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Energy-efficiency of industrial area as a part of renovation project

T.A. Mussorina [1], R.I. Bagautdinov [2], X.M. Rakova[3]

[1-3] Peter the Great St. Petersburg Polytechnic University, 29 Politechnicheskaya St., St. Petersburg, 195251, Russia

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ABSTRACT

The paper considers a new concept of industrial zones sustainable development and its application to the renovation project, in order to increase the attractiveness of the territory and adapt modern energy efficient techniques. The ambitious goal of this work is to initiate unified standard concept development for the sustainability assessment of industrial areas renovation projects. The interest of rural and industrial areas redevelopment in the UK grows intensively. Therefore, it is highly important to arrange a list of sustainability indicators and the best set of energy-efficient solutions for renovation projects. All of the presented solutions in the article can be effectively used in the renovation of industrial zones for a variety of environmental and social issues, with direct control of the economic feasibility of their application. The key indicator of sustainable the specific energy consumption was calculated by MCH-Designer program, which sought-value 2.78 kWh / m^2.

Contents

Corresponding author:
1.* *+7(952)2860376, flamingo-93@mail.ru* (Tatyana Mussorina, Student)
2. +7(911)9789490, rusish93@mail.ru (Ruslan Bagautdinov, Graduate Student)
3. +7(905)2765963, p4uik@mail.ru (Xeniya Rakova, Graduate Student)

1. Introduction

Under the existing economic pressure, cities are no longer able to grow the way it used to, especially in the rebuilding of the unused industrial areas. They are in demand due to the lack of housing and infrastructure. The paper aimed to create new sophisticated general layout in order to run positive changes in harmony with existing urban structure [1].

From the ecological point of view great amount of infrastructure facilities and buildings, which can be renovated or rebuilt, were destroyed. Historical sites desolation and harmful influence to the environment by the demolition, wide scope and high rate of the construction process does not align with the community interests. So, it becomes more important to regenerate urban areas [2, 3].

Thus, modern methods of the industrial areas renovation allow to keep the sustainable concept of the modern city development. Based on the analysis of practical example the recommendations for the development and design of industrial areas renovation projects should be stated:

- Set up the establishments of social, trading and cultural services, new public catering facilities, retail trade;
- Set up parking lots for personal transport of enterprise workers and a parking lot on the basis of the existing depot of the underground;
- Improvement of sanitary and hygienic conditions in the area;
- Safe infrastructure for the pedestrian and transport;
- Recreation zones setting up, landscape development [4].

The government wonders what to do with vacant industrial areas in the city, sometimes in the very center. Renovation considers as an obvious decision, which is originally a repair of old buildings and building new ones. But experience showed that only refurbishment repair is not enough. Complex development program, including public funding will help to achieve positive results.

Authors E.Perlova, M. Platonova, A. Gorshkov, X. Rakova considered the problem of increasing residential energy-efficiency funding. Construction of buildings with low energy consumption becomes a tendency [5].

The author D. Bobrova considered the relationship between architects and engineers aimed at combination of the idea of using renewable energy sources, the building function and art of creating architectural shapes to get a harmonious result. Search directed to the optimal choice of shapes and structures, but in fact the building which help to increase the amount of energy transformed [6].

Author I.Zayats treats environmentally friendly energy sources usage in one of the areas in the modern wind power buildings [7].

Thus, the purpose of the article is to search for sustainability assessment method of industrial areas renovation projects applicable in various countries. To achieve these goal the following aspects were considered:

1. Improving the conditions in the territories of the urban environment for a comfortable stay and work. Creation of new facilities and reasonable layout.
2. The use of energy-efficient technologies to reduce the energy consumption of new buildings.

2. Methods and results of renovation project

When reconstruction is necessary to consider three aspects (Figure 1).

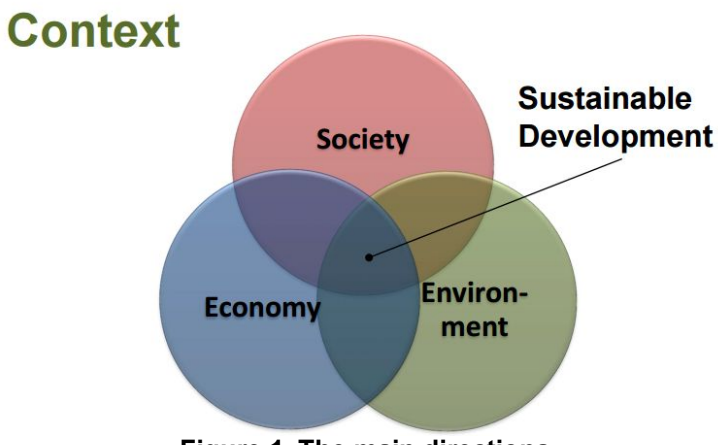

Figure 1. The main directions

Мусорина Т.А., Багаутдинов Р.И., Ракова К.М., Энергоэффективность промышленного района в составе проекта реновации / Mussorina T.A., Bagautdinov R.I., Rakova X.M. Heat and power characteristics analysis carried out for the residential building made of autoclaved aerated concrete blocks ©

The industrial district for the renovation located in Nottingham. Review of the area is presented in (Fig. 2). Since the considered area has low level of public services improvement, it surely has to be subjected to the substantial reconstruction. In the renovation project, which is called "Green World", it was tried to turn the industrial area into the oasis among the "concrete jungle" [8].

Figure 2. Review of the renovation area

The concept of the area sustainable development was proposed in the following directions:

1. *The idea of the project is to provide comfort conditions for the residents of the district, as well as for the visitors and tourists.*

The significant green spaces and roofs, as well as buildings-»the hills», which have not only an aesthetic and ecological functions, but also provide the significant energy savings [9], carry out this stage.

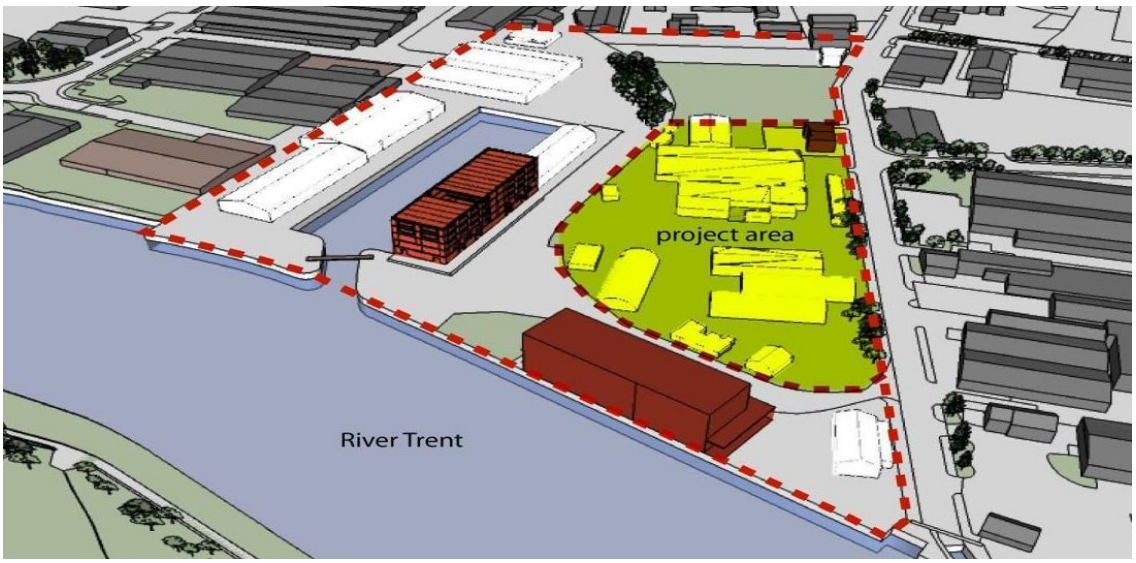

Figure 3. The general layout of the industrial area

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Figure 4. Models of the energy-efficient low-rise buildings

2. Proposal of the new facilities and buildings are shown in (Fig. 3) and (Fig. 4):

- The reconstruction of the two storage buildings.
- Renovation of the Victorian style building in the modern one with the new modificated functions. The reconstructed object should be renovated as the kindergarten;
- Two types of Multi-Comfort residential building projects (three low-rise apartment houses and individual one);
- The construction of new facilities: underground parking, community center, as well as service's and controller's offices for the water taxi.

The problem of providing workplaces in this district was solved as follows: the project Multi-Comfort apartment houses have office spaces in the basement [10-12].

The comfort condition improvement and the urban land improvement are very important in any renovation project, opposed to increased private sites number, which accompany with the separate individual houses. There are three Multi-Comfort residential buildings projects, which specific energy consumption is 2.78 [kWh/ m^2]. The calculation is presented in (Tab. 1).

Table 1. Calculation of the specific energy consumption for heating in the program MCH-Designer

Title	**Significance**
Areas	
energy reverence areas	1934.72 [m^2]
thermal envelope area	2541.82 [m^2]
Constructional U-values	
exterior wall to air	0.090 [W/ (m^2k)]
exterior wall to ground	0.290 [W/ (m^2k)]
roofs/top floor ceiling	0.090 [W/ (m^2k)]
cellar ceiling/floor	0.100 [W/ (m^2k)]
Glazing U-values	
mean U-values	0.49 [W/ (m^2k)]
Thermal bridge-free	
guaranteed	yes
Forced ventilation	33.00 %
present	
Calculation	
transmission heat losses	10.77 [kWh/(m^2·a)]
ventilation heat losses	5.66 [kWh/(m^2·a)]
total heat losses	16.43 [kWh/(m^2·a)]
internal heat gains	11.34 [kWh/(m^2·a)]
available solar heat gains	5.00 [kWh/(m^2·a)]
heat gains	13.66 [kWh/(m^2·a)]
annual heat demand	5370.33 [kWh/a]
Specific energy consumption 2.78 [kWh/(m^2·a)]	

Value of the specific energy consumption for the weather station "Nottingham Weather Centre, ENG, GB (1.25W, 53.01N)" (Station ID:03354), where heating degree days are equal to 2976 ºC·days hdd, is equal to 2.78 kWh/(m^2·a).

There is no standard blueprint for a Local Authority energy partner or a local energy efficiency project. However, energy suppliers are typically looking for the following three characteristics:

- Vision. The commitment to develop ideas for projects which incorporate a range of energy efficiency measures;
- Development of projects. The resources, commitment and data sources to develop ideas into viable projects, as well as the desire to work with others and balance the priorities of all;
- Delivery. The ability to leverage key advantages of resources and customer trust to the benefit of program delivery [13, 14].

Type A and B are the low-rise apartment houses. In the houses of type A there are offices in the basement [15, 16].

The use of energy efficiency technologies in Multi-Comfort passive houses:

- Helio-thermal plants;
- The system of forced air ventilation;
- Energy-saving triple glazing;
- Heated floors;
- Heat insulation materials.

The building, which located on the bank of the Trent River, is the office premises. The building beside the artificial gulf is the social and commercial center. The idea of the reconstruction based on the following energy saving principles:

- A small number of window openings on the northern, north-eastern and north-western part of the office building, its streamlined shape and full glazing of its southern part;
- Protection of the northern facade of the public shopping center by the layer of the soil;
- Solar collectors and winter gardens in both buildings [17-19].
- Energy efficiency status of the designed buildings provided by following statements:
- Interior load bearing wall is the partition between the two apartments;
- The perimeter of the envelope structures is less than the corresponding value of each house;
- Internal block of the apartments has the least heat losses;
- From the economics point of view it provides convenient furnishing with building services systems;
- Rational use of the urban area;
- Insulated attic eliminates apartments of the building from the heat losses [20,21].

It is obvious, that everyone gain from energy-efficient technologies usage. The holistic approach was taken in the renewable energy systems assessing and designing. Energy efficiency and the effective use of heat and electricity is often the predecessor to a renewable energy project [22].

Proposed design considerations are the same for the type B apartments and type C individual house, where the specific energy consumption does not exceed 3 [kWh / m^2].

Furthermore, in the design project there are boulevards, playgrounds and bike paths.

3. *Effective orientation of the residential and public buildings was provided.*

The following considerations were studied:

- The protection and insulation of the northern and north-western side of the largest public buildings provides the soil layer;
- The use of adjustable solar collectors. The slope of the roof and the correct orientation of the buildings should be taken into account in order to improve the effectiveness of solar energy using [20];

Virtually all the residential premises have the southern exposure in the triple height foyer of the greenhouse. Floor in the greenhouse is covered with special ceramic tile in order to accumulate heat, which is distributed around the house in the evening when the windows are open. At the same time, the greenhouse is protected from overheating in the summer and spring by the pergola, which does not prevent the penetration of the sunlight in autumn and winter.

To improve energy efficiency use:

- Mostly blue elements that convert sunlight into electricity (photovoltaic): Photovoltaic Systems: Solar cells (modules, generators): cells (modules, generators):

Solar Thermal Systems: Solar panels (solar thermal collectors): convert solar radiation into thermal energy (energy (solar thermal) solar thermal)

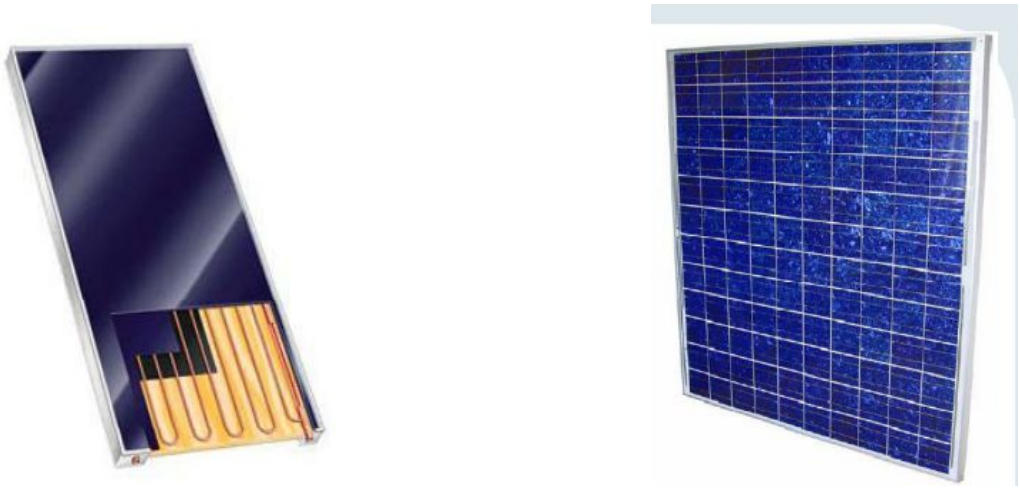

Figure 5. Solar panels

A set of activities was aimed to avoid the presence of the thermal bridges in the proposed project.

The territory appearance after the renovation of the area is presented in (Fig. 6).

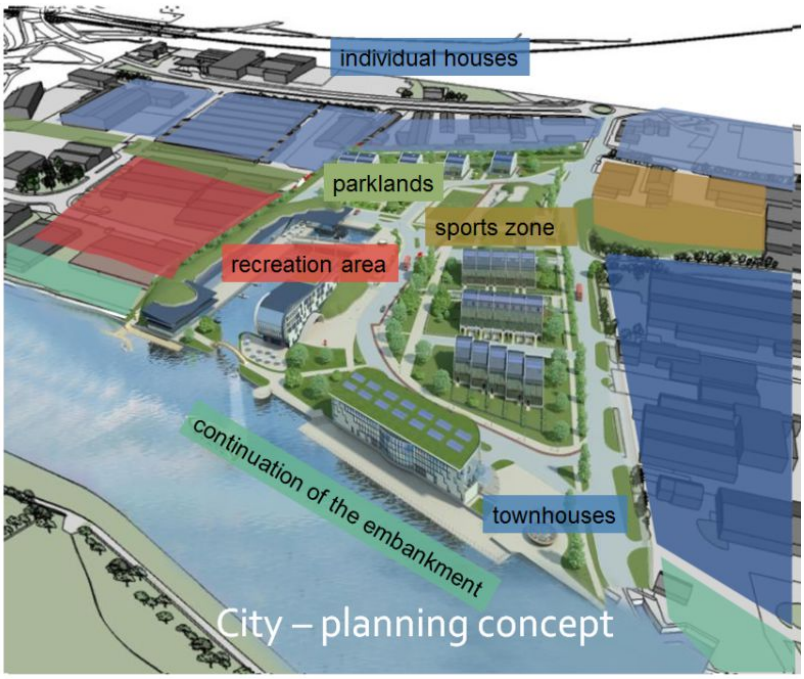

Figure 6. The final concept of the renovated area

In addition, the idea of two new facilities was proposed: at the northern part there is a three-level parking for all the residents of the district. In the southern part there are a two-level cultural and entertainment center for the arriving tourists. The building has the appearance of the "green hill", according to the proposed concept.

3. Discussion

The security of energy supply maintenance and dangerous climate change avoidance is the main problems nowadays. It is important to consider what opportunities it might take to work towards these national and, particularly in the context of climate change, international goals. Energy efficiency provides such an opportunity and, at the same time, an opportunity to save money and improve productivity.

Due to the significant number of green spaces and roofs, buildings-"the hills", which have not only an aesthetic and ecological functions, but also provide the significant energy savings.

In the construction of low-rise houses flats have the least heat losses, which increase the energy efficiency of the building. Also, it has the influence on the insulation of the attic floor.

Additional economic benefits can accrue to the electricity network companies in the areas where the houses are located, if households reduce peak demand. This benefit includes the value of avoided additional lines investment to cope with peak loads.

The impact of energy efficiency improvements on the Population:

- Analysis shows possible pathways which may help alleviate mental health problems.
- Alleviation of fuel poverty and the reduction of stress associated with greater financial security most likely route to health.
- Monetized benefits to health and wider society of investing in energy efficiency measures are greater than the costs

In addition, the idea of two new facilities was proposed: at the northern part there is a three-level parking for all the residents of the district. In the southern part there are a two-level cultural and entertainment center for the arriving tourists. The building has the appearance of the "green hill", according to the proposed concept.

Urban metabolism is a model to facilitate the description and analysis of the materials and energy flows for the urban territories, as it is conducted by a material flow analysis of a city. These models provides the possibility to study the model of natural and human systems concomitance in the rural and industrial zones. The urban metabolism model can be treated as a key technic of sustainability assessment. It is a unified way of dealing with all of the design decisions for the industrial zones renovation projects in a single model.

The article [26] consider a few methods comparison of urban planning options. On the basis of these approaches the industrial areas renovation assessment method can be formulated.

The international project BRIDGE DSS (decision support system) was also initiated, which main goal is to assist decision-making process by the alternatives and methods assessment that incudes main urban metabolism elements for their comparison. This project can provide mutually agreeable solution for the conflicting interests of the stakeholders. The BRIDGE DSS calculates the energy flows for the urban zones Renovation Alternatives (RA). In order to overcome the complexity of urban metabolism the goals can be defined as priorities of the components of urban sustainability interactions relation (energy, water, carbon, etc.) and socio-economic components (investment rate, housing, employment, etc.). Indicators used in sustainability assessment of the RA characteristics, while it is possible to deal with the priority of each factor for rural and industrial zones redevelopment level. In order to deal with lack of precise socio-economic information of the RAs, comparison of absolute appraisal scores is used in the MCE method. One of the RAs is stated as the base one, so the other variants are compared to the base variant, that in the case of renovation could be the actual situation. Considered project have the actual situation as a reference alternative of the industrial area at the Trent River basin.

4. Conclusions

There are table of sustainability Indicators (SI) of different Planning Alternatives (PA) present in the context of renovation. That can form unit model

Table 2: sustainability Indicators nomenclature

	Indicators group 1		**Indicators group 2**
1	Environmental Indicators	2	Social Indicators
1.1	Energy	2.1	Land Use
1.1.1	Energy consumption by cooling/heating (kWh/m^2);	2.1.2	New urbanized areas (m^2);
1.1.2	Anthropogenic heat (W/m^2);	2.1.3	Brownfields re-used (m^2);
1.1.3	Bowen ratio (unitless);	2.1.4	Density of development (built m^2/total m^2)
1.1.4	Percentage of energy from renewable sources (%)	2.1.5	
1.2	Thermal Comfort	2.2	Mobility/Accessibility
1.2.1	Thermal Comfort Index (Cooling Power);	2.2.1	Quality of pedestrian (qualitative);

	Indicators group 1		**Indicators group 2**
1.2.2	Air Temperature (°C);	2.2.2	Length of cycle-ways provided (m);
1.2.3	Number of days above threshold (days/total period)	2.2.3	Length of new roads provided (m); Use of public transport (% of total population); Number of inhabitants with access to public transport (inhabitants within 500m of public transport)
1.3	Water	2.3	Social Inclusion
1.3.1	Water consumption (mm^3);	2.3.1	Number of inhabitants with access to services (inhabitants/ m^2);
1.3.2	Evapotranspiration (mm^3 / m^2);	2.3.2	Number of inhabitants with access to social housing (inhabitants/m^2)
1.3.3	Infiltration (mm^3 / m^2);	2.4	Economic Indicators
1.3.4	Surface run-off (mm^3 / m^2);	2.4.1	Cost of proposed development(€ or €/m^2);
1.3.5	Potential flood risk (peak mm^3 / m^2 discharges)	2.4.2	Effects on local economy (No. of new jobs created);
1.4	Air Quality	2.4.3	Effects on local economy (€ or €/m^2)
1.4.1	NOx, PM10, PM2.5, O_3, CO, SO_2 concentrations (μg/m^3);		
1.5	Greenhouse Gases		
	CO_2, CH_4 Emissions (tonnes)		

1. The set of urban land improvement solutions of the territories can be easily found in the world experience and integrated in modern renovation standards for the residents comfort living and working in the district. That include architectural appearance transformation, social and business facilities development, residential buildings with high class of energy efficiency.
2. For the residential multicomfort houses specific energy consumption was obtained up to 2.78 kWth/m^2 by the intensive energy-efficiency solutions usage. Only one parameter estimation was made - Energy consumption by cooling/heating

The new facilities and its favorable location proposition, that was considered in the paper, not only improve infrastructure, boost economics, diversify the areas, increase job opportunities, but, also, have numerous of effects in different ways of residents lives and region development rate.

In paper [26] it was stated that sustainable development must be considered as a decision-making strategy by all stakeholders from the local to the global level. Doing so turns sustainability from an “action-guiding” concept into an “action-generating” concept. In decision-making for sustainable development key challenges include interpretation, information structuring and influence. The SA and SI purposes demonstrate that they have the potential to address them. The definitions demonstrate that SA deals with the assessment “process” while SI deal with the “technical” aspects of measurement. Thus, these two approaches should be considered together, also, in industrial zones renovation strategy.

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Энергоэффективность промышленного района в составе проекта реновации

Т.А. Мусорина[1], Р.И. Багаутдинов[2], К.М. Ракова[3]

[1-3] Санкт-Петербургский политехнический университет Петра Великого,195251, Россия, г. Санкт-Петербург, Политехническая ул., 29

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Ключевые слова

реновация;
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городское благоустройство территорий;
промышленный район;
пассивные дома;
удельное потребление энергии;

АННОТАЦИЯ

Для того чтобы развивать инфраструктуру, способствовать быстрому развитию экономики района, добавить новые функции и повысить потенциал трудоустройства, необходимо грамотно подходить к реновации. В статье была рассмотрена новая концепция устойчивого развития промышленных зон и ее применение на практическом примере, с целью повышения привлекательности территории и адаптирование современных методов повышения энергоэффективности. Предлагается подход для реновации промышленного района в Великобритании. Был подобран оптимальный набор энергоэффективных решений для обеспечения высокого уровня комфорта и низкого потребления электроэнергии. Все рассмотренные в статье примеры могут эффективно применяться в реновации промышленных зон для решения множества экологических и социальных проблем, контролируя экономическую целесообразность их применения. С помощью программы MCH-Designer был посчитан один из показателей устойчивого развития - удельное энергопотребление жилых мультикомфортных домов, которая составила 2,78 кВтч/м^2.

Контактный автор:

1.* *+7(952)2860376, flamingo-93@mail.ru* (Мусорина Татьяна Александровна, студент)

2. +7(911)9789490, rusish93@mail.ru (Багаутдинов Руслан Ильдарович, аспирант)

3. +7(905)2765963, p4uik@mail.ru (Ракова Ксения Михайловна, аспирант)

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Мусорина Т.А., Багаутдинов Р.И., Ракова К.М., Энергоэффективность промышленного района в составе проекта реновации // Строительство уникальных зданий и сооружений. 2016. №12 (51). С. 61-72.

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