PRIMENA OBNOVLJIVIH IZVORA ENERGIJE U ZGRADARSTVU

APPLICATION OF RENEWABLE ENERGY RESOURCES IN BUILDINGS

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Struktura objekata koji se grade moraju biti projektovani tako da budu energetski efikasni. Doprinos svakog objekta za stanovanje ili za poslovne, proizvodne i skladišne potrebe mora biti posmatran u kontekstu ušteda energije i transformacije kroz centralizovan sistem. Značajan doprinos energetskoj efikasnosti u zgradarstvu daju obnovljivi izvori energije, koji mogu da se međusobno kombinuju i kroz transformacije termalne u električnu energiju, ostvare ogromne uštede. Pored ušteda i efikasnosti, OIE utiču i na izgradnju objekata koji se uklapaju u životni prostor i kompenzuju modalitete grejanja-hlađenja-transformacije-čuvanja-prodaje viška energije.

U radu se analizira trenutno stanje izdavanja dozvola, projektovanje i izgradnja objekata, kao i davanje upotrebnih dozvola uz osvrt na ugradnju „zelenih“ materijala i stvaranja odgovarajuće atmosfere koja podržava obnovljive izvoreenergije i energetsku efikasnost.

***Ključnereči**: Obnovljivi izvori energije; energetska efikasnost; zgrade; „zeleni materijali“; arhitektura*

The structure of the facilities under construction must be designed to be energy efficient. The contribution of each residential or business, production and storage facility must be viewed in the context of energy savings and transformation through a centralized system. Renewable energy sources (RES) make a significant contribution to energy efficiency in buildings, which can be combined with each other and through huge transformations from thermal to electricity, achieve huge savings. in addition to savings and efficiency, RES also affect the construction of facilities that fit into the living space and compensate for the modalities of heating-cooling-transformation-storage-sale of excess energy.

The paper analyzes the current state of licensing, design and construction of facilities, as well as the issuance of use permits with reference to the installation of "green" materials and the creation of an appropriate atmosphere that supports renewable energy sources and energy efficiency.

***Key words:** Renewable energy sources; energetic efficiency; buildings; "Greenmaterials"; architecture*

1 Renewable energy sources

Energy resources were previously considered limited and unavailable for widespread use. However, with the development of technology of transfer, reception, processing and supply, its appearance and use form is viewed in a different way.

Dependence on traditional energy is increasing due to technological development and real needs for sustainable energy. Unlike these sources, renewable energy sources have consistency and are environmentally friendly. Their renewability does not depend on the consumption of resources but on a continuous inflow through the development of technological capacities, such as turbines, photovoltaic cells, thermal sensors and rods, mechanical pendulums and propellers. As a renewable energy source (RES) we know biomass (wood and waste) and biofuels (biogas), wind energy, solar energy, hydropower (watercourses, small hydropower plants, sea currents, tides), wave energy, geothermal

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energy and the Earth's internal heat,geothermal water), as well as combined forms of renewable energy sources (water, air, light, waves). The use of RES has become an important part of the design and development of green building (Hashim H, HoWS, 2011).

The main difference between energy used in the world and in our country is that the developed world cares about reducing environmental pollution, consumption of traditional energy sources and trying to increase the energy efficiency of individual households, either through incentives and regulations or through greater availability of renewable materials and technologies centralized supply system. Figure 1 shows the connection of different forms of renewable energy that a building can use to meet the thermal needs for heating water and premises, as well as the production of electricity from its own sources.

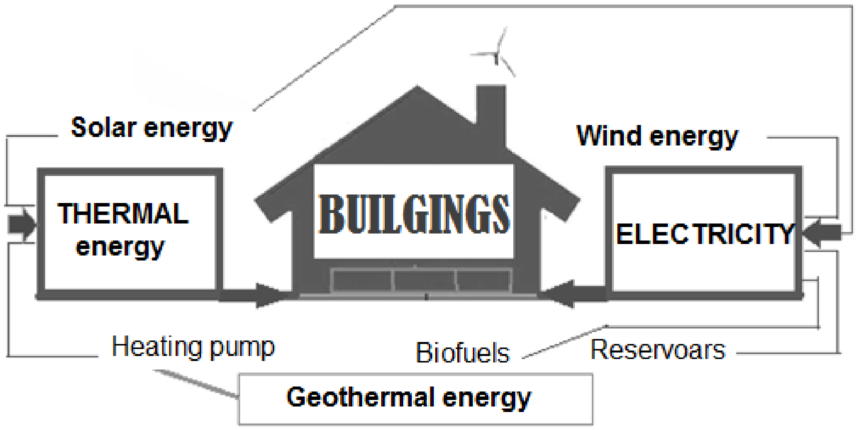

Figure 1. Integration of different forms of RES in buildings

1.1 Solar energy in buildings

Solar radiation is a completely pure form of energy that has no harmful consequences, because it is far enough away from the source and has a protective coating that is damaged by the use of fossil fuels in some layers. The application of solar energy is under great care because it is free of harmful gases; it is used in photovoltaic systems, for solar water heating and a hybrid photovoltaic solar system (Golić, Kosorić and Furundžić, 2011).

Most often, the sun's energy is used directly by means of solar panels, creating thermal energy for heating water or an object. Since solar energy is an inexhaustible source of supply, its renewableness is unquestionable, but the problem occurs with day-night phases or seasonal oscillations of weather conditions. The possibility of using nanomaterials in the production of solar panels and solar cells due to toxic semiconductors that emit harmful gases is increasingly being investigated.

So much solar energy is transferred on Earth during two hours that it is enough for the year-round energy needs of all humanity. Hot water heaters can save 10-15% of energy consumption and a solar heating system can create 45% energy savings in buildings (China wind power and solar photovoltaic industry association).

Passive solar energy technology is applied in houses and for ventilation. A passive solar house requires the rationality of the interior and exterior so that the position of the building is chosen, materials that will enable the collection of heat rays in cold periods or in the mountains. These passive houses are usually built, cheap, adaptable to life but with larger temperature changes. Solar ventilation technology uses hot air pressure to increase the effect of solar radiation so that internal ventilation grows and refreshes, cools and removes gases (Shule Wei, 2018).

Solar water heating technology is an energy saving system by converting solar rays through a collector, storage device and pipe, whose air collector is placed on the roof.

1.2 Biomass in buildings

Although biomass is a renewable energy source, it can produce a lot of energy, heat but also produce harmful gases in the environment. By building high chimneys, it is possible to reduce suspended particles, but the central heating systems must be technologically improved by installing filters and purifiers. In addition to the environment in which trees are planted, it can create a comfortable space near buildings, protecting them from the heat during the summer months. The installation of natural materials in buildings is a trend that the architectural profession returns and integrates into the space, by introducing partition walls in the rooms for easier fluctuation of air and heat, and it can also have a pleasant sound effect.

1.3 Wind energy and buildings

Primitive forms of wind use existed in China or Japan, so that windmills began to work in Europe only in the 12th century. Wind energy is quite expensive for individual needs, and the biggest drawback is insufficient efficiency and installation.

The use of wind energy is possible with the systematic monitoring of the atlas with the characteristics, wind speed, height at which it has a satisfactory strength, wind intensity and pressure. It is desirable that wind farms be located where the average wind speed is higher than 4.5 m / s. Wind power changes over time, and forecasting is acceptable in a longer time interval where there is a balance of electricity produced and consumed. The most common problem is that the regulations for planning and construction on facilities are not sufficiently developed, so independent installation of wind turbines is not recommended due to low power, only in combination with other sources, and in a windy place.

1.4 Hydropower and buildings

Large hydroelectric power plants are buildings that change the natural features, animal habitats, populated areas and reduce the navigability of rivers due to dams. Particularly interesting types of hydroelectric screens are small HPPs, which can destroy mountainrivers and fish stocks, tourist sites and the agrarian existence of households. In the case of buildings, hydropower can be interesting at the time of the influx of torrential rivers, floods in order to use mechanical energy to pump out excess water, generate electricity or reheat or dry buildings through heat pumps.

1.5 Geothermal energy in buildings

In the interior of the Earth, there is heat that is concentrated in the core, and which is heated by constant movement and cracking of the rocks. The energy generated through the various spheres of decomposition, transmission and transmission in the depths of our planet represents geothermal energy.

Hot water can be used directly to heat houses and greenhouses, and the island is a good example of that. Indirectly, geothermal water and steam can drive a generator motor to produce electricity, but the temperature must be above 100 degrees Celsius. Hydrogeothermal resources can currently be used up to a depth of 3 km, and in households they can be installed through heat pumps arranged horizontally and vertically. Horizontally immersed rods have a variable ratio to the outside temperature, while vertical ones are characteristic of narrower areas with a constant temperature due to the depth. For housing needs in individual and collective residential buildings, geothermal energy requires large initial costs of investment in installations with which comes a fixed cost in the form of a heat pump that heats the buildings with electricity (Dragović, 2015).

Surface water in the form of rivers, lakes and rainwater near buildings can drain into the depths and be a source of supply for heat pumps. This exchanges surface water temperatures with groundwater in the rocks, so the system is not expensive, but you should take care of problems with corrosion and freezing during the winter. Groundwater heat pumps have a direct and indirect system, and are characterized by significant savings.

1.6 Biofuels in facilities

Biofuels are in a fluid state and the most well-known form is bio-oil, ie biodiesel and pure vegetable oil, while there is also bioalcohol as ethanol fuel. Biodiesel fuel can be used with minor processing in diesel engines that are primarily designed to run on vegetable oil. Natural plant material, such as corn stalk or sugar beet, is specially grown to produce ethanol to supply internal combustion engines and all of this can be applied in rural areas where there are crops.

Biogas occurs by the decomposition of organic waste generated in a landfill or in a wastewater treatment plant. The entire production of this fuel is accumulated from residues after the production of sugar (cane, coleseed), paper and cardboard, animal residues (dung) and fecal waste.

In order for biofuels to be used in buildings as a heat source for heating water and rooms, filtration devices must be installed, and it is important not to install them in the basement of buildings because there is high humidity and accelerated corrosion of equipment, which means that biofuels are not an adequate choice for buildings in urban areas, and is ideal for RES for rural facilities.

2 Building - comparative analysis in the world and Serbia

Building could be defined as a space intended for a shorter or longer stay, where non-industrial services, cultural and sports events, education, etc. are performed. As an energy sector, it is composed of a large number of small consumers, who use about 40% of primary energy worldwide. Energy consumption in buildings in Serbia (public and private sector) in final energy consumption is 36%, which is more than industry and transport alone. Electricity consumption in buildings is about 60%

With the adoption of the National Strategy for Sustainable Development of the Republic of Serbia in 2008, with the Action Plan for Implementation, energy efficiency was identified as a priority measure to adopt the First National Plan for Energy Efficiency in 2010 and since then Serbia has been working intensively on implementing energy efficiency. 2010/31/ EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (Manual for the energy certification of buildings, 2017).

According to the consumption sectors, most final energy was consumed in the household sector - 36%, followed by industry - 29%, then in the transport sector - 23%, while other sectors participated with 12%. Of the energy sources, final energy consumption is dominated by oil with 30% and electricity with 28%, followed by coal with 8%, natural gas with 12%, thermal energy with 9%, while renewable energy sources (firewood) participate with 13% (Ministry of Mining and Energy, 2015).

The greatest potential for energy savings is related to the improvement of thermal protection of buildings, in order to reduce heat losses. In the housing sector, most of the construction stock was built more than 30 years ago. The average consumption of thermal energy, which is around 170 kWh / m^2, compared to 70-130 kWh / m^2 in Western European countries (Šumarac et al., 2010).

At the EU level, about 2/3 of consumption in buildings is realized in residential buildings (Institute for European Environment Policy, 2015). In Serbia, about 45% of total energy consumption is realized in households and in the public and commercial sector (based on the Energy Balance of the Republic of Serbia, 2016).

There are over 2.2 million housing units in Serbia, with a total floor area of 290 million m2. It is estimated that they consume 65 million MWh of heating energy annually, while the average consumption of heating energy is 224 kWh / m2 per year, which is far higher than the EU average. The average consumption in residential buildings in the European Union is 138 kWh / m2, Denmark 96 kWh / m2, Poland 90-120 kWh / m2. Average old houses consume 200 -300 kWh / m2 of heating energy per year, standard insulated houses under 100, modern low-energy houses about 40, and passive 15 kWh / m2 and less (Manual for energy certification of buildings, 2017).

The ways of heating buildings in Serbia are as follows: 26% of the total area is heated from district heating systems and local boiler rooms with central heating (14% from district systems and 12% from local boiler rooms), 14% from the electricity system, 10% from the natural gas system and 50% of the total area uses solid fuels in local furnaces (coal, firewood, agricultural biomass, waste, etc.).

3 Construction and adaptation of buildings

The construction and adaptation of residential buildings has the greatest potential for development, primarily when the recommendations of construction experts and the scientific preferences they bring through energy strategies are taken into account. Energy savings have been identified as the most important area because over two-thirds of the energy invested is lost through outdated installations, lack of insulation and energy inefficiency.

There are many plans for energy savings, which focus on thermal amenities in buildings, such as walls, floors, doors or windows (Marszal, Heiselberg, Bourrelle, Musall, Voss, Sartori, & Napolitano, 2011). Passive and active energy saving strategies achieved in heating, cooling and lighting come into consideration (Sadineni, Madala, & Boehm, 2011). One of the important decisions in building is the orientation of the building in relation to energy consumption, due to thermal amenities, ventilation and lighting. In the room simulation, the energy consumption of the north-south facades is close to the east-west by close to 10%, with a reduced annual consumption of 13% (Ashmawy&Azmy, 2018).

Sustainable green buildings have several advantages such as 26% lower energy consumption, 13% lower cumulative maintenance costs, 27% higher customer satisfaction and as much as 33% lower CO2 emissions (GSA Public Buildings Service, 2008).

A proposal for an architectural system and optimization algorithm called Green Charge can efficiently manage renewable energy and storage to reduce electricity bills (Sawant&Patil, 2017). This system supports a smart server that monitors electricity prices over the Internet, household consumption, the inclusion of renewable sources and the sensor status of battery charging. Special mention should be made of auxiliary software for modeling energy efficient buildings such as Design Builder, insight 360, TRNSYS, Skellion.

Serbia has adopted regulations, typology of residential buildings and trained experts to introduce the Central Register of Energy Passports (CREP), which is available online with data on energy certification of buildings, location and licensed contractors. All new facilities, which are currently being reconstructed or energy rehabilitated, must have an energy passport according to the law on construction, and energy efficiency has been introduced as a public interest where municipalities will be able to allocate funds for which housing communities will apply.

Most residential buildings in Serbia have inadequate thermal insulation (windows, doors) and excessive heating installations (boilers, heating stations). The recommendation for building owners is to put a good thermal insulation layer on the facade, to insulate the roof (with mineral stone wool), to replace damaged windows and put insulating strips on doors and windows, to remove double panes or to install thicker or triple glazing. The benefits of investing in energy efficiency are that electricity expenditures will be reduced, internal temperatures will rise and the value of the facility will increase.

3.1 Integration of renewable energy sources in buildings

The buildings are used for residential, service, production needs and combined purposes, so it is recommended that the construction of new facilities be in accordance with regulations, using technological solutions in construction, the use of materials that contribute to energy savings, moderate heating and easy maintenance. The essence is to find materials at the construction site that will not disturb the ambience, and which will contribute to light being available during the day in work spaces, not rooms, and for geothermal energy to be conducted to the place where it is necessary during cold periods.

It is very difficult to integrate all renewable energy sources in the same facility, and apart from the lack of funding for such a project, the problem may be the lack of wind, light, water, biomass, biofuels, while geothermal energy is not in question. A complete system would include quality installation in an individual power supply system (solar cells, wind generators, mini-hydropower plants) and a thermal profile (solar panels, biofuels and geothermal heat pumps).

Figure 2 shows a model that enables a combined supply of thermal and electricity from renewable sources for homes, businesses and public institutions (schools, health facilities, buildings of local and state authorities).

Most often, integration is carried out in business buildings, in facilities for health care and education, as an example that should be followed by others, but without the help of the state or local communities, that investment is impossible. Increasingly, this concept is said to integrate renewable energy and the IT sector into smart homes or facilities, making it the term smart cities, which are managed remotely over the Internet.

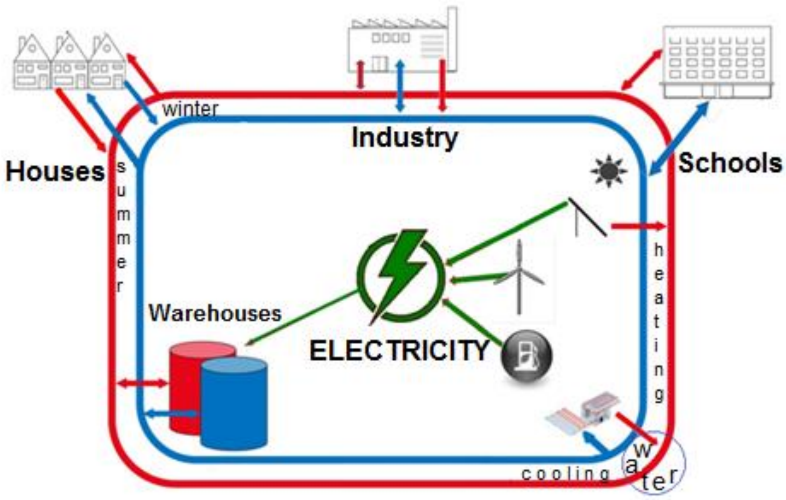

Figure 2. Combined model of thermal and electric power supply

4 Green construction and energy efficiency of buildings

Green construction supports the use of materials from the environment (stone, wood) with integration with the space so that it rests on rocks or land, which fits into the proctor.

Directive 2002/91 / EC of the European Parliament and of the Council on the energy performance of buildings, which aims to promote improvements in the energy performance of buildings within the community, lays down a set of requirements for the energy performance of buildings, including energy certification of buildings.

Table1. Energy efficiency classes of buildings (http://ec.europa.eu/environment/index_en.htm)

Classes	*Heating Indicator [kWh/m^{2}year]*	*Energy efficiency level*
A	0-30	BEST ENERGY EFFICIENCY
B	31-50	HIGH ENERGY EFFICIENCY
C	51-70	ENERGY EFFICIENT BUILDING
D	71-120	AVERAGE ENERGY EFFICIENT BUILDING
E	121-160	UNSATISFACTORY ENERGY EFFICIENCY
F	161-200	VERY ENERGY EFFICIENT BUILDING
G	201+	COMPLETELY ENERGY EFFICIENT BUILDING

Energy efficiency of buildings can be implemented in several ways individually or in combination, starting from the most available:

- Replacement of light bulbs in households, industry, public institutions,
- Switching from heating to electricity,
- Improving building insulation
- Window and door replacement,
- Electronic energy management,
- Application of construction standards,
- Change of heating consumption calculation (from lump sum to consumption).

Introduction of energy efficiency certification of the building (a prerequisite for a building permit, and old ones for a better price).

5 RES application model in buildings

The building must have several levels of savings and sustainability, such as:

- Sustainability of building materials (construction, interior, roof),
- Sustainable construction environment (adapted to the site, without landslides),
- Good ventilation and ventilation (windows, solar lighting and fan),
- Efficient heating and cooling (panels, cells, heat pumps, water),
- Savings (insulation, facade, solar roof-no tile).

The materials from which the building is built or renovated must meet quality standards, crack resistance and serve as noise insulation, retain heat and be waterproof. It is important to make a quality selection of insulation materials and install double insulation on the corners of the building, while the floor and ceiling insulation with mineral and stone wool is necessary. The airiness of the building is important because of the daylight in the rooms, but also because of the evening needs for light that is accepted from the solar panels that can be fixed on the roof. Windows and doors are sealed, which contributes to reducing heat loss, while increasing daylight and indirectly heating the space. Heating of the building is possible with solar collectors that heat water for hygiene, as well as through heat pumps that heat the building. Ventilation is done to let in fresh air, and warm air can circulate and heat up.

The model of integration of some of the RES in buildings can be called hybrid energy of buildings: solar-wind-electricity system; solar-wind-battery, solar-wind-biogas-hydrogenerator; solar-wind generator-rain and groundwater. In order for the process of integration of RES and the building to be successful, there must be an architectural design of the building, energy design, structural design, IT design and evaluation of the introduction of innovations.

Architectural scheme involves site selection and fitting design. When choosing a position, it is important to match the appearance of the building with the space that will be next to the energy source, dimensions and spatial features with software simulations when choosing solar collectors, wind turbines on the location or size of rooms and windows, tree positions and daylight, nesting or close to water tank. The fitting design requires integration with the building material, entrance or functionality of the building, such as the roof, wall or balcony,roofintegration is a choice in which solar panels are placed aesthetically above the tile, as a mobile or fixed part, or instead of the tile itself, where good roof ventilation is important, integration with the wall is a large space in which there is the possibility of painting in a darker color for indirect heating or placing panels on the wall, integration with elements such as balcony, window is important if greenery is added or reflective glass is installed.

Energy design is an important part of new buildings and includes software, equipment selection, consumption determination, space estimation, heat source selection based on input data. Construction design is based on materials, size and needs to meet space and cost goals in order to integrate hallways, staircases or balconies with RES. Information design is a structure that includes the installation of programs for the operation of machines, RES that starts working at a given moment, saving energy and electricity. Assessing the introduction of innovations in a building is a process that includes repaying investments, saving on RES, reducing pollution, and assessing working and maintenance conditions.

6 Conclusions

The building sector is large, and the savings that can be achieved by using renewable energy sources are multiple, because they are free energy sources, economical and environmentally friendly. Energy efficiency enables individuals who have realized the benefits of responsible use of energy in the form of renewable sources (biomass, solar energy, wind energy, geothermal energy, etc.) to see savings in payment and rationally control costs because they decided to solve the long-term energy stability of their construction object.

Buildings that consume less energy have a sustainable pleasant temperature, programmed lighting and the ability to easily switch from one renewable energy source to another and all with the concept of a smart building. If an efficiently insulated building consumes less energy in winter for heating and in summer for cooling, the stay is of better quality, and the long-term use value is higher.

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