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Strategic guidelines of a megalopolis’s development: new industrialization and ecological tension

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Abstract. The article is devoted to the integration of environmental concerns in the development strategy of the metropolis. The authors substantiate the relationship of the new industrialization and reduce the burden on the environment. For example, a large city in Russia – Ekaterinburg – projections and strategic directions of ecological development of the city for the period up to 2035. The basis for the forecast were the methods of aggregation of economic sectors, functional relationship and forecasting algorithms. The article describes three scenarios for the development of Ekaterinburg, the results of calculations by the author's method. The authors have shown the relationship of industrial development of the metropolis and the anthropogenic load, which is assessed using such indicators as emissions of harmful substances into the atmosphere, discharges of sewage, green spaces per inhabitant. The authors note that the ecological security of the residents is directly related to the improvement of controllability of the municipal economy, the increased control in the field of the environment, reduction of environmental burden on humans and the environment, zoning of the city with a goal differential application of indicators of the quality of the environment.

1. Introduction
The future of million-plus cities in Russia in a medium-term horizon is approximately the same. It aims to create a quality of urban environment, not inferior to the world cities, the most accessible of which is Moscow. In fact, we are talking about the construction of a “post-industrial city”, with developed economy of services, modern trade, entertainment and public spaces. At the same time, industrial megacities, which historically developed as centers of industrial territories, faced a key contradiction – how to assess an objectively occurring deindustrialization process. On the one hand, a growth of trade, public catering and services sector certainly changes a face of a city, attracts investors and population, raises a quality of life level, forming a “city for a person”. However, on the other hand, a decline in an industry share in the city’s economy structure may be disastrous for the city’s economy, since an industrial complex, being a material basis where innovations are realized, provides high-performance and highly paid jobs, each of which places a demand for highly skilled professionals.

Considering an issue of de-industrialization, it is widely believed that an industrial segment squeezing will solve environmental problems. Socio-ecological tension indeed characterizes a relationship between a city development and a real anthropogenic load on the natural environment. A need to increase an economic growth rate of a city reflects an universal (for post-industrial society) setting for a growth of material well-being of population. According to German philosopher W. Hesle,
with a transformation of “liberal legal states into social services states” a maximum satisfaction of people material demands became the main goal of an existing socio-economic system [1]. Formed on a basis of consumer culture, a lifestyle of megacity population aggravates a relationship between a society and the environment, stimulating an economic development. To meet new needs, a society accelerates a scientific and technical progress, which, in accordance with prevailing attitudes in public consciousness, is also perceived as “a foundation of material prosperity and as a foundation for conquering nature” [2].

However, at present in the post-industrial countries the orientation towards ecology becomes a significant factor that intensifies economic development. Consistent implementation of environmental activities leads to accelerated economic progress, since both environmental protection and economic growth have a common basis – a technological progress. Environmental programs stimulate economic development, an implementation of structural changes, new jobs creation and further progress in science and technology.

Thus, a new industrialization goes hand in hand with a new environmental imperative at a level of the urban environment. An industrial sector is qualitatively changing in terms of a set of technologies used. It ensures a slowdown in a growth rate of emissions into the environment. Reindustrialization, namely, a strengthening of an industry share in city economy, is associated with a development of new sectors of industry that were previously absent, a growth of a high value-added industry share, an increase in a production in more complex, convergent activities, a replacement of sectors going obsolete and sectors with low productivity by modern industry with the philosophy of Industry 4.0.

Considering Ekaterinburg as an example of one of the largest megacities of Russia – we will trace basic tendencies of industrial development and ecology.

2. Methods
In our study, we adhere to the national school of spatial development (N.N. Kolosovsky [3], G.M. Lappo [4], P.M. Polyan [4] and others [5–8]) whose representatives study large cities with a high concentration of industrial production, complex production and technological and labor connections, a concentration of a cultural, information and educational potential.

The Institute of Economics of the Ural Branch of RAS has developed a megacity model with a system of interrelations (Figure 1) and a methodology for forecasting socio-economic indicators. The model formed a basis of a software complex which was used to develop a long-term socio-economic forecast for Ekaterinburg for a period up to 2035. The methodology includes a logical scheme of aggregation of economic sectors, functional relationships, prediction algorithms, formulas for calculating indicators, links to statistical compilations. The methodology provides an opportunity to get a systematically coordinated forecast of structural changes in the economy for a long term, as well as to take into account changes in an ecological situation of a city.

3. Object of study
An object of our research is Ekaterinburg. Among Russian million-plus cities, Ekaterinburg has a leading position after Moscow and St. Petersburg. According to Russian Statistical Office, Ekaterinburg has a combined rating equal 1. This high rating is due primarily to high rates of wages, a trade, services and housing construction development. An Eurostat data analysis allowed to single out European million-plus cities with the same structure of a city’s economy as in Ekaterinburg. Currently, a share of Ekaterinburg population working in industry, is 19.4 %. Industrialized European million-plus cities with the closest values for this indicator are: Greater Milan (19.3 %), Greater Naples (15.7 %), Lyon (11.9 %), Munich (11.3 %), Greater Manchester (10.7 %), Budapest (10.7 %), Hamburg (10.3 %) and Cologne (10.2 %). Comparison of Ekaterinburg with these cities in terms of level and quality of life, as well as environmental friendliness, will help identify targets for the city development in a planning horizon until 2035.
4. Development analysis

Ekaterinburg has historically been the capital of an industrial region – Sverdlovskaya Oblast’, and therefore, an industry share in a organization turnover structure is significant – over the past decades about one-third of an turnover on average. However, a share of industry is declining, driven out by accelerated growth in trade. While in 2006 the share of an industry was higher than the share of an trade and service sector (39.1 % vs. 31.6 %, respectively), then in 2015 a trade and service sector had already a larger share than the industrial sector (40.5 % against 37.4 %). The share of an industrial sector in a number of employed at the end of 2015 was 20.5 %, of which 16.3 % were employed in processing industries.

Throughout the analyzed period, an industry share in a turnover structure reached its maximum in 2010 (43.2 %), and then the slowdown in an industrial growth began, which led to a loss of industrial sector positions. As a result, we can talk about an emerging trend of de-industrialization of Ekaterinburg city.

An index of industrial production in Ekaterinburg for a period 2000–2015 amounted to 107.7 % annually, however there were periods of a significant decline in 2008–2009 and 2014–2015. A fairly high average annual growth rate over a 15-year period is provided by a high rate of recovery growth in 2010–2011.
The volume of wastewater discharge

| Year | Discharge Volume |
|------|------------------|
| 2000 | 98.0             |
| 2001 | 103.6            |
| 2002 | 107.0            |
| 2003 | 107.8            |
| 2004 | 114.8            |
| 2005 | 118.5            |
| 2006 | 123.4            |
| 2007 | 120.0            |
| 2008 | 119.3            |
| 2009 | 114.0            |
| 2010 | 108.8            |
| 2011 | 105.0            |
| 2012 | 99.7             |
| 2013 | 102.3            |
| 2014 | 101.0            |
| 2015 | 98.0             |

**Figure 3.** An index of industrial production for a period 2000–2015, %

Thus, today Ekaterinburg is at a fork in whether it will remain the capital of an industrial region or whether a trend of de-industrialization will continue. Despite an inevitable accelerated development of a tertiary sector, an industrial sector of Ekaterinburg has a significant innovative potential. This is due to the fact that a core of a city industrial sector is made up of military-industrial complex enterprises, where high-tech productions of new technological structures are developing. Non-alternative processes of new industrialization will form prerequisites for building up an innovative potential of city industrial enterprises. An implementation of these opportunities will become available in a formation of a sound industrial policy in the city.

An ecological situation of Ekaterinburg as a whole is characteristic for any megacity – a volume of an anthropogenic pressure on environment increases every year. So, an average annual growth rate of emissions of harmful substances (both from stationary and mobile sources) for a period 2000–2015 was 103.2 %. A situation is positive only in a part of waste water – an average annual decrease in a discharge volume during an analyzed period was 1.8 %. This fact is related to activities of a strategic project "Water for Life" aimed to improve a quality of water in surface water bodies, to reduce a risk to health of a younger generation associated with a quality of drinking water from water supply networks, to observe sanitary requirements for coastal areas, to monitor a water quality of water bodies. One of components which improve these indicators is an increase in a number of enterprises that have received permits for a right to use water bodies up to 94.2 %.

![Emissions of harmful substances into the atmosphere](#)

**Figure 4.** Average annual growth rates of the main indicators of anthropogenic load on environment for a period 2000–2015, %

Today, a specific volume of emissions of pollutants per an inhabitant in Ekaterinburg equals 0.148 tons. However, an emissions share of stationary sources (industrial enterprises) is only 25.6 %. The main polluter is a road transport and city buses. A development of any megalopolis is inevitably...
associated with an increase in a level of motorization – in Ekaterinburg only in the last 10 years this figure has grown by 1.4 times, amounting to 410 cars per 1000 inhabitants – in fact, every second resident of Ekaterinburg has a car.

![Figure 5. A level of motorization for a period 2006–2015, cars per 1000 inhabitants](image)

5. Forecast of industrial development and ecological situation

In a horizon of strategic forecasting up to 2035, one can single out a set of contradictions that allow to structure a scenario choice, to identify possible strategies for a city and substantiate purposes of its development in new conditions.

A key contradiction in a development of a historically industrial Ekaterinburg is the contradiction in a structure of the city’s economy. This is what determines a quality of life in future. Since 2000, an indicator characterizing a ratio of a turnover volume of a trade and service sector to that of an industrial sector of an economy is constantly increasing. This is due to high growth rates of a trade and service sector of economy in comparison with an industrial sector. So, for 15 years an average annual growth rate of a trade and service sector was 12%, while an industrial sector – 8%. A sphere of production and a sphere of circulation come into conflict, while a financial sector and a social sector (education, health) act as sectors serving a development of main sectors.

Ultimately, when we were forming scenarios for a development of Ekaterinburg, we used three scenario forks, each fork gave two alternative scenarios. A main fork of scenarios – structural – defines two vectors of development: an industrial and a trade-service. For a forecast calculations, one scenario was chosen within a framework of an industrial vector and two scenarios within a trade-service vector. A scenario in a framework of an industrial vector was called “innovative”, or “a new industrialization in conditions of an accelerated investment and an intensified migration”. A preservation of existing trends of an uncontrolled trade sector growth is fully visible in a inertial scenario, which can lead to complete deindustrialization of the city and loss of its status as the “capital of an industrial region”. And, finally, a base scenario will be implemented within a trade vector, but with a preservation of an industrial component of the city’s economy.

A forecast of city economy structure both in terms of a turnover and a number of population is a starting point for predicting a quality of life indicators. A loss of the city industrial status is clearly visible in an inertial scenario. By the end of 2035 a share of an industrial sector will not exceed 30%, while a share of a trade and service sector will account for a half of a city organizations turnover. An innovative scenario will allow talking about a parity of two the most important sectors for the city’s economy – their shares will amount to 40%, which will allow to use a potential of a trade and service sector for investment development of an economy’s real sector. A basic scenario assumes an intermediate version of a turnover structure.

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1 A retail and service sector of an economy includes retail trade, catering, paid services to the population, household services to the population.

2 An industrial sector of an economy includes mining, processing industries, production and distribution of electricity, gas and water.
Without going into details of all socio-economic indicators of the forecast, let us dwell on indicators of an environmental block. An amount of air emissions will continue to grow objectively, due to the fact that the main air polluter is road transport. Following an increase in a level of motorization, air emissions from mobile sources will also increase. At the same time, it should be noted that the smallest growth will be based on an innovative scenario. An amount of emissions from stationary sources due to emission control and implementation of corresponding measures at industrial enterprises of the city will decrease according to a basic and innovative scenario. A discharge of waste water will significantly improve a situation, especially in an innovative scenario.

The main goal of an overall strategy is an environmentally sound sustainable development of Ekaterinburg and to create a favorable habitat and comfortable conditions for life and reproduction of population, to ensure a protection of natural resources and biodiversity, to prevent man-made accidents and catastrophes, and to ensure a social and economic growth and people's well-being in present and future. The main indicators of sustainable development and, accordingly, the main priority in environmental policy at all levels are: health of population; a rational use of natural resources; high quality of the natural environment which is formed from a quality of specific ecosystems (an atmosphere, a water basin, flora, fauna, etc.); economic well-being of population.
Table 1. Forecast of ecological indicators of Ekaterinburg up to 2035.

| Indicator                                                                 | 2016          | Inertial scenario | 2035 Base scenario | Innovative scenario |
|---------------------------------------------------------------------------|---------------|-------------------|--------------------|---------------------|
| Emissions of harmful substances into an atmosphere, total, thousand tons | 218.9         | 235.0             | 222.0              | 215.0               |
| Average annual growth rate, %                                             |               | 100.4             | 100.1              | 99.9                |
| Growth rate by 2016, %                                                    |               | 107.4             | 101.4              | 98.2                |
| Stationary sources, thousand tons                                         | 24.2          | 25.0              | 22.0               | 20.0                |
| Average annual growth rate, %                                             | -             | 100.2             | 99.5               | 99.0                |
| Growth rate by 2016, %                                                    | -             | 103.3             | 90.9               | 82.6                |
| Mobile sources, thousand tons                                            | 194.7         | 210.0             | 200.0              | 195.0               |
| Average annual growth rate, %                                             | -             | 100.4             | 100.1              | 100.0               |
| Growth rate by 2016, %                                                    | -             | 107.9             | 102.7              | 100.2               |
| Volume of wastewater discharge into water bodies, million cubic meters    | 159.5         | 155.0             | 150.0              | 140.0               |
| Average annual growth rate, %                                             | -             | 99.8              | 99.7               | 99.3                |
| Growth rate by 2016, %                                                    | -             | 100.0             | 94.0               | 87.8                |

To provide an environmental safety for city residents it is necessary to improve a manageability of urban life, to strengthen control in a field of environmental protection, to reduce and bring to safe levels a technogenic stress to human and the environment, to zone a city territory to differentiate a quality of living environment.

An important element of a long-term strategy is a formation of an ecological outlook of city residents through environmental education, upbringing and education, as well as an ecological and urban development of Ekaterinburg.

6. Conclusion

A development of any industrial megalopolis in its development approaches a point of bifurcation, after which a path of a development can change irrevocably: a megalopolis can lose its industrial status for good and became a large shopping center in a center of an industrial region, or it can go on a path of a radical modernization of an industry based on principles of the fourth industrial revolution.

A renewal of an industry on a new technological platform will lead to a gradual stabilization of an ecological situation and an achievement of environmental pressure regulatory indicators – a decline in a level of technogenic air basin pollution by reducing road and industrial emissions, satisfying population drinking water requirements of standard quality, etc. A simultaneous rationalization of nature use and protection of natural resources for each of the components of the natural environment will ensure environmental reproduction and environmentally oriented city development including a rationalization of a structure and level of fuel and energy resources consumption, an implementation of new low-waste technologies, as well as an optimization and dislocation of industrial production.

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