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RESOURCE- AND ENERGY- SAVING TECHNOLOGIES FOR THE PRODUCTION OF BUILDING MATERIALS AND STRUCTURES

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Relevance of research. Spread in the field of construction methods of economical use of heat and energy resources, to prevent damage to the environment and save money. Since the construction industry is one of the largest consumers of energy and natural resources, it is necessary to find innovative solutions to reduce its impact on the environment. To spread the development of energy-efficient buildings.

Review of prior studies. The operations of buildings account for 30% of global final energy consumption and 26% of global energy-related emissions [1] (8% being direct emissions in buildings and 18% indirect emissions from the production of electricity and heat used in buildings). Direct emissions from the buildings sector decreased in 2022 compared to the year before, despite extreme temperatures driving up heating-related emissions in certain regions. In 2022, buildings sector energy use increased by around 1%.

Minimum performance standards and building energy codes are increasing in scope and stringency across countries, and the use of efficient and renewable buildings technologies is accelerating. Yet the sector needs more rapid changes to get on track with the Net Zero Emissions by 2050 (NZE) Scenario. This decade is crucial for implementing the measures required to achieve the targets of all new buildings and 20% of the existing building stock being zero-carbon-ready [2] by 2030.

1 Energy sector CO2 emissions include emissions from energy combustion and industrial processes.

2 Zero-carbon-ready buildings are highly energy-efficient and resilient buildings that either use renewable energy directly, or rely on a source of energy supply that can be fully decarbonised, such as electricity or district energy. The zero-carbon-ready concept include both operational and embodied emissions.

Results. There are a number of innovative technologies that can help to reduce this impact. Here are a few examples:

1. Recycled and reused materials:

• Recycled concrete: Concrete is one of the most commonly used building materials, but its production is energy-intensive. Recycled concrete - mixture, made from crushed concrete debris, can be used as a substitute for virgin gravel in new concrete mixes, reducing the need for quarrying and processing new materials.

Construction contractors and customers alike, look for affordability and strength above all else. A world of difference can be seen in both these factors when the right concrete aggregate is utilized. One viable aggregate that comes in multiple sizes and scales is hardened concrete.

As buildings, roads, bridges, and other structures are demolished every year, hundreds of thousands of tons of debris is generated. As the world moves towards saving the environment, and governments offer tax rebates to those investing in fuel-efficient technologies in an effort to reduce their carbon footprint; recycling this debris is the perfect way for any contractor to save the environment and their expenses, all while ensuring strength in the foundation of their new structures.

Reclaimed wood: Wood can be salvaged from demolition projects or sustainably harvested forests and used for flooring, paneling, and other structural elements.

Environmental benefits:

Using reclaimed wood reduces the demand for new lumber, which helps to conserve forests.

It also helps to reduce landfill waste, as it diverts wood from being thrown away.

Reclaimed wood often has a lower embodied energy than new lumber, as it has already been processed and transported once.

Bio-based materials: Materials like bamboo, straw, and mycelium can be used as sustainable alternatives to traditional building materials. These materials often have lower embodied energy and can grow quickly.

As a lightweight local material, using bamboo minimizes the environmental costs of harvesting and transportation. Bamboo also sequesters carbon both as it grows and after harvest, making it potentially carbon-negative.

Bamboo’s renewability credentials far exceed timber. It can be harvested within three to five years of planting, as opposed to the decades’ timber requires. It regrows without needing to be replanted, which provides additional environmental benefits. Its large root network also protects against soil erosion and landslides.

Of course, none of this matters if bamboo’s mechanical properties can’t bear structural loads. A growing body of research shows that certain bamboo species have impressive and efficient mechanical properties, including possessing a strength-to-

weight ratio equal or better than that of steel and lumber. Certain bamboos also have the compressive strength of concrete.

• Salvaged steel: Steel is another durable and versatile material that can be recycled and reused in construction. Salvaged steel beams, columns, and other components can be incorporated into new structures.

2. Renewable energy sources:

• Solar panels: Solar panels can be installed on rooftops or integrated into building facades to generate electricity for on-site use. This can reduce reliance on traditional grid-based power, which often comes from fossil fuels.

• Geothermal energy: Geothermal energy systems use the Earth's natural heat to provide heating and cooling for buildings. This can be a very efficient and sustainable way to manage indoor climate. 3. Energy-efficient construction methods:

• Prefabrication: Prefabricating building components off-site can reduce waste and improve energy efficiency. Prefabricated walls, floors, and roofs can be assembled quickly and accurately on-site, minimizing construction time and energy use.

Modular construction creates less waste and requires little space. By fabricating building components in a controlled environment, projects are less prone to delays and come with an additional benefit—workers have safe, comfortable conditions in which they can be more productive, leading to higher-quality products.

Passive design: Passive design principles, such as natural ventilation and daylighting, can help to reduce reliance on mechanical heating and cooling systems. Strategically placed windows, overhangs, and thermal insulation can create comfortable indoor temperatures without the need for excessive energy consumption.

Green materials are a vital component of energy-efficient construction, offering numerous benefits, including reduced environmental impact, reduced waste, and improved indoor air quality. By encouraging the use of environmentally friendly materials, governments can increase market competitiveness, save money, and promote technological innovation in the construction industry.

The introduction of sustainable materials must be accompanied by supportive public policies such as tax incentives, regulations, and public procurement strategies. Stakeholders in the construction sector must collaborate and prioritize the integration of sustainable materials to promote a greener and more sustainable future.

Objectives. The purpose of this work is to analyze data on the level of global greenhouse gas emissions for the main sectors of the economy of the European Union countries. In addition, based on quantitative analysis data, a predictive study of emission levels for each sector separately will be conducted.

Results. Based on statistical data presented in work (3), dependencies of the level of global greenhouse emissions in the countries of the European Union were constructed separately for the following sectors of the economy: agriculture (index A), fuel exploitation (index F), transport (index T), buildings (index B), industrial combustion and processes (index I) and power industry (index P). The observation interval was $\Delta t \subset (1970 \div 2022)$.

The annual distribution of global emissions Gt CO_{2eq} in individual sectors (A, F, T, B, I and P) of the economy is presented in the diagram (Figure 1).

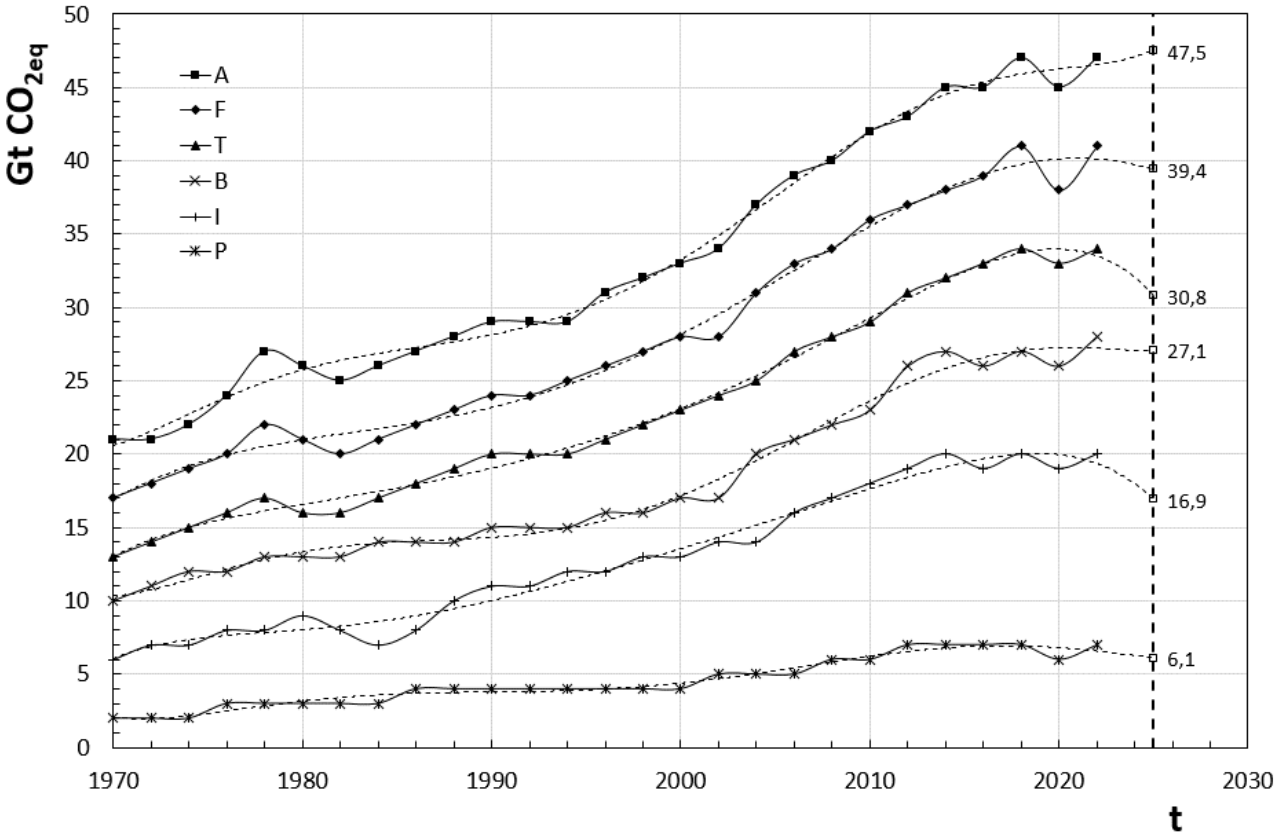

Figure 1. Global GHG emissions by sectors: A (Agriculture), F (Fuel Exploitation), T (Transport), B (Buildings), I (Industrial Combustion and Processes) and P (Power Industry)

The obtained dependencies (with the exception for P curve) were approximately equidistant for the interval (1970 - 2018). The maximum greenhouse gas emissions were recorded for the agricultural sector. For each sectoral dependence, trend curves were constructed with a forward shift of three periods. The generalized matrix equation for trend curves can be represented as

$$GtCO_{2eq_j} = \alpha_j^{(k)} t^{k-1}; \qquad j = A,F,T,B,I,P; \;\; k = 1,...,7 \tag{1}$$

where t is the registration time (years) and $\alpha_j^{(k)}$ are the matrix coefficients

$$\alpha_j^{(k)} = \begin{pmatrix} 3\cdot10^{12} & -8\cdot10^{9} & 1\cdot10^{7} & 6{,}5\cdot10^{3} & 2{,}4 & -5\cdot10^{-4} & 4\cdot10^{-8} \\ 4\cdot10^{11} & -1\cdot10^{9} & 1\cdot10^{6} & -9{,}3\cdot10^{2} & 3{,}5\cdot10^{-1} & -7\cdot10^{-5} & 6\cdot10^{-9} \\ -8\cdot10^{11} & 3\cdot10^{9} & -3\cdot10^{6} & 2{,}1\cdot10^{3} & -7{,}9\cdot10^{-1} & 2\cdot10^{-4} & -1\cdot10^{-8} \\ 2\cdot10^{12} & -6\cdot10^{9} & 7\cdot10^{6} & -4{,}7\cdot10^{3} & 1{,}7 & -4\cdot10^{-4} & 3\cdot10^{-8} \\ -1\cdot10^{12} & 3\cdot10^{9} & -4\cdot10^{6} & 2{,}7\cdot10^{3} & -1 & 2\cdot10^{-4} & -2\cdot10^{-8} \\ 9\cdot10^{11} & -3\cdot10^{9} & 3\cdot10^{6} & -2{,}3\cdot10^{3} & 8{,}7\cdot10^{-1} & -2\cdot10^{-4} & 1\cdot10^{-8} \end{pmatrix} \quad (2)$$

The approximation reliability value is in the range: $R^2 \subset (0{,}96 \div 0{,}99)$.

Analysis of trend dependencies indicates a violation of equidistance for the T (transport) and I (industrial combustion and processes) sectors ($t' \sim 2025$).

Conclusions. Statistical data on the level of global greenhouse gas emissions make it possible to construct annual dependencies for individual sectors of the economy in the European Union countries. The functional behavior of the emission level for all sectors of the economy can be quite accurately described by a 6th order polynomial. The functional difference for the interval (2018-2022) causes a violation of the equidistance of the curves for a shift forward by three periods.

Анотація

У роботі наведені способи мінімізації використання тепло та енергоресурсів у будівництві. Методи заощадження будівельних матеріалів шляхом використання природніх ресурсів. Проведено статистичний аналіз даних викиду парникових газів у різних сферах людської діяльності країнами Європейського Союзу за 1970-2022 роки. Показано динаміку росту рівня викидів з плином часу.

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