Development of the methodical foundation of energy saving reconstruction of urban development with account for energy characteristics of housing facilities

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Abstract. Rapid development of towns and growing urbanization level create the demand for adequate ways of further development of urban territories. Perspectives of growth of energy consumption in towns require shifting to energy efficient course of development. In most cases power supply problems in towns are viewed only in the context of general economy of fuel and energy resources and are almost fully ignored in planning of urban territories. Methodical foundation of energy saving reconstruction of housing facilities has been developed to solve energy saving problems in town planning.
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Introduction

A town is a complex territorial social and economic system with specific features formed as a result of economic, social and geographic, environmental and social factors. Urban system consists of social, economic, spacial and ecological subsystems [1]. Subsystems are linked with each other with numerous information, energy and material links necessary for effective functioning of urban system. Town is integral energy system functioning in single environmental, economic, social and physical space.

Competitiveness of territorial economic system is comprised of effectiveness of regional resources utilization and is defined by capability to create and support attractive environment for business development and people welfare. Infrastructure, environmental state and housing quality are the most important factors of inhabitants' satisfaction [2]. Energy saving and related ecological problems started to attract primary attention last years [3, 4].

Effective energy saving should be based on rational production and utilization of energy in all levels. It should consider the choice of the most effective measures, feasibility study of these measures, adequate energy consumption policy, energy management, energy processing and recuperation as well as education in energy saving [5]. Making effective energy saving decisions in each stage of design starting from individual building to general town planning scheme has a potential of developing of integral system of town energy saving management. The lack of complex approach to urban reconstruction with account for energy saving policy is one of the barriers to effective energy saving and sustainable development. It cause the necessity to develop methodical foundation for energy saving reconstruction of urban development to support making decisions on compliance with the requirement on energy efficiency, ecology and comfort living on urban territory.

Substantiation method of energy saving urban development reconstruction.

The concept of energy efficient reconstruction of urban development is realization of complex approach to energy saving tasks applied to housing and communal services. Reconstruction of development in wide sense is focused on making the structure, objects and facilities of the development modern, socially oriented and technically advanced [6]. But now municipal authorities are required to realize Federal Law # 261-FL dated 23.11.2009 "On energy saving and energy efficiency increase and on making corrections to individual Laws of Russian Federation" as to town planning problems. Municipal authorities have been set a task to comply the requirements to energy efficiency of buildings and constructions as to decrease specific energy consumption on 15% to 2016, on 30% to 2016-2020 and more than 40% after 2020 [7].

In recent years many countries started to realize energy saving programs. Most of these programs are focused on reduction of energy requirements of new generations, preserving energy resources and environmental protection [5]. In Russian Federation the problem of energy preservation is also solved via targeted programs. The programs that had been developed as usual do not consider solving of industrially specific problems. But energy saving problems should and ought to view

in territorial dimension applied to urban territory and its parts [8]. Large scale development of new production facilities cause the necessity of energy saving measures that account for town planning specifics of municipal entities, energy efficient distribution of vendors and consumers of energy, housing sphere in space. Importance of energy saving by methods of regional planning, territorial planning and architectural and development design also grows. Thereupon both architectural and development and civil as well as tow planning energy saving solutions should be mandatory accounted in town development reconstruction.

Energy saving reconstruction of town development may be defined as the process of transformation and renewing of existing layout and development of a town caused by the necessity to comply to today requirements on energy saving and energy efficiency. Energy saving reconstruction is fulfilled to support effective and rational utilization of energy resources in the process of town and inhabitants functioning, development of energy effective production and consumption of energy as well as leveraging of energy standards of town development's elements i.e. residential buildings and public buildings, heat supply sources. The research resulted in the method of energy efficient development and reconstruction of urban territory that consists of 6 steps (see Figure 1).

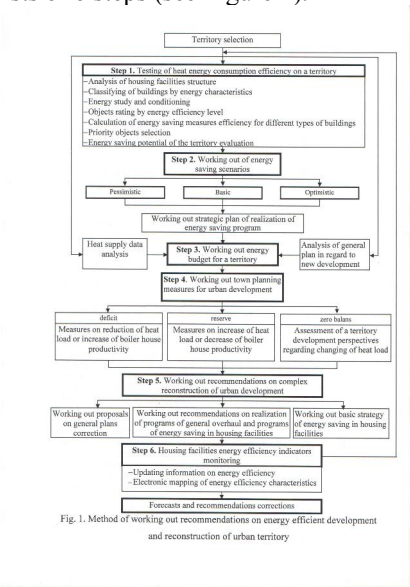

Fig. 1. Method of working out recommendations on energy efficient development and reconstruction of urban territory

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The concept of energy efficient reconstruction of urban development comprises the following:

- analysis of energy efficiency of urban development and revealing of problem areas in town territory;
- energy reorganization of inefficient apartment housing stock;
- evaluation of heat supply efficiency and compliance of heat loads to heat source capacity;
- rational distribution of power consumers to reduce energy drains;
- choice of energy saving town planning measures: modernization, reconstruction or elimination of existing boiler houses, load correction or capacity correction considering reduction of heat energy demand of reorganized housing stock;
- rationalization of general plan from energy position;
- analysis of placement variants for new energy efficient development on the territories of boiler houses service zones, reconstruction of problem energy inefficient zones in general plans of settlements using energy saving technologies in town planning.

Main body

Realization of developed method:

Step 1. Testing of heat energy consumption efficiency on a territory.

Testing of heat energy consumption efficiency on a territory is made on the base of analysis of housing stock structure and buildings classification by energy characteristics i.e. the year of building, number of floors, material of walls [9]. List of analogous objects is compiled for each group of buildings to carry out energy survey and computation of energy passport. Housing stock is being rated by the level of energy efficiency basing on the result of computation and recommendations for deployment of energy saving measures for different types of buildings are being worked out.

Carrying out complex energy conditioning i.e. complete overhaul of buildings realizing energy saving measures is the key element of energy saving reconstruction of urban development taking into consideration insufficient technical condition of a part of living buildings. Mandatory measures of energy conditioning are heat insulation of fronts, roof decks and attics, ceilings of basements, replacement of windows and balcony doors, modernization of heat and hot-water supply, ventilation system and power supply system. Research that has been carried out allowed evaluating efficiency of these measures for different types of buildings (see Table 1).

Table 1. Energy saving potential of energy saving measures in percents

Period of development	Material of walls	Number of floors	Energy efficiency class	Percent of heat energy demand reduction due to measures:					
				walls	Ceiling deck	basement	Heat and ventilation	Windows	Power supply
Before and after the October revolution, up to 1927	Timber houses (wooden (lodging houses), wattle and daub houses	1,2	D/E	7	1	3	19	1	10
	Brick houses (lodging houses), brick-faced houses	1	E	23	4	10	13	1	4
		2	E	38	7	16	6	0	2
		3,4,5	E	15	3	6	10	4	2
Before the Second WorldWar (1928-1945)	Brick houses, brick-faced houses	1…3	E	38	7	16	6	0	3
		4..8	E	19	3	8	17	7	2
After the Second World War (1946-1957)	Brick houses, frame-and-panel houses and single-layer bearing panels	1…3	D/E	16	3	7	10	10	6
		4,5,6	E	15	3	7	17	4	1
1958-1970	Brick (brick-faced)	1…4	E	25	4	11	12	5	6
		5…11	E	16	3	7	14	6	2
	Panel	5..10	E	11	2	5	25	7	1
1971-1980	Brick	1…4	E	16	3	7	18	6	7
		5..16	E	17	3	7	16	6	2
	Panel, frame-and-panel houses	5..17 (9-17)	E	11	2	5	25	7	1
Modern (1981-2000)	Brick	1…4	D/E	13	2	6	13	1	6
		5..9	E	15	3	7	12	6	1
		10..19	E	14	2	6	6	5	2
	Panel, frame-and-panel houses, monolithic houses	4..9	E	16	3	7	20	6	1
		10..18	E	14	2	6	9	7	1
Houses with increased heat saving characteristics (after 2000)	Brick, panel, monolithic houses	1..9	C	2	1	1	22	1	6
		10…24	B/C	2	1	1	22	1	3

From economical point of view measures on apartment buildings energy efficiency increase is rational to fulfill in the scope of regional and municipal programs of complete overhaul and modernization of apartment houses. Town planning energy saving measures are rational to fulfill after energy conditioning of housing stock.

Step 2. Working out of energy saving scenarios.

Three possible scenarios of energy saving measures may be provided to comply with requirements of energy efficiency – pessimistic, optimistic and basic (see Table 2).

Table 2. Energy saving scenarios

#	Name	Essence
1	Pessimistic scenario	Presume repair works in preset terms in the volumes presumed in complete overhaul programs. Energy saving measures are limited to installation of energy resources recording instruments. As a result insignificant growth of energy efficiency of buildings are foreseen, energy efficiency requirements are not complied.
2	Optimistic scenario	Carrying out a complex of measures of energy efficiency increase at a time in a scope of complex complete overhaul. Optimistic scenario will fully support energy efficiency growth of reconstructed buildings and compliance with energy efficiency requirements. But such scenario may cause problems in drawing funding from inhabitants and needs joint financing.
3	Basic scenario	Focused on compliance with energy efficiency requirements and presume energy saving measures fulfillment on steps with energy resources rate decrease on 15, 30, 40 % of basic level for all buildings. Heat insulation of fronts is viewed as additional measure for high priority objects. Dividing of repair works in steps in accordance with the periods of energy efficiency characteristics revision – once in 5 years – allows making repair works in the least possible time with lower fees for inhabitants than in optimistic variant.

Selected scenario lays the foundation for basic energy saving strategy.

Step 3. Working out energy budget for a territory.

Deployment of measures on energy saving in housing stock causes the rise or growing of energy imbalance in a territory. Town planning measures are focused on optimizing heat balance of development in accordance with changing energy and town planning characteristics of a territory. Working out heat balances between the source of heat energy and end consumer results in a conclusion about existence of reserve or deficit of heat energy in the zone of heat energy source.

Step 4. Working out town planning measures for urban development.

Classification of town planning measures by heat balance was compiled on the base of the research (see Table 3).

Table 3. List of town planning energy saving measures for urban development reconstruction

Period of development	Material of walls	Number of floors	Energy efficiency class	Percent of heat energy demand reduction due to measures:					
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	Panel, frame-and-panel houses, monolithic	4..9	E	16	3	7	20	6	1
		10..18	E	14	2	6	9	7	1

Realization of town planning decisions requires high investments and long time (standard project period is 20-30 years). But these are the decisions that have significant impact on the level of territorial energy consumption.

Step 5. Working out recommendations on complex reconstruction of urban development.

The complex of town planning and technical measures on energy saving is included in projects of

reconstruction of urban development. They are also used as recommendations on town development general plans correction and recommendations on realization of complete overhaul programs and energy saving programs in housing stock.

Step 6. Housing facilities energy efficiency indicators monitoring.

The most complicated task in town planning is decision making on town development, forecasting and monitoring of results of these decisions. Town planning specifics of municipal entities are fully accounted in work with GIS. GIS tools are widely used for solving tasks of town planning and ecological monitoring, development of general plans, managerial decisions computer systems and system of urban territories analysis [10, 11].

Taking GIS into consideration in solving energy saving problems is rational because this system allows accounting for spacial and geographic factor that is key criteria of town planning activity. Energy saving objects i.e. buildings in towns are distributed over town territory irregularly so geographical dimension in housing stock energy efficiency monitoring system development and in working out decisions on reconstruction of towns is not less important that numerical indicators. Spacial analysis provides wide possibilities for monitoring energy efficiency of urban development.

Unit of simulation modeling of energy characteristics of urban development may be created on the base of computer system of town planning support. It is based on drawing and spacial analysis of energy efficiency of urban development as a result of energy saving measures. The scheme of simulation model is shown in Fig. 2.

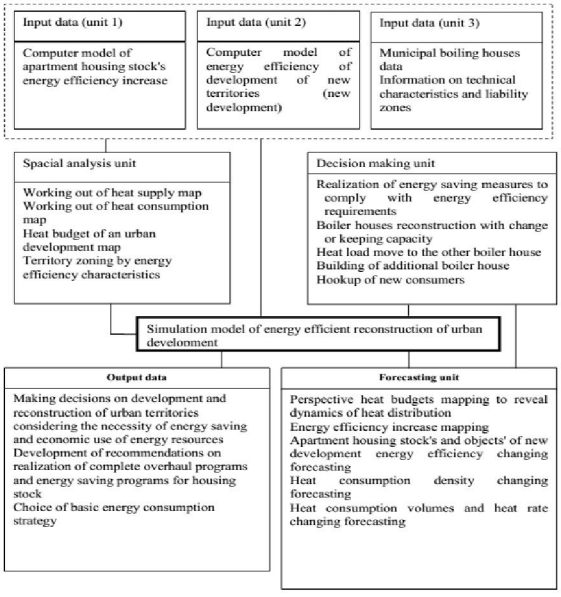

Fig. 2. Simulation model development scheme

Figure 3 shows an example of realization of simulation model resulting in computer maps of territory energy characteristics changing after consistent realization of mandatory measures for housing stock objects: initial class; after windows replacement; heat insulation offending constructions; heating system reconstruction; ventilation system and power supply system reconstruction (complex of measures).

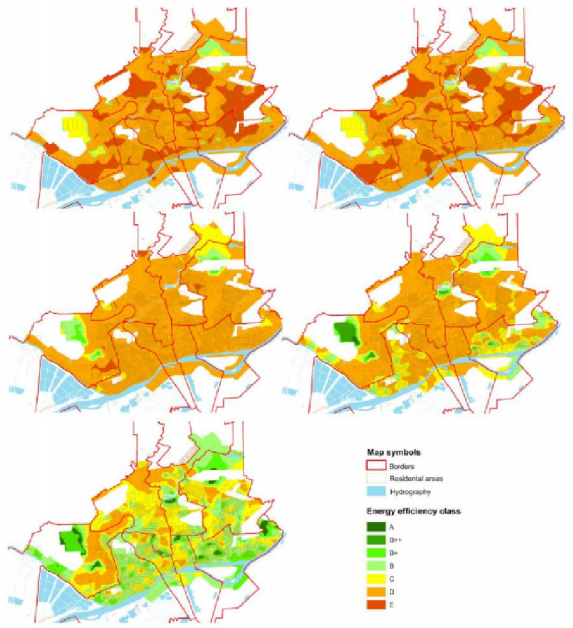

Fig. 3. Simulation model realization example: leverage of energy efficiency classes of urban development as a result of energy saving measures

Simulation model that has been developed allows making spacial analysis of new territories development process with simulation of input parameters that provides the possibility to make forecasts of territorial development with regard for their energy efficiency growth.

Conclusion.

Theoretical and experimental survey that had been made allowed developing complex concept of realization of energy efficient reconstruction of urban development.

Thus, proposed method allows solving the following tasks:

- Test efficiency of heat consumption on developed territory basing on classification of buildings by energy characteristics;
- Work out energy saving scenarios, select the most relevant of them and develop energy saving strategy;
- Propose the complex of town planning energy saving measured on urban development

reconstruction basing on the value of heat budget of development;
- Make effective decisions on urban territories development with regard energy saving in the base of GIS.
The method is applicable for each municipal entity and the subject of Russian Federation.

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