A Novel Public Utility Layout for Sustainable Development of Major Cities

A I Finogenov
Department of Architecture, Institute of Construction and Architecture, FSBEI HE NRU MGSU, Moscow, Russia
E-mail: finogenov45@mail.ru

Abstract. The paper presents the science-backed concept of a layout for specialized public utilities and their placement within major cities. It analyzes the shortcomings of utility placement in the historical build-up of Russia’s major cities; the shortcomings make such utilities inefficient, overload the inner-city trunklines, and are suboptimal with respect to sanitation and environment. The paper proposes a novel model for a more optimal functional layout of placing such utilities as support modules within the structure of residential property; the modules are designed to enable the city’s sustainable development and livelihood.

1. Introduction
The global practices show that in most developed countries, urbanization has been associated with territorial expansion, ever more complex functional layout, ever more advanced architectural and spatial arrangement.

The predominant trend in urban development lies in intensifying the construction of residential, office, commercial, recreational, and transportation properties. Extensive development is often associated with disorderly expansion of the urban areas, over-complicating the existing layout of transport lines, and anthropogenic effects that disarray the natural environmental balance [1].

For major cities in the today’s Russia, an important factor that has profound effects on planning and layouts is that such cities have historically been centered around large industrial areas that persist today. It is common for 15% to 20%, or even a greater part, of a city’s territory to be occupied by heavy industries. Today, such cities share a characteristic zoning pattern, where the old space-efficient industrial utility areas remain within their historical borders, surrounded by later urban space structures: residential, commercial, cultural, and recreational properties. Such structural imbalance is found in major cities like Moscow, St. Petersburg, Yekaterinburg, etc. [2].

From the standpoint of urban planning and socioeconomics, there is a need to thoroughly analyze the existing urban reserves, which has given rise to urban development programs seeking either complete elimination or functional rearrangement of the existing industrial areas. As a rule, such programs intend to fully or partially move the remaining industrial facilities beyond the city limits
while constructing new innovation centers, large-scale residential or commercial properties in the freed-up space.

2. Results and Discussion

Analysis shows one fundamental shortcoming of this urban development strategy, which is the lack of a sustainable and balanced approach to the preservation and placement of specialized categorized public utilities. In a developing city, public utilities are intended to ensure comfortable living, to maintain proper sanitation and ecological condition of the urban environment [3].

The public utility complex in a major city today is complicated; as a rule, it is part of specialized utility categories that comprise combined heat-and-power providers, water and sewerage suppliers, repair and construction services, warehouse services, road maintenance and sanitation utilities.

Water and electricity suppliers use a relatively independent but orderly layout of for placing their facilities within the city limits; they utilize long off-street above-street or underground communication lines.

The second category comprises numerous urban public utilities that differ in functionality and belong to different departments. Such utilities serve the residential and public areas, the road and transport facilities, the landscaping and sanitation facilities. First of all, those include: road repair services, asphalt-concrete and mortar-concrete nodes; construction waste and demolition debris storages and recyclers; urban warehouses for construction and inert materials; snow-melting facilities and warehouses for deicing agents; sanitary facilities such as incinerators and recycling plants as well as garbage disposal stations; road maintenance machinery hangars [4].

Unlike the first category, companies in the second one recycle a considerable bulk of materials every year; they have extremely high cargo traffic, use only heavy-duty road transport. In Moscow alone, over 5.0 million tons of solid household waste is transported every year, with another 2.0 million tons in St. Petersburg; non-ore (raw) construction materials, industrial waste, construction waste and demolition debris is transported in dozens of millions of tons per annum. In this regard, these facilities need a well-thought-out and balanced approach to their design and placement in the urban layout. In essence, they must be satellites to most of the structural components and nodes in the city: major residential areas, commercial and administrative properties, industrial facilities.

An overview of the today’s structure and arrangement of transport infrastructure in Moscow, St. Petersburg, Yekaterinburg, and other major cities reveals the placement and development of the public utilities of the second category is not balanced. In most cases, the current structure of such companies lacks an ordered systematic layout and fails to link itself to the existing city blocks, not to mention the emerging ones in the periphery.

This imbalance gets worse due to lack of spatially arranged cooperation between individual functional units of the public utility complex, the underrated status of low-waste energy-saving technologies, the use of outdated, ‘open-pit’ methods for the processing and storage of raw materials, and the use of obsolete equipment [5].

The scatter and remoteness of such utilities from the areas they serve coupled with ever greater production needs in the city induce the intraurban and intercity materials and waste traffic to skyrocket. This exacerbates the already challenging issues related to the bottle-necking of urban roads and intercity highways while also causing the sanitation and environment in the city to degrade further. In this regard, a poorly thought-out strategy for the functional rearrangement or complete elimination of the existing intraurban industrial areas will fundamentally prevent an optimal placement of public utilities that could serve the city sustainably [6].

The factual lack of a balanced placement of public utilities in most major cities has critical manifestations in a number of important aspects of urban life, such as urban sanitation (the collection, processing, and removal of solid household waste); transport and processing of construction waste and
demolition debris; road maintenance, which relies on machinery hangars and deicing agent warehouses; disposal of old and abandoned vehicles, etc. When large cities emerge, such utilities must be able to serve clearly laid-out and easily accessible territories so as to minimize the daily travel, have low-waste processes in place, and ensure high sanitary quality [7].

Thus, analysis shows the efficient setup and run of urban public utilities has everything to do with drafting a general science-backed strategy for the sustainable development of a modern city and maintaining a comfortable living environment. In this context, this first of all applies to optimizing the layout and cooperation of individual public utilities while also assigning each of them an optimal area to serve (‘the service area’). This approach necessitates comprehensive thinking of how to optimize the sets of public utilities—full-cycle low-waste production complexes—so as to provide highest-grade service to the areas they are designed to serve while also leaving room for expansion [5, 8].

This requires differentiating the strategy of placing the public utilities in the existing urban areas and one for the placement of such facilities in areas under construction/future development zones.

The author hereof believes that in the former case, partial re-use of the existing but dilapidated industrial areas (urban redevelopment) might be a solution. The today’s state-of-the-art makes it clear issues like that require deep and well-thought-out analysis, as in terms of urban redevelopment, industrial areas are seen as promising areas with the no-longer-in-use facilities being replaced with residential or commercial properties. However, sustainable development of such territories requires a reliable life support from public utilities. Apparently, this must be one of the first questions to cover when drafting a balanced functional layout for urban redevelopment [9].

Similar feasibility study must be done for newly developed (expanded) areas in the city. Of fundamental importance is to pre-plan and pre-design public utility complex tailored to the specifics and size of the area it is going to serve. The functional and design typology model of such a satellite complex must be based on novel resource-saving waste-free technologies integrating deep comprehensive recycling of raw materials and construction waste. Besides, it is necessary to coordinate facilities of different categories and designs to share production programs, engineering, and transports. It is important that such organization of processes will create jobs for the residents of the area the complex is to serve [10].

Figure 1 presents the recommended model for the functional arrangement of a next-gen interdistrict public utility complex, which itself is part of technologically connected production facilities and of the system of cooperating economic and cargo communications. Apparently, developing such a model necessitates a feasibility study to optimize the size and boundaries of the service area, the potential density it could sustain, the functionality, the cargo traffic, and the future development of intraurban transport lines.

The conceptual model of a localized satellite complex is designed to prove a full range of services to the residential area it is intended to cover while minimizing the cargo traffic. The model provides autonomous power sources with a gas-turbine unit (GTU) for power generation and a distribution substation. At the same time, such a layout may have room for an eco-friendly low- or medium-power incinerator implemented as a standard constructional and technological module; the facility will employ solid household waste (SHW) pre-sorting. Coupled with the GTU, it will be able to provide process steam, heat, and electricity all year round. Such power sources are extremely important for the placement of other technologically connected auxiliary elements of the complex. These may include, for instance, a district-wide snow-melting facility that will collect and process snow from the entire service area [11; 12] or a asphalt-concrete production module coupled with auxiliary production facilities.
1. snow-melting facility; 2. gas-turbine power generator set; 3. incineration module; 4. concrete-mixing node; 5. asphalt-concrete node; 6. construction waste recycling module; 7. road maintenance machinery hangar; 8. integrated warehouse for mineral and processed materials; 9. intermediate buffer zone for collecting and processing snow in winter.

**Figure 1.** Recommended singular model: residential development and public utility complex, including

One important functional element in this model is the hangar for road maintenance machinery. Small-area, multi-level hangars are recommendable; the machinery it hosts can be made available to any facility within the complex. An obligatory functional element of such a complex is an integrated warehouse of non-ore raw materials combined with a recycling plant for construction waste and slag waste generated by SHW incineration, as well as a module for making small-unit building materials. Such facilities are better contained in closed venues equipped with aspiration systems for better environmental friendliness [13, 14].

**3. Conclusions**
This paper demonstrates that the actual layout and roster of facilities in the proposed modular public utility complex will greatly depend on how it is placed in the structure of residential areas with respect to the existing or new transport lines. Notably, the model provides for an urban network of low-waste eco-friendly and small utility complexes to be predesigned as part of urban planning and tailored to the number and layouts of major urban spaces.
The proposed solution answers the questions of sustainable public utilities for older major cities. It also conceptualizes further designs and experiments to be done in cooperation by technologists, planners, architects, designers, economists, and environmentalists.

References
[1] Bityukova V R 2015 Ecological rating of Russian cities Ecology and Industry of Russia 19(3) pp. 34-39.
[2] Lezhava I G 2013 Cities of Russia. Problems of design and implementation Industrial and civil engineering 5 pp 3-10.
[3] Argunov S V 2013 Evaluation of the effectiveness of the implementation of the state program "Urban planning policy" Industrial and civil construction 6 pp 7-8.
[4] Kozlov K V, Leonov V V 2013 Ensuring the construction of urban order facilities with engineering infrastructure Industrial and Civil Engineering 6 pp 35-37.
[5] Abakumova A V 2013 Methods of optimizing industrial territories Industrial and civil engineering 11 pp 37-39.
[6] Bahirev I A 2016 Transport problems of the modern city Urban planning 2(42) pp 12-17.
[7] Aleksashina V V, Kartashova K K 2014 Problems of municipal solid waste (MSW) in a metropolis (for example, Moscow) Ecology of urbanized territories 4 pp 59-67.
[8] Oleynik P P 2013 Organization of building waste management system Industrial and Civil Engineering 7 pp 72-75.
[9] Butyrkin A Yu, Chernyshev A V, Grabovy K P 2014 Characteristic aspects of the housing and communal complex as a complex organizational and economic system Vestnik MGSU 2 pp 196-202.
[10] Butovsky M E 2010 The organization of non-waste production in the urbanized territory is one of the criteria for the sustainable development of large and large cities Ecology of urbanized territories 2 pp 73-77.
[11] Epifanova I P, Gopko V F 2009 Organization of a waste management system in a municipality Ecology of urbanized territories 3 pp 60-64.
[12] Deryusheva N L 2014 Issues of rationing of snow melting points in drainage systems Ecology of urbanized territories 1 pp 76-79.
[13] Padalko O V 2007 A typical program for preparing an industrial enterprise for its transfer to the regime of clean (resource-saving, sustainable) production / consumption Ecology of urbanized territories 2 pp 68-71.
[14] The state program of the city of Moscow "Development of communal engineering infrastructure." Decree of the Government of Moscow No. 451-PP dated March 28, 2017. URL: https://www.mos.ru/upload/documents/docs/138-PP.pdf.