The role of The construction Industry in the energy sector

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Abstract

This research paper examines the crucial role of the construction industry in the energy sector, particularly in shaping energy consumption and efficiency. The focus is on the industry's impact throughout the lifecycle of buildings, encompassing design, construction, maintenance, and demolition, with an emphasis on energy efficiency not only during construction but also during the operational phase. The paper highlights the European Commission's directives on building energy performance, aimed at reducing energy consumption through more energy-efficient and materially efficient buildings.
The research advocates for a multi-criteria approach in construction, balancing environmental, economic, and functional considerations in building design and operation. It addresses the challenges and negative consequences of energy-saving measures, emphasizing the need for balanced and sustainable building practices. The paper underscores the construction industry's potential in reducing global energy consumption and the importance of legislative incentives for promoting energy-efficient buildings.

Keywords

Construction Industry, Energy Efficiency, Building Lifecycle, Renewable Energy, Sustainable Practices, Energy Consumption Reduction, Environmental Impact, Multi-criteria Approach, Energy Performance

JEL Classification

Q4 - Energy; Q5 - Environmental Economics; R3 - Real Estate Markets, Spatial Production Analysis, Firm Location; O3 - Innovation; Research and Development; Technological Change; Intellectual Property Rights

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Introduction

The construction industry reduces energy demand

The role of the construction industry has an irreplaceable place in the field of energy. The current construction industry has certain visions and applies a number of energy-saving measures. For this purpose, analyzes of the construction project are carried out. Emphasis is placed on energy efficiency, not only in the construction phase, but also in the operation phase. Current topics include the advantage of using alternative energy sources and designing energy-efficient buildings.

The European Commission assumes that the implementation of the directives on the energy performance of buildings will bring the countries of the European Union a reduction in final energy consumption and that this will be achieved, among other things, by supporting less materially demanding and more energy efficient buildings.

It is clear from the legislative documents that the construction and reconstruction of power plants, or all energy sources, including the transmission system, is necessary. It is necessary to build, for example, additional gas reservoirs and power lines. At the same time, however, it is also necessary to strengthen the area of construction and reconstruction of technical infrastructure, especially water management structures - both sources and distributions, e.g. drinking water and, last but not least, wastewater treatment plants.

Construction, maintenance, modernization, reconstruction and demolition of buildings necessary in the energy industry are ensured within the construction industry. The entire process of the creation of new buildings and the reconstruction of existing ones is shaped by relationships along the axis of need - public or private entity - state administration - architect - construction company - user. Each of these links in the chain has a significant role in the process, in creating a suitable environment, working environment, while preserving both natural and cultural monuments, the functionality of buildings, including energy efficiency, etc. [1] [2]

The above-mentioned important component within the construction industry is the construction of buildings for the production of energy and its transmission. However, energy production is opposed by consumption and its reduction. In the field of construction, it is about saving energy consumption, both for the production of building materials and for the actual construction, and last but not least, for the period of use. At this stage, the key is to properly design the building so that operating costs are as low as possible. It is therefore essential to assess buildings throughout their entire life cycle.

The goal of the construction industry is to satisfy the needs of man and society as such. The construction industry has a significant impact on public interests and its results are significantly applied in public space. To ensure that the interests of the parties concerned and the public interest are not violated, experts take care of the correct design and use of buildings. [3] [4]

The term construction does not only include construction production - i.e. the execution of construction works, but also the already mentioned production of building materials, transportation of materials and others. The construction industry is also dependent on engineering production, on the production of the glass industry, the wood industry, but also the chemical industry and many others.

Energy in the Czech Republic includes both energy resources as such (coal, nuclear, gas, water, etc.) and, in particular, energy production and its consumption, and last but not least, transmission. Electricity is produced in coal power plants, in steam-gas power plants, in nuclear power plants, as well as in facilities using photovoltaic cells, wind power plants, biomass power plants, etc. Although the Czech Republic's power balance is in surplus, as a member of the European Union, it is bound by the obligation to reduce and optimize consumption and increasingly use renewable resources. The European Union financially supports the production of renewable energy in the Czech Republic. [5]

Reducing energy consumption - the task of the construction industry negative consequences of energy savings

The design of buildings and their construction should therefore be focused on increasing support for the use of materials that are less demanding in terms of energy (including their production) and on more energy-efficient buildings.

The task of reducing energy consumption and using more energy from renewable sources is supported by the commitment of the European Union. This represents not only the task of increasing the share of energy production from renewable sources, but also of reducing energy consumption and greenhouse gas emissions. This task is closely related to the environmental situation and also to other areas. The situation is thus influenced by energy consumption in buildings in all countries of the European Union. In this context, energy consumption is one issue, CO_2 emissions are another. [6]

Building energy optimization is currently a very topical topic. It is necessary to deal with the calculation of heat losses of buildings, the need for energy for heating and for heating hot water. This is also related to the design of the heating source, which must be assessed in terms of efficiency and financial costs in the life cycle.

Investors' interest in buildings with higher efficiency - especially with lower energy costs - is continuously increasing, mainly due to rising energy prices. The situation is solved for buildings by a number of legal regulations and standards, both for new buildings and for reconstruction of buildings. There are a number of monitoring procedures reacting to the amount of energy consumed, especially for heating, hot water preparation, cooling, conditioning the internal environment through natural ventilation, infiltration or using air conditioning, as well as lighting. This is the so-called Energy Performance of Buildings. This is solved for existing buildings and also for new building projects, where the amount of energy determined by calculation according to the requirements for standardized use of the building is taken into account. Knowledge of the layout and operational solution of the building, construction-technical solution of the building and knowledge of the project solution is essential. Heat loss through heat transmission of the heated space, calculation of design heat loss through transmission, design heat loss through ventilation of the heated space, calculation of design heat loss for natural ventilation are addressed.

Unfortunately, in recent times, preference has been given to saving energy and heat leakage from buildings, while the resulting negatives have not been addressed. [7] [8]

Nowadays, it is already obvious that buildings must be assessed comprehensively. For this purpose, the so-called 3E can also be used, when the economy, efficiency, and effectiveness of every decision must always be seen. Such a decision-making system regarding energy must, as a process, contain paths and benefits in the subsequent use, i.e. in the life cycle. The connection of points of view must be expedient, the solution economical and the benefit must bring maximum effect. [9]

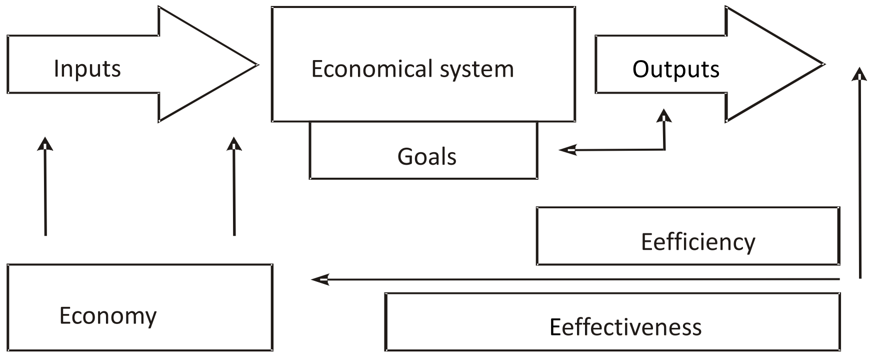

Figure 1: Schematic illustration of the links between e economy, efficiency, and effectiveness [9]

In many areas, the assessment of building efficiency is thus focused on energy, the acquisition of the building and the operation of the building. There is also computer support for assessment – e.g SW SBTool, which uses the Microsoft Excel environment as well as the Japanese CASBEE assessment system.

Multidisciplinary balance in construction demands

The architect usually plays an important role as the coordinator of the individual subjects of the investment process, and it is therefore crucial that he orients himself in their requirements and is able to find a multidisciplinary balance in the conflicting demands on the building.

Each building, when designing it, should be assessed during the actual processing of the project with regard to the location, the own architectural design and solution, the use of environmentally suitable materials, products and the maximum use of local raw materials. The evaluation of building constructions is used for this purpose. This is done mainly with the aim of using environmental products, local materials, but also recycled materials, etc.

The assessment must be carried out with regard to the life cycle of the building itself, primary energy required for extraction of resources, transportation, manufacture, assembly, disassembly, and end of life disposal must be calculated.

The environment in buildings depends on all of this, thermal comfort in heated spaces, thermal comfort during the cooling period, ventilation, noise reduction - both through the building envelope and between individual spaces, daylighting, shading or shielding, artificial lighting, materials used for equipment, elimination of pollutants in the space, etc. are addressed.

For example, for the area of BSE (Building Services Engineering), the aspect of forced ventilation of the building is necessary. A forced ventilation system is often used, connected to the heating of the building and the use of waste heat with the use of a heat recovery unit. This is beneficial because only a minimal amount of heat needs to be supplied and savings are ensured by preheating the air. It is also advantageous to use ground exchangers, where the principle of preheating the air is similar to recovery using heat from the ground.

Thermal output calculations

The aim of the following text is to show that energy consumption and its acquisition cannot be viewed only on a macroeconomic scale, but that every smallest saving and ways to it are beneficial.

The heat loss of the room or building is determined according to the currently valid standard EN 12 831 Energy performance of buildings - Method for calculation of the design heat load. The EN 12 831 standard represents the calculation of the design heat loss for a heated space for the dimensioning of heating surfaces, for a building or a part of a building for the dimensioning of a heating source.

The approximate calculation of heat loss is based on the total design heat loss for a heated space (i), i, is calculated as follows:

$$i = T,i + V,i \qquad [W] \qquad (1)$$

where:

T,I = design transmission heat loss for heated space (i) in Watts (W);

V,I = design ventilation heat loss for heated space (i) in Watts (W)

The design transmission heat loss is the heat loss to the exterior as a result of thermal conduction through the surrounding surfaces, as well as heat transfer between heated spaces due to the fact, that adjacent heated spaces may be heated, or conventionally assumed to be heated at different temperatures. For example, adjacent rooms belonging to another apartment can be assumed to be heated at a fixed temperature corresponding to an unoccupied apartment;

The design ventilation heat loss is the heat loss to the exterior by ventilation or by infiltration through the building envelope and the heat transferred by ventilation from one heated space to another heated space inside the building. Ventilation is necessary to ensure minimal air exchange to prevent the accumulation of harmful substances in the given space. The minimum air exchange is 25 m³/h per person or at least once every 2 hours = (0.5 h-1).

The design transmission heat loss for a heated space (i), T,i, is calculated as follows:

$$T,i = (HT,ie + HT,iue + HT,ig + HT,ij) * (\ int,i - e) \qquad [W] \qquad (2)$$

where:

HT,ie = transmission heat loss coefficient from heated space (i) to the exterior (e) through the building envelope in Watts per Kelvin (W/K);

HT,iue = transmission heat loss coefficient from heated space (i) to the exterior (e) through the unheated space (u) in Watts per Kelvin (W/K);

HT,ig = steady state ground transmission heat loss coefficient from heated space (i) to the ground (g) in Watts per Kelvin (W/K);

HT,ij = transmission heat loss coefficient from heated space (i) to a neighbouring heated space (j) heated at a significantly different temperature, i.e. an adjacent heated space within the building entity or a heated space of an adjacent building entity, in Watts per Kelvin (W/K);

int,I = internal design temperature of heated space (i) in degrees Celcius (°C);

e = external design temperature in degrees Celcius (°C).

The design ventilation heat loss, V,i, for a heated space (i) is calculated as follows:

$$V,i = HV,i * (int,i - e) \qquad [W] \qquad (3)$$

where:

HV,i = design ventilation heat loss coefficient in Watts per Kelvin (W/K);

int,i = internal design temperature of heated space (i) in degrees Celsius (°C);

e = external design temperature in degrees Celsius (°C).

The design ventilation heat loss coefficient, HV,i, of a heated space (i) is calculated as follows:

$$HV,i = Vi * p * cp \qquad [W/K] \qquad (4)$$

where:

Vi = air flow rate of heated space (i) in cubic metres per second (m3/s);

P = density of air at int,I in kilograms per cubic metre (kg/m3);

cp = specific heat capacity of air at int,i in kilo Joule per kilogram per Kelvin (kJ/kg

The equation for determining the air flow rate of heated space (i), which is used for calculating the design ventilation heat loss coefficient, is as follows:

$$Vi = Vinf,i + Vsu,i * f_{V,J} + Vmech,inf,i \qquad [m3/h] \qquad (5)$$

where:

Vinf,i = infiltration air flow rate of heated space (i) in cubic metres per hour (m^3/h);

Vsu,i = supply air flow rate of heated space (i) in cubic metres per hour (m^3/h);

Vmech,inf,i = surplus exhaust air flow rate of heated space (i) in cubic metres per hour (m^3/h),

fV,i = temperature reduction factor

It can be summarized that the calculation of operating energy costs is carried out using the quantities needed to calculate the costs of heating and water heating, thereby obtaining the resulting annual heat demand for heating and water heating in units of MWh/year (GJ/year). In the calculation, it is also necessary to include the monthly fees for power consumption in CZK/month, the fixed price of power electricity in CZK/month. The price per 1 MWh is further assessed according to the tariff and is given in CZK/MWh.

On the basis of processed calculations of the building's energy demand, it is necessary to add information about data in the life cycle and also the impact on the environment from the point of view of eco-efficiency. The range of SW applications is expanded to include modeling of the energy demand and eco-efficiency of energy and ecologically efficient building variants, and is thus the basis for the application of the resulting output and is also the basis for applying for state support.

However, the economic analysis, depending on the type of building, prioritizes only the costs of heat, possibly also of water heating, as stated in the previous text. During the assessment, the acquisition and operating costs of the life cycle of the building are taken into account, and the length of the life cycle is considered to be approximately 30 years. In calculations, however, the problem is estimating the growth of energy prices for the considered long period. Although this factor represents the biggest risk in the calculation of heating costs, it is necessary to include other necessary factors, such as CO_2 in buildings or humidity. [10] [11] [12] [13]

A multi-criteria approach to reducing energy savings

The constant pressure on energy efficiency and improving the quality of the environment needs to be seen and addressed multidisciplinary with a multi-criteria approach in order to take advantage of a global perspective. It is necessary to solve the problem comprehensively - i.e. reduce energy consumption, reduce pollutant concentrations, change energy sources - especially the consumption of fossil fuels - but do not neglect relatively small solutions, which in their frequency can bring significant effects.

It is not possible to look only at energy saving, but all factors affecting the internal environment of buildings must be monitored. A concrete example is the use of a number of subsidy programs for monitoring the internal environment. With financial resources from a number of subsidy titles, insulation, replacement of windows and others were achieved on the properties of municipal and private owners - but the internal environment in these buildings deteriorated.

In order to eliminate erroneous past decisions, for example, measurements are currently carried out with subsequent evaluation on a sample of buildings. This shows that the buildings show a reduced energy demand, but thanks to the new windows, there is no natural ventilation due to the leakage of the old windows, and the spaces are therefore less ventilated, and as a result, mold develops and thus damages these buildings.

However, the consequence is the increased concentration of CO_2. It is necessary to realize that the decision-making process regarding energy costs needs to be solved in terms of economic analysis, but also the quality of the environment.

It is necessary for investors and designers to be educated in this area and to be able to eliminate the effects of various factors influencing the internal environment of buildings, on the one hand by optimizing energy efficiency, on the other hand user comfort, and possibly affecting other aspects as well (e.g. the health status of the people present). [14]

Elimination of the negative consequences of energy savings

In general, attention is paid to the environmental friendliness of buildings and their energy efficiency. But the right way is to change the way of thinking in the design of buildings on the part of designers in the case of new buildings, but also in their reconstructions and at the same time the thinking of building users.

During the operation of the building, it is up to the owner (or investor) to take care of maintenance and to monitor compliance with a suitable internal environment - or rather set parameters, to optimize the energy demand of the building with appropriately set automation technology, so as not to overheat the building, for example.

The issue of thermal comfort and methods of heat propagation is based on Fourier's laws. It is based on a steady temperature state and an unsteady temperature state, spatial three-dimensional heat conduction. For this purpose, standard requirements and priorities supporting efforts to reduce the need for heat are established.

There are a number of SW applications for building assessment. For example, the SW program: "Stability" is used, calculations such as the Building Energy Performance Certificate (PENB), Energy Audits (EA) and Energy Assessments (EP), Energy credits for BREEAM certification, energy credits for LEED certification, SBToolCZ etc. are processed. [15]

Processed technical audits of buildings should be solved with a number of experts and specialists in the given fields - such as structural engineers, BSE specialists (air-conditioning, heating and others), electrical specialists, hygienists. As standard, a visual inspection is carried out, as well as technical measurements, electrical network analyzers, hygrometers, thermographic cameras, CO_2, VOC (volatile organic substances), noise, lighting quality meters are used. The schedule, the output report with the classification of detected defects is also important.

It is positive that building owners and operators are currently using systems whose task is to reduce energy consumption while maintaining a healthy and productive environment inside the building, and that building management is trying to implement measures to improve the indoor environment.

Conclusion

The goal of the construction industry in general is to satisfy the needs of man and society as such. The construction industry has a significant impact on public interests and its results are significantly applied in public space. In order to ensure that the interests of the parties concerned and the public interest are not violated, experts pay attention to the correct design and also the use of buildings in their life cycle.

The influence of the energy demand of buildings cannot be neglected, as the construction industry as a whole consumes around 40% of global energy consumption, mainly thanks to buildings that need to be heated or cooled. There is therefore a significant potential for its reduction.

In the construction industry, it is not only a matter of saving energy consumption for the production of building materials, for the construction itself, but above all for the period of use of the buildings. At this stage, the key is to properly design the building so that operating costs are as low as possible. It is therefore essential to assess buildings throughout their entire life cycle.

However, some steps in the area of energy savings cause negative consequences. In order to save energy, the buildings are insulated, the windows are changed, and thus natural ventilation is prevented due to leaking windows and many others. This situation, for example, in some cases causes the appearance of mold, CO_2 values above the limit and other negatives. The condition is determined by thermovision measurement, dectoscopy is used.

It is therefore necessary to look at the field of energy comprehensively and to involve a wide range of experts in the processing, especially of conceptual materials, and to use a wide range of optimization approaches.

It is generally known that energy is not saved much in the construction industry, and this was not the case even in the past, when energy was much cheaper, and on the contrary, high-quality technological construction of buildings was (and still is) relatively expensive.

In recent years, however, the situation has changed and low-energy houses, passive houses or zero-energy houses have started to be massively built and promoted. It started to save more energy in the production of building materials, in the actual implementation, and most importantly - the overall efficiency of use also started to be addressed more.

Currently, energy consumption is covered in ways that are usually not very environmentally friendly, and it can therefore be assumed that in the future there will be an effort to choose a more appropriate strategic mix of these sources, or to completely shut down some of them.

It is therefore necessary to direct the construction industry to a comprehensive reduction of its needs throughout the entire life cycle, to introduce legislative incentives for energy efficient buildings, but also to build new energy sources that represent potential work opportunities in the form of construction contracts for construction companies.

It is necessary to support the most environmentally acceptable source of energy, which in the Czech Republic is nuclear energy and energy from renewable sources. The importance of producing energy from one's own resources is underlined by the fact that the current political situation in the countries that access these energy sources within the EU is often very unstable, and the supply of these raw materials can be

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