochastic optimization. Ann Oper Res 2010. – Vol. 77.- P. 9–19.
4. Ermoliev YM, Robinson SM, Rovenskaya E, & Ermolieva T. Integrated Catastrophic Risk Management: Robust Balance between Ex-ante and Ex-post Measures // SIAM News.- 2018. - Vol. 51 (6). - P. 4.
5. Gritsevskii, A., Ermoliev, Y. Modeling technological change under increasing returns and uncertainty. In Managing Safety of Heterogeneous Systems; Ermoliev Y., Makowski M., Marti K., Eds. – Springer Verlag, Heidelberg, Germany, 2012. - P. 109-136.
6. Komendantova, N, Neumueller, S., Nkoana, E. Public attitudes, co-production and polycentric governance in energy policy. // Energy Policy. – 2021.- Vol. 153, 10.1016/j.enpol.2021.112241.
7. Komendantova, N., Maraschdeh, L., Al Salaymeh, A., Bohm, S., Ekenberg, L., Krüger, C., Zejli, D., Mtimet, N., et al. Energy Policy at Crossroad: potentials for sustainable energy transition in the Middle East and North African region. IIASA Working Paper. Laxenburg, Austria: WP-19-004, 2019.