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TASKS FOR IMPLEMENTATION OF BUILDING ENERGY PASSPORTIZATION PROCESS

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Abstract- From the moment the building is put into operation, it begins to consume resources - energy, mechanical, electrical, automatic. The operating energy costs of buildings account for approximately 70-80% of the total costs throughout the entire life cycle of a building. All building and technical systems naturally degrade over time, both in terms of performance and in terms of their efficiency, i.e. operating and maintenance costs are rising, energy consumption is increasing and the quality of the microclimate is declining. One of the methods for assessing buildings in terms of efficiency energy use is a building energy passport that creates the basis for their direct assessment and comparison of the energy consumption of different buildings. The system is also the basis for financial incentives, and obtaining an energy efficiency class creates prerequisites and motives for design new energy efficient buildings and modernization of existing ones. The building passport for energy efficiency (BP) and rational use of material resources is a special document-certificate that contains information about the geometric and technical parameters of the building, its functional purpose, design solutions, thermal characteristics and energy performance. This paper discusses the current state of the process of building pass poetization in Azerbaijan, analyzes the existing shortcomings. Building energy efficiency rating classes are calculated, and a list of the main procedures to enhance the energy efficiency class is given. Template of building passport is given.

Keywords: Building Passport by Energy Efficiency, Specific Annual Energy Consumption, Template of Building Passport, Rating Classes of Building Energy Efficiency, Expert, Material Resources.

1. INTRODUCTION

Although Azerbaijan owns significant fuel, energy and material resources, the problem of their effective accounting and optimal consumption is quite relevant today [3]. As in many countries of the world, most of the country's final energy consumption is comes from the buildings and structures. For Azerbaijan, this figure is approximately 45%. Therefore, increasing their energy efficiency requires significant efforts to implement effective measures, which include energy certification of buildings [1, 2].

On July 1, 2022, Azerbaijan adopted the Law "On energy efficiency and efficient use of energy resources" [3], which is an addendum to the previous law "On the applying of energy sources in Azerbaijan" of 1996. According to the new law, the main areas of activity are:
- Ubiquitous pass poetization of buildings, keeping up-to-date with four types of essential data (Figure 1);
- Applying of active energy-saving procedures, including the installation of smart meters that determine the volume and cost of energy used;
- Creation of the "Energy Efficiency Fund" [4, 5].

The main tasks for the implementation of this law are:
- Development of a regulatory framework in accordance with international experience in this area;
- Stimulation and encouragement of application of energy efficiency mechanisms;
- Informing users about the benefits of energy efficiency: environmental, social and economic;
- Training of personnel for the certification of buildings in the field of efficiency and rational use of natural resources;
- Conducting regular energy audits and mandatory once every 3 years.

Each building has its own life cycle, which includes the following stages [6]:
1. Production and transport of building materials and equipment,
2. Design
3. Construction
4. Operation, modernization, reconstruction, overhaul
5. Demolition of a building that has exhausted its potential

According to experts, the operating energy costs of buildings account for approximately 70-80% of the total costs throughout the entire life cycle of a building [7]. From the moment the building is put into operation, it begins to consume resources - energy, mechanical, electrical, automatic. All building and technical systems naturally degrade over time, both in terms of performance and in terms of their efficiency, i.e. operating and maintenance costs are rising, energy consumption is increasing and the quality of the microclimate is declining.

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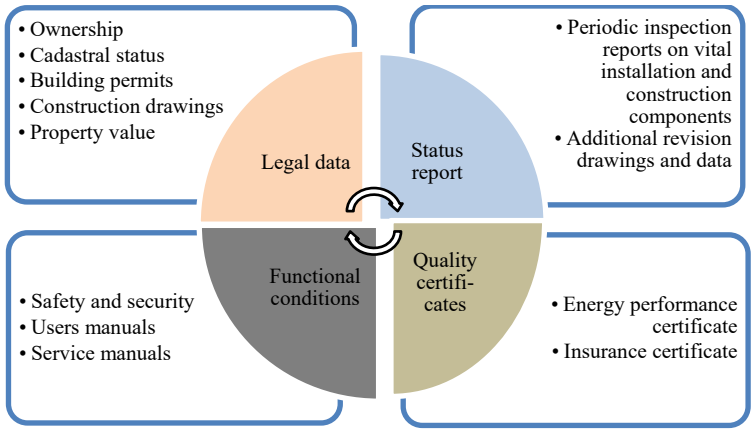

Figure 1. Scheme of essential data of building

As a solution to this problem, certification of buildings for their energy efficiency can be considered, which allows for controlled operation in accordance with passport indicators [8] (Figure 2) and long-life pass poetization components (Table 1). The building passport for energy efficiency (BP) and rational use of material resources is a special document-certificate that contains information about the geometric and technical parameters of the building, its functional purpose, design solutions, thermal characteristics and energy performance. The BP is compiled based on the results of an energy inspection to assess the efficiency of consumed energy and material resources and contains recommendations for the use of energy saving procedures, information on the building efficiency class.

Building Energy Passport

Building Energy Performance	During construction, calculated *	During operation measured **
Space to indicate the energy certification procedure used		
Very high efficiency A B C D E F G Energy inefficient	C	D
	130 kWh/m²a	160 kWh/m²a

Space to indicate additional information on the energy consumption of the building

Management information:
building address
air-conditioned area
validity name of the person who performed the certification and signature

* Calculated figure assumes standard conditions. It only takes into account energy used for heating, ventilation, cooling, hot water supply and lighting (add others if necessary)

** The measured value is determined under specific conditions. All goals are taken into account energy use

Figure 2. Template of building passport

Table 1. Long-life pass poetization components

Building passport	- detailed description and graphical depiction of the assessment results (scores for indicators and overall result)
Building logbook	- documentation of the planning & construction process & operation phase through a structured "building folder" (drawings, operation costs, insurances, etc.)
Label	- visualization of sustainable building quality (indication of the certification level)
Sustainable planning checklist	- guideline including mandatory core requirements and voluntary additional measures
Building folder	- pre-prepared structure for the filling of building documents
Audit form	- recording of on-site inspections through a structured questionnaire/checklist
Full declaration of materials	- complete list of materials used: metals, organics, plastics, hazardous substansions, etc.
List of life-cycle costs	- compilation of life-cycle costs including cleaning, dismantling, further costs
Positive-negative-list	- list indicating materials to be excluded and materials to be preferably used in construction

In many countries in Europe, BP is mandatory for residential buildings and even individual apartments, such as in Germany. The composition and content of the energy passport of the building are given in [9]. According to the Energy Efficiency Law of 2022, the next generation BP is a comprehensive step-by-step roadmap for the long-term operation of a building for 15-20 years, if a building needs to be renovated while ensuring optimal indoor comfort parameters or the required microclimate indicators with individual solutions for each specific building. BP shows the energy quality of a building. This paper discusses the current state of the process of certification of buildings in Azerbaijan, analyzes the existing shortcomings. Building energy efficiency rating classes are calculated, and a list of the main procedures to enhance the energy efficiency class is given. The requirements for experts who carry out the certification of buildings are systematized.

2. METHODS AND MATERIALS

The review was based on materials from the Web of Science, Scopus, and other databases to familiarize with publications on the reference topic. To study the stated task, a literature review was conducted to study the experience of foreign countries in this area and an analysis of the situation in Azerbaijan was carried out. Many years

of experience of the author of the paper as a certified energy auditor of the international category (ENSI, Norway) also served as a source of information for this study. It must be admitted that the process of pass poetization for residential buildings in Azerbaijan is not carried out [4]. There are isolated cases for old buildings - two nine-story buildings, - in a residential area of Baku and one architectural house in the suburbs in the village of Mardakan. For industrial buildings and structures, certain activities are already planned in the light of the 2022 Energy Efficiency Law. On the part of the specialists of the Azerbaijan Architecture and Construction University, a methodology for carrying out the certification of buildings is being developed, it is proposed to conduct a series of trainings for local specialists on building energy auditing and certification, including by the involvement of foreign specialists and companies [3].

3. RESULTS AND DISCUSSION

3.1. Current State of Building Pass Poetization in Azerbaijan

The existing pass poetization system before the adoption of the 2022 Energy Efficiency Law had mainly the following shortcomings:

- Only individual buildings were subjected to an energy audit followed by certification;
- There was no regular monitoring of structures and engineering systems;
- Due to the lack of technical data and indicators of the building in electronic format and their unsystematic storage, there was no organized exchange of documents, information between specialists in different areas, and the search for the necessary information slowed down.

Since 1996, Azerbaijan has applied the law "On the use of energy resources of Azerbaijan" almost similar to the new one. It included the following issues:

- the mechanisms of control over the consumption of energy resources by state structures were considered;
- measures were taken to account for energy resources;
- the use of PEE was of a recommendatory nature;
- there were proposals to attract foreign specialists and investments;
- some attention was paid to the training of national staff of energy auditors.

Therefore, the main trends in the widespread introduction of pass poetization after July 2022 are as follows:

- To adopt and implement the best world experience in this type of activity; to use a single form of certification, as a model, to use the energy passport of buildings in Russia or Germany [12, 13];
- To conduct the process of pass poetization in stages, starting with public buildings, initially buildings of industrial enterprises.

The use of BP in electronic format (digital building passport) will help to eliminate the shortcomings and problems listed above. An electronic building passport (EBP) is an information automated interactive building model that stores all catalogs with design, technical, operational, graphic and calculation documentation [6, 14]. With the help of EBP, it is possible to quickly assess the current state of the building in terms of the state of structures and thermal parameters and propose appropriate energy-efficient measures [15].

3.2 Passport Section for Building Materials

The DBP contains a section on the thermal characteristics of the applied building materials and engineering equipment. The new law recommends using certified building materials, i.e. having a technical passport. Just as a building data sheet provides information on its energy performance, an equivalent building material data sheet provides detailed information on the thermal and other important characteristics of the materials, and especially on the recyclability and reusability, which facilitates the recycling of materials at the end of a building's life cycle, i.e. the trend of non-waste demolition and reconstruction of buildings are maintained, which is significant from the view of their environmental friendliness (Figure 3).

Energy certificate Energy performance			
Num.	Category	Valid	
Building envelope			
Components	Area, m^2	Heat transfer coefficient	
		Actual, W/m^2K	Reference, W/m^2K
Walls			
Windows			
Roof			
Floor			
Evaluation of current state:			
Issued on	Issued by	Reg. nub	

Figure 3. BP section with technical data of the building envelope materials

3.3. Passport Section "Rating Class of Building Energy Efficiency"

The most modern way to determine the energy efficiency class is the calculation-experimental, i.e. accounting of all energy-using equipment, a detailed calculation of the energy consumption of engineering systems and a detailed analysis of efficiency of the building as a whole are carried out [16]. The BP also has a section on building energy efficiency class (BEE). The BEE reflects the result of the application of cumulative energy-saving measures taken at the design and construction stages, carried out during operation. All necessary calculations are carried out by means of special programs and the energy consumption curve is modeled, as a result the class of the building is established.

In addition to the calculation and experimental, there are also the following methods for checking the energy efficiency rating class of buildings:

1. Short-term measurements;
2. Through a series of continuous measurements;
3. Based on the analysis of the readings of energy consumption meters.

For the calculation and experimental method for assessing energy efficiency, control and measuring equipment and instruments a thermal imager, a flow meter, a gas analyzer, a range finder, a pyrometer, a light meter, etc. are used. According to the calculation-experimental assessment method, building energy efficiency rating class of a building is a generalized indicator of its quality [17, 18], which is assessed by the deviation gap (Δ) of the actual specific building energy consumption (q) by q-normative. The class of the building is indicated by Latin letters A-G and is posted on the facade. The deviation interval is calculated by the formula:

$$\Delta = \frac{q - q_{normative}}{q_{normative}} 100\%$$

where, q is specific annual energy consumption, containing t ventilation and heating, hot water supply, electricity costs, (kWh)/m^2, $q_{normative}$ is a standardized base level of the actual specific annual energy consumption, (kWh)/m^2.

Indicators of the total standard level of the specific annual consumption of energy resources and the corresponding interval of deviations of the actual specific energy consumption from the standard according to the energy efficiency classes are given in Table, 1 according to the degree-day value for Baku`s heating period, which equals early 2000 °C day. The presence of class B, A, A+ or A++ means that such a building saves 30-60% of energy resources due to the use of modern engineering equipment and optimal thermal insulation of external building envelopes [8, 19].

A building with an energy efficiency index D allows you to save up to 15% of resources. The smallest energy efficiency class is G, i.e. half of the energy costs are lost. According to the new law, renovation works will be carried out in such buildings to upgrade the building envelope, energy meters will be installed, motion tracking sensors and energy-efficient lighting lamps will be used. For new buildings, the energy efficiency class should be higher than class C (Table 2,3). Buildings of levels D, E, F, G are referred to the low class. The author's practice shows that buildings built before 2011 in Baku clearly do not meet the requirements of energy saving and energy efficiency.

Table 2. The number of total specific annual energy rate of residential buildings by efficiency rating classes A++ -G

Energy efficiency class of buildings (EECB)	Deviation value %	Specific annual rate of building energy resources, (kWh)/m^2 at baseline	
		for a 5 -story building- 109.56	for a 9 -story building
A++	-60	47.83	44.98
A+	-50	55.82	53.59
A	-40	65.78	63.11
B	-30	76.74	75.67
C	-15	93.28	89.23
D	0	109.56	104.72
E	+25	137.06	131.27
F	≤50	184.47	167.99
G	≥50	184.47	167.99

Table 3. The number of total specific annual energy rate for different buildings types by efficiency rating classes

EECB	A	B	C	D	E	F	G
Single Family house	<51	51-97	98 - 142	143 - 191	192 - 240	241 - 286	>286
Apart blocks	<43	43 - 82	83 - 120	121 - 162	163 - 205	206 - 245	>245
Hotels restaurant	<102	102 - 200	201 - 294	295 - 389	390 - 488	489 - 590	>590
Offices	<62	62 - 123	124 - 179	180 - 236	237 - 293	294 - 345	>345
Hospitals	<109	109 - 210	211 - 310	311 - 415	416 - 520	521 - 625	>625
Edu. buildings	<47	47 - 89	90 - 130	131 - 174	175 - 220	221 - 265	>265
Sports facilities	<53	53 - 102	103 - 145	146 - 194	195 - 245	246 - 297	>297
Shop. centers	<67	67 - 121	122 - 183	184 - 241	242 - 300	301 - 362	>362

The main procedures to enhance of energy efficiency rating classes of buildings [14] include:

- Facade regulation of heat and cold supply, i.e. different thermal conditions for the premises of the northern and southern facades;
- Heat-reflecting glazing, which saves up to 25% of energy costs;
- Mechanical ventilation with recuperation system (Figure 4);

Energy certificate Energy performance			
Num.	Category	Valid	
Heating, ventilation and domestic hot water (DHW) systems			
Systems	Energy source	Annual energy consumption	
		Specific, kWh/m^2	Total, kWh
Heating			
Ventilation			
DHW			
Fans and pumps			
Heating degree-days			
Total annual energy consumption for heating and ventilation		kWh/m^2 degree-days	
Annual amount of CO_2 emissions		t	
Issued on_____	Issued by_____	Reg. nub_____	

Figure 4. BP section of technical data for HVAC and DHW

- Innovative systems for monitoring and recording energy consumption, tracking energy flows in automatic mode, recognition of leaks, unauthorized connections, quick response to emergency situations;
- Smart Home system- remote control of equipment operation using a smartphone thermal insulation of the facade, which, although it is a laborious and expensive process, but allows you to reduce heat loss up to 12%;
- Possible risks and benefits in making better use of the building data are given at Table 4.

3.4. Specifications for Specialists Conducting of the Building Passport

The need to ensure the proper quality of certification of buildings has made specialists endowed with very specific competencies in demand. Energy certification experts are recognized as experts of the new generation. They must have different competencies.

Specifications for specialists are [20]:

- qualification, the specialist must have:
- higher technical education;
- at least 3 years of experience in the specialty (design, supervision, control, construction management of

buildings or their engineering systems or power systems), this requirement does not apply to university teachers in specialized specialties;
- certificate of completion of the course on energy audit of buildings, issued by an accredited institution, a recognized organization or an authorized body;
- professional skills, the specialist must:
- have knowledge to calculate energy characteristics and energy efficiency indicators (Figure 5);

Table 4. Key issues in making better use of the building data

Benefits	Risks	Considerations
Increase research and technology innovation to improve energy efficient building knowledge and performance	Increase in unwanted marketing (considered to be low risk as there are other legislated mechanisms dealing with direct marketing)	A lot of data about buildings is readily available in the public domain
Enable households at risk to more readily identify and support local programmers	Security i.e. potential for increase in burglary (considered to be low risk)	Benefits outweigh risks
Enhance the role of real estate companies to enable potential buyers / tenants to compare properties		Select specific data items to make available (73 items selected)
Enable property management companies to better manage and upgrade their building stock		Provide Opt. Out clause

- Have knowledge and qualifications in the technology associated with the surveyed object;
- Know metering devices and measuring equipment;
- Have the skills to summarize the results and technical data.

This study provides a generalized scheme of the building's electronic passport for energy efficiency, analyzes the situation in Azerbaijan, calculates the specific annual energy consumption by energy efficiency class, and systematizes the requirements for specialists in the certification of buildings. The results of this study will contribute to the acceleration and systematic process of certification of buildings and improve their energy efficiency.

Energy certificate Energy performance			
Num.	Category	Valid	
Normalized annual energy consumption			
	Thermal energy, MWh	Electricity, MWh	Water, m^3
Energy conservation measures	Investments	Annual energy savings, kWh	Measure priority
Issued on _____	Issued by _____	Reg. nub _____	

Figure 5. Final energy data of BP

Benefits of building passports:
1. Cost savings: information and data no longer lost and collected and recorded only once; no more duplication.
2. Improved efficiency: all information is accessible in one place; simplification of processes and reduction of administrative burden; digital version has unlimited information storage capability.
3. Greater transparency: accurate information is accessed more easily, providing third parties with information, needed for specific purpose; all stakeholder can access the same information; reduces the scope for corrupt practices.
4. Risk mitigation: accurate information enables better risk assessment and mitigation.
5. Improved basis for decision-making: accurate information allows decisions regarding the building to be made on the basis of verified evidence.
6. Overcoming sectoral fragmentation: better alignment, creation of synergies of sectoral value chain through information sharing.
7. Fostering of innovation: higher productivity levels and the development of new business models.

Depending on the respective building passport format, a variety of future building passport functionalities will result in additional benefits. Assisting the facilitation of:
- Easier and more accurate life cycle costing;
- Estimation of the environmental impacts of the building over its lifetime (including deconstruction and material re-use);
- Targeted campaigns such as best practices in energy efficiency through social networking;
- Creating potential for:
- Generation of alerts and updates on the performance / condition of the building, renovation roadmaps, pdf reports and dataset exports in common formats (e.g., excel files);
- Monitoring of resource consumption (energy, water, gas, etc.) when the building passport is linked to meters;
- Authorizations to third-party stakeholders (e.g., solicitors, agents, public authorities, mortgage lending institutions, insurers, etc.) to use and/or update the logbook;
- Tracking of information changes through provision of a chronology function – for any information visible in the passport, it should always be possible to track changes and authors of those changes, i.e., who changed *x* to *y*, and when (potentially with the help of blockchain technology) support of portfolio analysis and management;
- Providing the basis for valuation, financial due-diligence and risk management benchmarking of assets with similar buildings.

4. CONCLUSIONS

Decarbonizing the construction and real estate sector is critical to achieving the Paris Agreement and the United Nations Sustainable Development Goals. The sector is responsible for almost 40 per cent of energy- and process-related greenhouse gas emissions. These include direct and indirect emissions from building use, the manufacturing of building materials, and building replacement and renovation.

Taking climate action in buildings and construction is among the most cost-effective ways to address rising global emissions.

The main goal of Law on Energy Efficiency and Efficient Use of Energy Resources, which came into force on July 1, 2022 in Azerbaijan, is to reduce the consumption of energy and fuel resources by 30% by 2030. Buildings and structures, as the largest energy consumers, have the greatest potential for energy saving, and therefore energy saving measures in them are a priority. Active energy-saving measures include the certification of buildings for their energy efficiency, the installation of smart meters that determine the volume and cost of energy used, and the creation of an "Energy Efficiency Fund".

Certification of buildings helps to reduce energy consumption and protect the environment. The above law established the registration principle of certification of buildings for their energy efficiency, and also determined the procedure, promising deadlines, budgeting and stages of certification of buildings of all types, starting with budgetary and industrial enterprises. The types of passports for buildings of various purposes are determined on the basis of a single form, a link is given to Russian, European standards and directives when maintaining the settlement part of pass poetization [21, 22].

Data and information needs arise across the whole life cycle, but certain types of information are in particularly high demand:

- Energy performance certificate/real energy consumption
- Greenhouse gas emissions (conversion from energy consumption)
- Detailed results of a sustainability assessment / label
- Material inventory (type, quantity, quality of installed
- Materials, risks to health and the environment)
- Evidence of systematic commissioning
- Evidence of systematic maintenance and repair
- Resilience to current and future natural hazards at the site
- User satisfaction (for rented properties)
- Activities around the buildings and construction life cycle that typically represent data demand trigger points include, among others, transactions, buying, selling, insurance, renting and refurbishment.

The competence of specialists in certification of buildings is ensured by the establishment of relevant qualifications:

– Work experience,
– Pre-qualification,
– Mandatory completion of training programs,
– Passing exams,
– Continuous improvement.

This study provides a generalized scheme of the building's electronic passport for energy efficiency, analyzes the situation in Azerbaijan, calculates the specific annual energy consumption by energy efficiency class, and systematizes the requirements for specialists in the certification of buildings. The results of this study will contribute to the acceleration and systematic process of certification of buildings and improve their energy efficiency.

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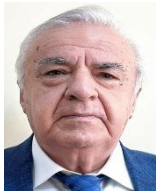
BIOGRAPHIES



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