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ANALYSIS OF ENERGY EFFICIENCY OF DESIGNED BUILDINGS

Abstract. *In this article, the research is conducted with a purpose to assess energy efficiency of engineering systems. The main role of ALDREN-EPC certificate is described here, which is to determine the indicator of smart readiness of a building and the procedure for its evaluation. Also, the article recommends a tool to improve the effectiveness of SRI. The requirements and prospects of the EPBD ecosystem are outlined as well. Moreover, main causes of project degradation companies are investigated. Such as the lack of specialists of the proper level, the outdated structure of the project organization, as well as the lack of an understandable regulatory framework and training materials.*

Keywords: *Intellectual buildings, Smart Readiness Indicator (SRI), certificate of energy efficiency (ALDREN-EPC), building renovation passport, ALDREN-BRP, EPBD (Energy Performance of Buildings Directive), energy efficient house, engineering systems.*

Introduction

A sharp reduction in both fuel reserves and energy resources, climate change and pollution have made people to reconsider and change the attitude to energy consumption and energy conservation. A large number of modern engineering equipment, new building materials, electronic automatic control systems, management and regulation of in-house engineering systems have become available in Kazakhstan.

In order to reduce energy consumption, appropriate amendments and additions have been made to building codes and other regulatory documents across Kazakhstan. The Law of the Republic of Kazakhstan "On Energy Saving and Energy Efficiency Improvement" is introduced as a smooth transition to construction of energy-efficient buildings. Two projects initiated by the United Nations Development Program (UNDP) are ongoing in Kazakhstan, in particular "Energy efficient design and construction of residential buildings" and "Removing barriers to improving energy efficiency of municipal heat supply" [1].

An integrated use of new technologies in construction makes it possible to reduce consumption several times. In residential buildings of a new generation, with the use of innovative technologies, most comfortable microclimate and wellness conditions for living are achieved affecting human health in a positive way.

According to the Technical Regulations and Eurocodes, buildings are expected to meet such requirements as saving energy and reducing heat consumption; and, additionally, rational use of natural resources is also to be considered. The efficiency of energy use is a kind of an indicator of scientific, technical and economic potential of society, which enables us to assess the level of its development [2].

The European Union has developed and approved certain methodology that determines an indicator of smart readiness (Smart Readiness Indicator, SRI). The SRI indicator embraces numerous information in relation to quality condition of a construction object and plays a significant role in obtaining an energy efficiency certificate for a building that has undergone a deep renovation.

Materials and methods

The objective of H2020 ALDREN project funded by the European Commission is to contribute to the evaluation of buildings after renovation in terms of energy efficiency by providing certain ways and tools that facilitate EU member states to introduce new requirements of an updated EPBD directive. Having done this, buildings are ready to receive European Voluntary Energy Efficiency Certificate (ALDREN-EPC).

This very certificate covers a full range of data, including information about a share of non-renewable primary energy, quality of indoor microclimate, financial risks and reliability of a building (Figure 1).

Evaluation procedure for smart readiness indicator of a building

Evaluation is accomplished in three dimensions according to SRI:

• Principle A is simplified to some extent and is based a short number of services (for example, for a residential building). Evaluation procedure of a single-family residential building should be no more than an hour.

• Principle B relies on a full range of intellectual agencies (appropriate for more complex non-residential buildings). Assessment can be half day or a day long.

• Principle C is based on measurements and various considerations.

As regards the duration of the evaluation, it fully depends of SRI complexity level as well as data availability, hence SRI chapter has been added considering smart readiness outlined in a catalogue of data passport on building renovation ALDREN-BRP.

Along with ALDREN-EPC certification, data should be collected which is designed to assess the SRI building's intellectual readiness index. Some of them are duplicated: for example, heating system management data is required for both SRI and EPC. The coordination of SRI data with ALDREN modules ensures proper interaction and prevents repeated data collection work. In the future, unified inspection and data collection protocols will be developed for the RECAST-EPC certificate (for buildings under reconstruction process).

One of the main tasks of Energy Efficiency Certificates (EPC) is to facilitate building owners and investors adequately evaluate the quality of an existing building, including management systems, engineering systems and the potential for modernization. Possible measures for improvement are outlined in the SRI assessment methodology in the levels of functionality for each of 55 types of operational intellectual readiness of a building. This leads to fragmentation of information and complicates the work of SRI appraiser who is obliged formulate recommendations for a building owner in a precise and coherent way.

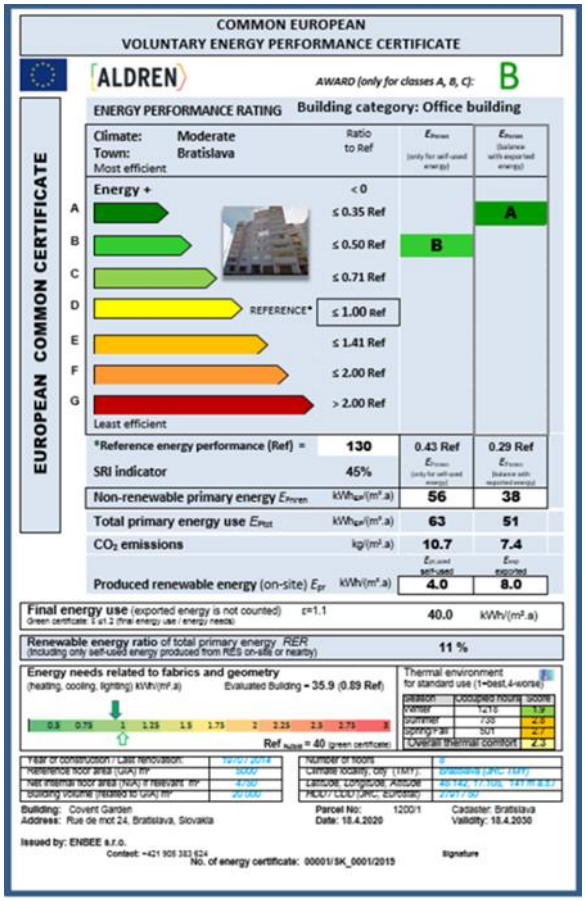

Figure 1 – Energy Efficiency Certificate ALDREN-EPC
(Electronic resource: The ALDREN project https://aldren.eu/)

Recommendations to boost SRI - a series of measures for modernization

Smart readiness of engineering systems along with associated levels of functionality are grouped by technical areas. In addition, a tool has been developed that enables grouping applicable in terms of efficiency measures into so-called action packages. For example, recommendations for obtaining a higher SRI index using digital systems are presented in the following packages of modernization measures:

- flexibility of management system;
- interaction with network;
- management and control on demand (DSM).

ALDREN-EPC certificate has a particular page that covers information in relation to smart readiness indicator. SRI evaluation is not only given with regard to current situation, but it also outlines the evaluation that is likely to appear as long as all necessary actions on realization have taken place. For smart readiness indicator according to the criterion of influence "Flexibility in Energy Consumption", recommendations for improving building evaluation in this direction are given under the table (Figure 2).

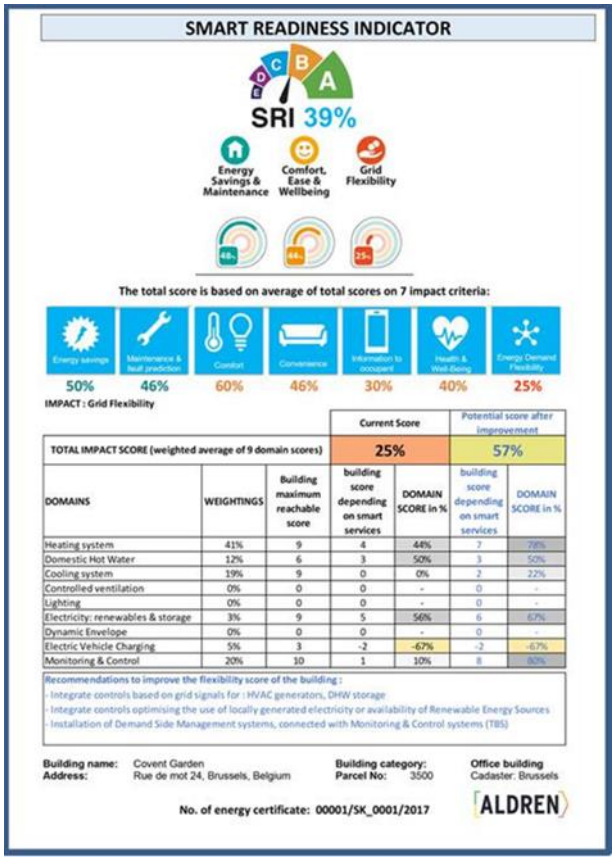

Figure 2 – ALDREN-EPC certificate page - evaluation of SRI for flexibility of energy consumption system
(Electronic resource: The ALDREN project https://aldren.eu/)

SRI as part of ecosystem EPBD

The EPBD ecosystem is primarily formed by building quality assessment (EPC energy efficiency certificate, BRP building renovation passport), and it also includes reports from qualified experts working according to European standards. The EPBD Directive contains various indicators (for example, renewable energy share (RUR), the indicator of non-renewable primary energy (PEnren), etc.), which together provide more reliable information about building quality. All of them are covered in both energy efficiency certificate and building passport. In the EPBD ecosystem, SRI is also an auxiliary tool taken for granted when quality of a building needs to be evaluated. Thus, SRI indicator should not be considered as an "independent" characteristics.

Experts on smart readiness indicator

As far as EPBD requirements are concerned, they prescribe the necessity for engineering systems to undergo certification and inspection by impartial and certified experts. Therefore, training and certification of EPBD ecosystem experts should include SRI evaluation of a building. However, it is economically and technically impractical to certify experts exclusively for SRI, since this does not provide complete information about the object. SRI training should be an inherent part of a particular system designed for modular training and certification of experts.

As EPBD Directive is some kind of a framework, technical features of its transfer to national level are determined by the EU member states. Thus, there are about 30 different regional and national methods for calculating energy efficiency of buildings based on EPBD directive. This leads to a division of the EU market and fails to compare and evaluate energy efficiency in relation to construction projects. As a result, certifying experts at the EU level becomes challenging contributing to extra exspenditures. To prevent similar situation when introducing CRM in the EU, the development of European standards (Mandate 480) has been supported to assist member countries in coordinating their calculation methods. The standards EN 15232, EN ISO 52000-1 should be used as the basis for smart readiness catalog and corresponding levels of functionality. The link with EU standards will also enable to refine the SRI methodology and add quantitative values to proper evaluation [3].

Perspectives

Europe is regarded as a leader in achieving the effect of climate change mitigation. A number of tools are under development or updating (for example, EPBD law amendments, EU green systematization**,** etc.)

Engineering equipment for energy efficient buildings

According to methodology of system approach, it is necessary to consider the thermal efficiency of a building as a single energy system, in particular:

- climatic conditions in the construction area;
- architectural and planning solutions with the focus on thermal insulation properties adopted by the project of enclosing structures;
- engineering equipment of a building aimed at creating favourable conditions.

According to expert estimates, the introduction of energy-saving measures has the potential to reduce heat consumption in a building by 2-2.5 times. At the same time, energy saving due to optimization of urban planning solutions is as much as 8-10%, architectural and planning solutions up to 15%, correct choice of solutions for enclosing structures up to 25%, engineering equipment up to 30%, in–house automation and accounting systems up to 20%. To determine and reduce heat loss, it is imperative to compile heat balance, Table 1 shows possible energy receipts and heat loss in a building. [4]

Table 1 – Heat balance of a residential building of cottage

Solar energy	Window 25%
Heat release from the vital activity of people and equipment 25%	Wall 15%
	Roof 15%
	Basement 5%
Heat accumulated by building structures 40%	Infiltration 40%
Inflow and accumulation of thermal energy in the building	Heat loss

Taking this into account, the greatest energy savings can be obtained through insulation and reduction of heat loss, building structures, the use of modern and modernization of existing engineering equipment, along with integrated automation of in-house processes. A more detailed focus is required here.

This position is a backbone for premises of energy efficient type. Hence, it appears that such construction projects are supposed to correspond to the following basic requirements:

- proper documentation work with reference to design and budget;
- application of devices for favourable heating conditions;
- mechanical ventilation of premises;
- application of efficient heating equipment;
- efficient use of hot water supply;
- application of hydrothermal and geothermal installations for thermal energy production;
- application of air ducts and pipelines with the lowest hydraulic resistance;
- application of energy efficient household and domestic appliances;
- application for accumulation of thermal energy in premises;
- abandonment of unnecessary architectural details and the choice of architectural forms with the smallest area of enclosing structures.

The fundamental difference between energy efficient buildings is that they require significantly less thermal energy for heating than those buildings that are built according to current building codes. However, until now, the term "energy efficient house" has not received any official explanation. Therefore, this term is mistakenly referred to premises that do not meet any of these requirements.

Based on experience of similar premises in Western Europe, such buildings are considered to be houses that consume 25% less heat energy than is accepted by regulatory documents. In accordance with this, according to European standards, maximum annual heat demand for heating is calculated by the formula Q max = f (A/V), depending on the ratio of total heat transfer area A to the construction volume V not exceeding 40-75 kW per hour per m2 of heated area on a yearly basis. In practice, the consumption ranges from 35 to 80 kW per hour / m2 yearly which approximately corresponds to the consumption, from 3.5 to 8 liters of diesel fuel, or 3.5-8 m^3 of natural gas per 1 m^2 annually.

Energy efficient buildings have little need for thermal power for heating purposes. However, to order to ensure hot water supply and to cover the costs of heat loss and ventilation, it sometimes has to be increased 3-5 times. To create comforta-

ble conditions, residential buildings that require heating about 6 kW up to 24 kW, thermal energy may be needed for hot water supply.

Energy efficient houses are much more comfortable compared to houses where conventional construction is applied. As energy efficient building tend to ensure an energetically optimal operating mode, eliminate draft formation, reduce noise emissions, and they are also deprived of any unpleasant odors and, in general, such buildings reduce operating energy costs considerably.

Drawing conclusions, the use of contemporary engineering equipment aligned with automatic regulation and reliable insulation of enclosing structures enable to reduce energy costs by 2-2.5 times, and it also has a positive impact on the reduction of heat consumption in a building. However, it is possible only with the integrated use of energy saving methods of all in-house systems.

Results and discussion

As regards main reasons for the degradation of project organizations, these are the deficit of high quality specialists, outdated structure of project organizations, as well as the lack of an understandable regulatory framework and training materials. This puts project organizations under disadvantage in terms of unenviable status. Necessary paperwork and documentation is no longer properly arranged, however, creators react to this by organizing their own technical departments. So, when this is the case, we make an effort to understand ways to overcome this issue so that engineering industry accepts any market challenges.

Poor organization and inability to have rapid expansion always result in procrastination of duties and deterioration of product quality. The domain of engineering systems is currently undergoing such investigation and, unfortunately, the results of this are quite disappointing. The majority of objects that we have to work with are now becoming more and more complex [5].

Therefore, standard solutions that can be copied fail to find any application. Growing demand with reference to object complexity has revealed two main problems of our sphere.

Insufficient level of instruction and qualification

The knowledge that a person has allowed him to do everything correctly, but why this knowledge did not help in this case, that is the question. The answer to this question is not so much technical as more managerial, which is commonly a weak point of the industry itself.

The more building planners are required, the more a special type of training material is needed as well – clear a practical instructions on how and what to do are also valuable. An overwhelming amount of work is done by ordinary building planners who most need such instructional materials.

Building rules generally describe what needs to be done. However, very few sources contain information with clear instructions of how to do this. Building planning procedure these days is more time-consuming than it used to be when building planners were to suggest technical part only. Unfortunately, the culture of writing in-

structions has not been instilled in our country in a proper way. Designers need a particular document that describes the nuances of passing examination procedure. Instructions give a building planner proper understanding of the subject, enables to eliminate any errors, teaches correct sequence of actions, and introduces a design of a building under a construction.

Outmoded enterprise structure

A new relationship has developed between designers and customers to date. Now, technical decision making is given to a customer. Consequently, competence center which meant to be important in decision-making process is no longer necessary for design companies.

Many project companies have a special department which is responsible for control of building standards, however this very department is to blame for poor quality of documentation. This department was arranged in order to identify violations of registration rules and possible facts concerning the use of non-standard or non-standardized products in documentation. And the level of engineering is now so much vulnerable that is even contains fundamental errors or suboptimal solutions in the projects in high quantity [6].

To realize this contradiction, the entire structure of the project company must be revised.

1. Responsibility for proper design solutions is assigned to chief specialists or heads of departments, who are to be freed from daily technical and administrative routine. Then, they can influence decision-making process by verifying and approving certain resolutions.

2. Competent main architect is to head a team of engineers. He/she should perceive a project as a single organism in which everything fits and works smoothly, without spoiling the exterior.

3. Control department needs to be reformatted into the computer-aided design department, where programmers must develop and adapt software for accurate documentation.

The conclusion is apparent a company that can regain the status of a respected design institute should expand its staff. The rising cost of design is likely to enable to have investments in business transformation.

According to a survey answers, participants expressed deep concerns about engineering systems. This situation cannot be tackled unless the development of proper amount of instructions and training materials are in place, it also impossible without increasing the value of the engineering work in the eyes of customers, which will allow investments to be allocated for construction of worthy engineering competence centers [5].

Conclusions

Effectiveness of building design solutions is determined by a number of factors. The use of energy efficient engineering systems will save energy resources and provide comfortable conditions in premises.

Having investigated this issue, we propose to apply certain equipment relying on proper use of energy sources. In draw-in air systems, systems with the utilization of heat of removed air should be used, which reduces the consumption of thermal resources. The use of cooling systems with utilization of heat removed can reduce the consumption of thermal resources for hot water supply or other needs. The choice of a rational heating system contributes to comfortable conditions and it also saves thermal resources by reducing air temperature inside heated rooms.

Thus, the choice of heating, ventilation and cooling systems should be set at the initial design stage, depending on the purpose of a building and other factors affecting the rational choice of engineering systems.

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ЖОБАЛАНАТЫН ҒИМАРАТТАРДЫҢ ЭНЕРГИЯ ТИІМДІЛІГІН ТАЛДАУ

Аңдатпа. *Бұл мақалада инженерлік жүйелердің энергия тиімділігін бағалау бойынша зерттеулер жүргізіледі. ALDREN-EPC сертификатының негізгі рөлі сипатталған, ол SRI ғимаратының зияткерлік дайындық көрсеткішін және оны бағалау процедурасын анықтаудан тұрады. Сондай-ақ, мақалада SRI тиімділігін арттыру құралы ұсынылған. Жұмыста*

EPBD экожүйесінің талаптары мен перспективалары көрсетілген. Жобалау компанияларының тозуының негізгі себептері зерттелді, мысалы, тиісті деңгейдегі мамандардың жетіспеушілігі, жобалау ұйымының ескірген құрылымы, сондай-ақ түсінуге болатын нормативтік база мен оқу материалдарының болмауы.

Түйін сөздер: *зияткерлік ғимараттар, зияткерлік дайындық индикаторы (SRI), энергия тиімділігі сертификаты (ALDREN-EPC), ғимаратты қайта құру паспорты, ALDREN-BRP, EPBD (ғимараттардың энергия тиімділігі жөніндегі директива), энергия үнемдейтін үй, инженерлік жүйелер.*

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АНАЛИЗ ЭНЕРГОЭФФЕКТИВНОСТИ ПРОЕКТИРУЕМЫХ ЗДАНИЙ

Аннотация. ***В*** *данной статье проводятся исследования по оценке энергоэффективности инженерных систем. Описываются основная роль сертификата ALDREN-EPC, который заключается в определении показателя интеллектуальной готовности здания SRI и процедуры его оценки. Также, в статье рекомендован инструмент для повышения эффективности SRI. В работе изложены требования и перспективы экосистемы EPBD. Исследованы основные причины деградации проектных компаний, такие как, недостаток специалистов должного уровня, устаревшая структура проектных организации, а также отсутствие доступной для понимания нормативной базы и обучающих материалов.*

Ключевые слова: *интеллектуальные здания, индикатор интеллектуальной готовности (SRI), сертификат энергоэффективности (ALDREN-EPC), паспорт реконструкции здания, ALDREN-BRP, EPBD (директива по энергоэффективности зданий), энергоэффективный дом, инженерные системы.*