

# MODERNIZATION OF POWER SUPPLY SYSTEMS IN THE "SMART NORTHERN CITY" PROJECT. MULTI-AGENT MODEL

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A particular problem to implement a smart Northern city energy supply and consumption technologies is discussed. The Russian Arctic territory is divided on eight basic longitudinal regions (support zones) in accordance with the types of natural resources flow generated there. The fourth support zone specializing in gas and oil recovery includes Yamal Peninsular, where the most promising for the next semi century the liquefied natural gas producing cluster with possible annual capacity up to 70 ml tons is located. Significant incomes of regional budget allow to invest in transport networks over permafrost and to subsidize municipal costs on energy supply and central heating. Annually problems of efficient budgeting is sharpening, in particular, for the municipal community Salekhard, the capital of YNAO. It is the compactly located on the Polar circle, developing settlement with rather advanced infrastructure for 52 thousand inhabitance.

Salekhard is chosen here for a systematic analysis in accordance with the multi-agent version of system approach. It allows to describe efficiently for various practical applications including those under uncertainty and risk [15] wide classes of technical objects and abstract notions. Similar terms of agents and multi-agent systems (r/v/i)MAS present either real (r: equipment, mechanisms, vehicles) or virtual (v: agreements, messages, images, plans, programs, software) or intelligent (i: personal, organizational systems). For example, an informational system or an IT-platform may be presented by (r)MAS including on the lower level <hardware~(r)MAS, software~(v)MAS, staff~(i)MAS || Business Processes ~ technologies>. Intelligent agents or MAS are able to form a situation reflection in their internal information space.

In accordance with the multi-agent approach Salekhard, being a controlled system (**CS**)-{**G**: Environment || **M**: system of control; **B**: mechanism; **C**: object of control} is a (r)MAS. A verbal image of the city gives the Strategy, (v)MAS. Inclusion of a digital twin in a smart city **CS** structure may transform it into (i)MAS.

The Strategy has presented **M**: understanding of correspondence of Salekhard development prospects on decade period and **C**: problems of current status. Features of the city development concept are as follows.

- **G**: By the matter of fact, environment, the harsh circumpolar climate with a heating period (GSOP) of more than 7000 degree days, is supposed to be invariant up to 2030. The important natural factor, permafrost, is only once mentioned on 80 pages of the strategic planning document. Thus, the Strategy does not consider possible climatic conditions changes that create a risk of disrupting the city infrastructure stability.

- **G**: The responsibility delineation for participants in the Salekhard development process is reflected. However, the government of YNAO is actually considered as a component of the external environment, whose actions are not amenable to correction. To a certain extent, this may be justified by the independence of the municipal level in governmental hierarchy fixed in the RF Constitution. This item is corrected by an amendment adopted popular vote on July 01, 2020.

- **B**: In the current state of the municipality the problems relevance of the Smart City 1.0 level is shown. That are: the state of the housing stock; material flows processing (water intake, sewerage and wastewater treatment, garbage collection and processing); compliance with life support standards for the population, in particular, the national settlement of Pelvozh, etc.

- **B**: The dominant branch of the city's business, the production and distribution of energy resources and water, determines on more than 80% of industrial production. Municipal JSC "Salekhardenergo" is a leading nearly monopoly supplier of material resources and energy flows for the population. Therefore, technologically motivated controlled changes in volumes and costs of services may decrease the gross domestic product of city.

- **B**: The task has been set to implement "smart city" technological solutions by decentralized efforts of groups of IT enthusiasts, a way to involve socially active citizens in city problems.

The Strategy analysis shows that the inertial scenario of the consistent city development is accepted as the main. The target criteria (indicators) given in section [Task 2.2] demonstrate the limitations of this scenario, in particular, anticipating the degradation of the city's housing stock.

Therefore, it makes sense to examine alternatives for intensive development. One is a centrally governed project of Smart City 2.0 level implementing to create a digital twin. This case allows to realize in Salekhard a multicomponent hybrid energy system combining the innovated energy supply subsystem

and a newly creating subsystem to control the state of the engineering infrastructure in permafrost. The economic viability of the project depends on possible savings of energy resources and reducing losses from the destruction of engineering infrastructure. Preliminary expertise and data on Yekaterinburg show possibility to cut up to 15% of resource consumption.

The paper presents the results of research alternative ways to intensive development of the Northern city Salekhard. A centrally governed project of the Smart City 2.0 level implementing creating a digital twin is discussed. This case allows to realize in Salekhard a multicomponent hybrid energy system combining the innovated energy supply subsystem and the newly created subsystem to control the state of the engineering infrastructure in permafrost. The economic viability of the project depends on possible savings of energy resources and reducing losses from the destruction of engineering infrastructure.