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ENERGY ASPECTS OF GREEN BUILDINGS – INTERNATIONAL EXPERIENCE

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At present, reduction of greenhouse gas emissions is one of the main environmental priorities globally, and implementation of sustainability aspects in the construction industry, including energy aspects, is of major importance for long-term environmental development, as buildings have a long life cycle and require many resources both for construction and operation periods. The aim of the research is to analyse energy aspects of green buildings. The results of research show that the construction of green buildings can significantly result in energy savings and has other benefits for different market participants. Future research directions have been identified as well.

Keywords: *behaviour, construction, energy, energy efficiency, environment, green buildings, green materials, renewable energy, sustainability.*

1. INTRODUCTION

Improving energy usage in buildings is important for market participants at national, industry and company levels, and for every household as well. Implementation of green building concept includes a number of activities and is important because of great influence on consumption of resources, and especially energy resources, as the operation phase is the longest phase in the building life cycle. Energy solutions in green buildings can be an opportunity for investors and developers especially in long-term investments, and policies implemented in practice are an important step for solution to global environmental problems and achievement of millennium development goals.

The aim of the research is to analyse energy aspects of green buildings. The analysis, induction, logical access and literature review methods have been used in the research.

Growing population and high concentration of people as well as increased economic activities in urban areas have strengthened the link between cities, health and the environment, and the results of research indicate that green and sustainably renovated buildings can yield significant benefits in terms of energy and CO_2 reduction, cost savings, and improved health situation for building users [5]. It is important to note that a case study in the same research [5] has shown that buildings with the best two performances in Japan can achieve 33 % and 26 % reduction in energy use intensity, and 38 % and 32 % reduction in CO_2 emissions intensity in comparison with benchmark values. In the analysis of green building aspects in India [24], a method has been proposed, which can help increase a green building index by achieving more green points at less cost, and apart from technological parameters, socio-economic and construction strategies have also been analysed.

The ***object of the research*** is energy aspects in green buildings. ***The subject of research*** is green building development issues. The research includes international experience worldwide, including case of Latvia. As green buildings cover a variety of aspects, and as construction is a complicated process that influences and involves a number of different market participants, the research covers interdisciplinary aspects.

2. OVERVIEW OF THEORETICAL ASPECTS AND INTERNATIONAL EXPERIENCE OF POWER ENGINEERING ASPECTS IN GREEN BUILDING PRACTICES

Construction industry is one of the largest final consumers of environmental resources and one of the largest emitters of greenhouse gases and other types of pollution, but until the 21st century, for instance, in China, green building construction has not received much attention [15]. Currently, green building construction is considered to be an essential practice for achieving sustainability [24].

The usage of term "green building" has increased rapidly after implementation of green building certification; however, the idea of implementation of green building aspects in different areas has appeared earlier. Green building is defined as "the practice of: 1) increasing the efficiency with which buildings and their sites use energy, water, and materials, and 2) reducing building impacts of human health and the environment, through better siting, design, construction, operation, maintenance, and removal throughout the complete life cycle" [16].

Findings also identify that 43 % of the annual reduction in terms of energy consumption and energy expenditures for a typical American home with green building technologies can be observed, and energy efficiency performance of green building technology may differ depending on energy consumption-related resident behaviour [27]. In the other case study, development of multigeneration system of integrating renewable energy sources for a green house, the total net present cost for the optimised power system and wind turbines is found to be $345,481, with 100 % renewable fraction and no emissions of carbon dioxide or other pollutants, when the exergy efficiency is found to be 7.3 % for the system, and the energy efficiency is 46.1 % [13].

At the same time, according to the research on risk perception of the life cycle of green buildings in China, Xuan Qin, Yiyi Mo, and Lei Jing [18] have found that while a variety of benefits of green construction have been recognised, the risks associated with green buildings have not been addressed appropriately. As a result, among 56 risk factors, 36 are perceived as key risk factors affecting the success construction of green buildings (for example, political risks, certification risks, financial and/or cost risks, quality and/or technological risks, social risks and managerial risks), including bureaucracy, inappropriate green building maintenance, lack of green building design activities, high price of green building materials and other risks. The differences in risk importance to different stakeholders have also been identified.

In the estimation of dwelling energy consumption and the interpretation of the energy performance analysis, the results suggest adding to the analysis building related data and thermal modelling, urban geographical modelling, including socio-economic aspects, landscape and micro-climate [6]. Sustainable building performance requires behavioural aspects and interaction of elements such as movement patterns of people, indoor and outdoor conditions, walkability, social, psychological, or economic drivers of behaviour formation and change, as well as the micro-modelling of specific behaviours of occupants within their built environment [4]. They can also affect use of usergy. The research results on the analysis of the potential of energy savings in the Chinese building materials industry under different economic growth scenarios [17] show that a 1 % increase in technological progress, energy price and per capita productivity will produce respectively 1.1684 %, 0.8056 % and 0.3649 % decrease in the sectoral energy usage. The results also show that the potential of sectoral energy savings is one of the improvement opportunities.

Building design, as a building material, is of great importance in energy saving activities. A multi-objective optimisation model was developed [25] and included several conflicting criteria such as economic and environmental performance that could assist designers in green building design. Many studies on passive solar buildings demonstrated that the application of phase change heat storage materials could decrease the variation in the air temperature in the room, including decrease in energy consumption for maintenance of comfort temperature levels in buildings [12].

Energy consumption issues are important for sustainable long-term development of country and its environment. Special attention should be devoted to climatic aspects and seasonal characteristics of each country. Over-arching renewable energy associations in Latvia are as follows [23]:

- Latvian Biomass Association (LATBIO);
- Latvian Biogas Association;
- Wind Energy Association;
- Small Hydropower Association;
- Solar Energy Association;
- Latvian Bioenergy Association;
- Wind Energy Producer Association;
- Latvian Renewable Energy Confederation;
- Latvian Institute for Sustainable Development and other.

In a particular case in Latvia, the use of solar collectors can reduce utility bills by 30 % [20]; however, the potential of solar energy in Latvia is low, but it can be comparable with many European countries, where solar panels are used widely, and practice shows that for the production of electricity, solar radiation is used rather than heat. The same research shows dependence of conventional energy on the wind speed, including the fact that it is possible to use only 59.3 % of kinetic energy of the wind ("the limit of Betz-Zhukovsky") because the maintenance of the air flow is required for all wind machines. In the operational practice of solar pump "Saulessukni" EKTOS heating system, by using vacuum solar collectors TS400, there is a possibility to save up to 85 % of the energy consumed for heating and hot water [21].

Scientists of the Institute of Industrial Electronics and Electrical Engineering, Faculty of Power and Electrical Engineering (Riga Technical University) in cooperation with the German automobile company Daimler AG developed a unique direct current (DC) power supply system, which would save up to 15 % of electricity. At present, the world manufactures the alternative current (AC) mains, but in Riga the first laboratory has been set up where the electricity supply is used for direct current (DC) energy [19]. A major benefit of the solar water heater has been found that it is possible to save more money with a solar water heater than, for example, by investing the money in a low-risk fixed deposit account, including such aspects as investment interest rate of 6 %, high electricity inflation and consumer price inflation [26].

Recently researchers have found that pollution reduction can reinforce firm competitiveness by better access to the market, selling pollution reduction technologies, differentiating products because of better risk and stakeholder management, reduction of costs in materials, labour, and capital [3]. It has been analysed that internal rates of return grow with energy improvement actions [8]. Green building development can have a variety of reasons, for example [7, p. 3065]:

- Lower operation costs;
- Higher building value;
- Lower lifetime costs;
- Higher return on investment (ROI);
- Help in transforming the market;
- Increased staff productivity and retention;
- Enhanced marketability;
- Reduced liability and risk.

For modernisation of housing stock in general, there are European funds, which finance up to 85 % of the cost of the project. The financing measures of the European Union can be divided into 2 groups: measures for energy saving and purpose of the measures [14]. Table 1 demonstrates the energy saving measures in prefabricated buildings.

On example of green building analysis in Hong Kong and Singapore [7], such contractionary criteria as higher upfront costs, lack of education, lack of fiscal incentives and lack of awareness can appear, but issues such as "lack of coordination and consistency in rating tools and standards", "lack of research", or "unrecognised eco-labelling" are seen by a few building designers as the main obstacles to green building construction. One of the novelties in green building certification is the green building assessment tool integrated with BIM that can help the design team in the generation of necessary documentation to obtain green building certification [11]. However, socio-economic aspects still are important as they indicate well-being of society [10], and socio-economic aspects are especially important for green building construction and realisation opportunities. Green building certification is an indicator that can show building performance by many parameters, and the number of certified green buildings is increasing worldwide.

Implementation of green building technologies can reduce consumption of energy during the operation phase. The market size and structure of companies operating in it are also important. In such a way, the combination of economic and technical aspects can assist in energy planning activities at different levels.

Table 1

Energy Saving Measures in Prefabricated Buildings [14, pp. 144–145]

Energy saving measures	Purpose of the measures
Basic measures	
Insulation: exterior walls, cellar ceiling, ceiling over last living compartment	Reduction of heat losses through the outer part of the building
Installation of insulation	Unnecessary heat losses in the installation must be avoided
Replacing windows Ventilation slots Fittings for ventilation in the window	Reduction of heat losses due to formed surfaces, frames Unnecessary heat losses (due to uncontrolled air supply through cold window fittings) Sufficient air exchange rate
Accompanying measures	
Heating system modernisation	Weekly supplied hot water heating as required (according to reduced heat demand after heat insulation)
Modernisation of heating pipes and radiators	More precise regulation according to the requirements in the apartments
Counters on radiators	The use of the apartment (billing according to consumption) to avoid overheating the apartment
Renovation of the staircase	Effective element of modernisation (age friendly)
Other (additional) measures	
Energy certificates and energy balance	Incentive for the owner to carry out measures for energy saving, since this offers a favourable argument during negotiation or sale
Renewable energy	Heat recovery devices (e.g., the use of heat from waste air and wastewater): - Thermic solar systems (for preheating of heating system water and hot water) - Photovoltaic devices - Decentralised heat generation with cogeneration

3. RESULTS AND DISCUSSION

Results have shown that there is a high necessity for green building construction, but at the same time there are a number of risks and conflicting criteria during its implementation. It is suggested to select strategies with high energy efficiency at the design and operation stages of green buildings. It is suggested that clients should cultivate proper behaviour in terms of energy efficiency, and at the same time government preferential policies and financial incentives should motivate green building development to solve this conflict between cost and functions, and in this case post occupancy evaluation can be recommended [22]. Often more developed areas in ecological performance perform better than less developed areas mainly due to a higher technological level [15]. Thus, energy efficiency plan development at the regional level is important [1]. Certification systems alone cannot be enough to promote widespread development of green buildings, and it is also recommended to change energy and water consumption behaviour [5]. In successful implementation of green building methods, all stakeholders including architects, engineers, and contractors would benefit from a comprehensive framework that incorporates green building technologies and technologies during all phases of building life cycle [2]. Successful implementation of energy efficiency activities in green buildings requires involvement of many participants during different phases of building life cycle, but it is also important to implement all activities in a timely manner.

4. CONCLUSIONS

1. As economic, social and environmental aspects are interrelated, special attention should be devoted to all these aspects by all market participants, at all levels, and it is also necessary to analyse different consumer groups, especially in green building planning and its energy aspects. As economic and environmental aspects can be conflicting, there is also a necessity to implement green building motivating activities in the practice, for example, government support programmes.
2. For entrepreneurs, house managers and other market participants, it is recommended to regularly make energy audits, as it can help detect problems and find possible solution opportunities at early stages.
3. Optimal balance of integration of green building criteria in the construction process without limitation of construction industry development should be found. Future research directions involve the integration of ecological and green building aspects in environmental models at different levels.

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ENERĢĒTIKAS ASPEKTI ZAĻAJĀ BŪVNIECĪBĀ – STARPTAUTISKĀ PIEREDZE

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K o p s a v i l k u m s

Šobrīd siltumnīcefekta gāzu emisiju samazināšana ir viena no galvenajām vides prioritātēm visā pasaulē, un ilgtspējīgas attīstības aspektu īstenošanai būvniecības nozarē, tostarp enerģijas aspektu īstenošanai, ir augsta nozīme ilgtermiņa vides attīstībā, jo būvniecības objektiem ir ilgs dzīves cikls un to būvniecība pieprasa daudz resursu, gan būvniecības, gan ekspluatācijas fāzēs. Pētījuma rezultāti rāda, ka zaļā būvniecība var radīt būtisku enerģijas ietaupījumu, ka arī var sniegt vairākus citus labumus un iegūvumus vairākiem tirgus dalībniekiem vairākos līmeņos. Pētījumā tika identificēts arī nākamo pētījumu virziens.

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