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CBC SMART ENERGY CONCEPT IN THE CARPATHIAN REGION: "ECO-SMART ENERGY – CARPATHIA"

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Joint Concept of Smart Energy in the Carpathian Region "Eco-Smart Energy - Carpathia": Scientific and practical development carried out within the framework of the "New Energy Solutions in Carpathian area (NESiCA)" project developed under the Hungary-Slovakia-Romania-Ukraine ENI CBC Programme: prepared and edited by Oleh Luksha - Uzhhorod National University. – Uzhhorod, 2023. - 98 p. (with attachments in electronic format).

On the basis of the proposed system optimization method for the analysis of smart sustainable energy (SOMARCE) and other methodological approaches, taking into account the similarity of the natural-geographical, ecological and resource-energy characteristics of the integral European Carpathian region and the commonality of global value orientations of the active participation of European countries and their regions in the accelerated implementation of the Green Energy Transition, the conceptual foundations, the action algorithm and the list of tasks for the period up to 2027-2030 for key groups of stakeholders of the target border territories of Ukraine, Romania, Hungary, Slovakia and Poland (in particular, for territorial communities and regional authorities; development and innovation-implementing organizations; universities and scientific institutions; businesses and cluster formations, etc.) have been substantiated and developed.

The achievement of the goal and successful implementation of each of the 8 tasks of the Concept are proposed to be evaluated in the monitoring process according to the 5 criteria of the European strategic document: relevance (compliance); effectiveness; efficiency; influence; sustainability.

The core ideas of the Concept are the exceptional relevance and necessity of adopting management, urban planning and permitting decisions, as well as implementation of energy facilities based on renewable energy sources (RES) in projects in the integral Cross-border Carpathian region, taking into account 2 groups of challenges and threats:

1) ecological and environmental risks and threats to the unique mountain nature and ecosystems of the Carpathians, which should be minimized;

2) radical and systemic global changes in all areas of world politics, including energy and energy security that occurred in 2022 and were caused by Russia's full-scale aggressive war against Ukraine; the latter brings to the fore, at least in the Ukrainian Carpathian region, the implementation of technical solutions of distributed generation in the processes of implementing energy facilities based on RES.

Based on the work of the Concept, it is proposed to develop a Strategy for the development of smart energy in the European Carpathian region until 2030 and a Plan of measures for its implementation in 2024-2027, which requires additional international consultations, national working groups and a corresponding grant project.

The joint Concept of smart energy in the Carpathian region, "Eco-Smart Energy - Carpathia", was developed with the participation and collaboration of the creative works of the International Consortium of "New Energy Solutions in Carpathian Area - NESiCA" Project Partners:

- State University "Uzhhorod National University", Ukraine, represented by vice-rector Oleksandr Yanovych Rohach (Project manager)
- NGO European Initiatives Centre, Uzhhorod, Ukraine, represented by Nataliya Nosa-Pylypenko, Head of the Board
- Self-Government of Szabolcs-Szatmár-Bereg County, Nyíregyháza, Hungary, represented by Brigitta László
- University of Nyíregyháza, Hungary, represented by Dr. Zoltán Kovács vice-rector (energy expert), Dr. Péter Tarján (energy expert), Dr. József Barnabás Tóth (energy expert)
- Ștefan cel Mare University of Suceava, Romania, represented by Constantin Ungureanu (Project manager) and Radu Dumitru Pentiuc (Energetic researcher)
- Technical University of Košice, Slovakia, represented by Mária Gamcová (Project manager)

The scientific and expert community of civil society organizations in Ukraine (Zakarpattia region) was actively involved in providing informational, organizational, and methodological support in developing the concept and participating in project activities:

- International Institute of Human and Global Studies "Noosphere" (Head of the Board Oleh Luksha)
- NGO "Ecosphere" (Lead Ecology Expert Oksana Stankevych-Volosianchuk and Director Kateryna Stankevych-Koval)
- International Association of Regional Development Institutions - IARDI (Executive Director Nataliya Nosa-Pylypenko)
- Association of Project Managers "Yadro" (Head of the Board Yevhenii Luksha)
- Centre for Ukrainian-Slovak Crossborder Cooperation "Carpathians" (Head of the Board Vadym Pylypenko)
- Zakarpattia Regional Branch of the Association of Cities of Ukraine (Deputy Executive Director Iryna Chervinska-Kovach)
- Centre for Scientific Research of the Western Region of the National Institute for Strategic Studies (Head Volodymyr Khymynets).

Translators: Andrii Shytiev, Alina Nosa, Kateryna Putrashyk

TABLE OF CONTENTS:

GLOSSARY

Energy is a general quantitative measure of motion and interaction of all kinds of matter (from the Greek word energia - action, activity). The concept of Energy connects all phenomena of the nature. In accordance with different forms of motion of matter different forms of Energy are considered: mechanical, internal, electromagnetic, nuclear, chemical, etc. Energy does not arise from nothing and does not disappear, it can only pass from one form to another (Energy Conservation Law). It is measured in Joules (J). Energy flow and power is measured in watt (W).

Heat is a form of disordered (thermal) motion of particles of matter (molecules, atoms, electrons, etc.). Along with work, the amount of heat is a measure of changes in the internal energy of the physical system. The amount of heat, as well as work and energy, is measured in Joules (J).

Thermal radiation refers to electromagnetic radiation emitted (by a physical body), and which arises due to changes in its internal energy. Thermal radiation has a continuous spectrum, the position of the maximum of which depends on the temperature of the substance (physical body). Thermal radiation in the invisible to the human eye infrared range of the spectrum (with a wavelength greater than 0.8 μm) is visualised using devices, such as thermal imagers or night vision devices.

Heat transfer is a spontaneous irreversible process of heat transfer caused by a temperature gradient.

Thermal conductivity is one of the types of heat transfer from hotter parts of the body to the less hot ones, which leads to temperature equalisation. With thermal conductivity, energy transfer is carried out as a result of direct energy transfer from particles (molecules, atoms, electrons) with higher energy to particles with lower energy. The thermal conductivity coefficient λ of a substance does not depend on the temperature gradient, but is determined by the physical state of the substance, its atomic and molecular structure, temperature, pressure, chemical composition, etc. Thermal conductivity (thermal conductivity coefficient) λ is measured in W/mK.

Renewable energy sources (RES) are types of constantly present in nature and renewable energy sources: wind air flows (wind energy); streams of solar radiation (solar energy); heat flows in the near-surface layers of soil and in underground heated water bodies (geothermal energy); in mobile surface watercourses (hydropower); in the formation of gases in biological and biochemical processes (biogas energy); energy obtained from biomass combustion (forest shrubs and/or specially grown plants and crop waste).

"Passive" house is a building with low energy needs (maximum 15 kWh/m² during the year), which allows to abandon the traditional heating and cooling systems (air conditioning).

Zero-energy house is a building in which heating, air conditioning and heating of water for domestic use is a combination of passive use of solar energy on the roof and exterior walls and subsurface energy of the earth.

ESCO (Energy Service Company): provides comprehensive professional services to enterprises, organisations, institutions and individuals for energy audits of buildings, consulting and implementation of energy saving measures and energy efficiency of buildings and technological processes, etc.

LIST OF COMMON ABBREVIATIONS AND ACRONYMS IN UKRAINE IN THE FIELD OF ENERGY AND ENERGY SAVING

NPP – Nuclear Power Plant
AIC – Agro-Industrial Complex
GDP – Gross Domestic Product
RES – Renewable Energy Sources
SER – Secondary Energy Resources
WPP – Wind Power Plant
VAWT – Vertical Axis Wind Turbine
GNP – Gross National Product
HAPP – Hydroaccumulating Power Plant
HEPP – Hydroelectric Power Plant
SHEPP – Small Hydroelectric Power Plant
GPU – Gas Pumping Unit
DPI – Distribution Point Identifier
GDS – Gas Distribution Station
GTPP – Geothermal Power Plant
GTS – Gas Turbine Station
GTI – Gas Turbine Installation
EPC – Energy Performance Contracting
ESCO – Energy Service Company
EU – European Union
ESEC – Eco-Smart Energy-Carpathia - Concept of Smart Energy in the Carpathian region
CES – Combined Power System
CSESP – Comprehensive State Energy Saving Programme
COP – Coefficient of Performance
NEP – New Energy Paradigm
ARES – Alternative and Renewable Energy Sources
GHG – Greenhouse Gases
SGI – Steam and Gas Installation
FEC – Fuel and Energy Complex
FER – Fuel and Energy Resources
PE – Power Electronics
SPI – Solar Power Installation
SPP – Solar Power Plant
TES – Traditional Energy Sources
TEI – Technical and Economic Indicators
TPP – Thermal Power Plant
TPS – Thermal Power Station
CBC – Cross-Border Cooperation
HPI – Heat Pump Installation
toe – tonne of oil equivalent

INTRODUCTION

The Joint Concept of Smart Energy in the target border regions **"Eco-Smart Energy - Carpathia"** has been developed to contribute to the achievement of the specific objective 2 of the NESiCA project, namely:

Raising awareness, competence and skills of the population in border regions on global reductions in greenhouse gas emissions, and opportunities for the use of renewable energy sources (hereinafter RES).

At the same time, the **"Eco-Smart Energy - Carpathia"** Concept is also designed to promote the synergetic effect in achieving several other specific objectives of the NESiCA Project:

– ensuring strategic transition to energy efficiency and RES in border regions;
– increasing current low energy efficiency in the target border regions and communities by undertaking joint measures.

In the NESiCA project, the partners are universities and NGOs of four countries of the Carpathian macro-region:

– Ukraine: Uzhhorod National University and NGO Center for European Initiatives (Uzhhorod, Zakarpattia region);

– Hungary: University of Nyíregyháza (Nyíregyháza, Szabolcs-Szatmár-Bereg county);
- Self-Government of Szabolcs-Szatmar-Bereg County.

– Slovakia: Košice Technical University (Košice, Košice self-government region);

– Romania: Ștefan cel Mare University (Suceava, Suceava County)**.**

The development of smart energy approaches in the framework of the Project HUSKROUA/1702/6.1/0014 "New Energy Solutions in Carpathian area" developed under the ENI CBC EU Programme is certainly important for the entire Carpathian macro-region on the European continent. This is due to the territorial impact of the **new energy paradigm (NEP) in Europe and its components, namely energy conservation and energy security, energy efficiency of the economy and services, a new geography of energy systems and energy supply.** In particular, the emergence of NEP in Europe over the past 10-12 years was caused by the following factors:

a) significant increase in energy prices due to a persistent imbalance between supply and demand in the global dimension;

b) environmentalization of energy strategies of many European countries, including those that relate to significant reduction of shares or even waiver of energy contributions from nuclear power plants (NPPs) as energy generating capacities in the energy balance;

c) development and improvement of technologies of electric power capacities of RES, including through the tools of "energy democracy";

d) implementation of energy saving, energy monitoring and energy efficiency measures at each of the three stages of the energy cycle, namely: energy generation, energy transportation and energy consumption;

e) more rational and energy efficient use of traditional energy sources (TES) such as: oil and petroleum products; coal; gas; wood; wastes of agro-industrial production, etc.;

f) changes in urban transport systems, including the improvement of public and private transport routes; new approaches and modernisation of urban mobility infrastructure; support for the introduction of electric vehicles and non-motorised modes of transport, etc.;

g) technological and energy-saving improvements of street lighting and traffic light control systems;

h) introduction of diversified energy supply systems in Europe given the complexity of geopolitical relations between Western democracies and autocratic regimes in Eurasia, in particular with the Russian Federation;

i) the ongoing global economic, financial, transport, communication and social crisis in the vast majority of countries around the world, caused by the protracted impact and consequences of the COVID-19 coronavirus pandemic;

j) increasing manifestations of global climate change with the growing need to adapt to its consequences, which also largely affects the energy capacity of cities and communities, mostly in the energy sector and the housing and economy sectors.

The content of the "Eco-Smart Energy – Carpathia" Concept reflects the sequence in which smart energy solutions for cooperating territorial communities on the border of the target Carpathian region are proposed and substantiated using system analysis and approaches. And the generalisation of the developed solutions is given in the conclusions and recommendations of the "Eco-Smart Energy – Carpathia" Concept.

CHAPTER I.

SUMMARY OF THE JOINT CONCEPT OF CBC SMART ENERGY IN THE CARPATHIAN REGION . "ECO-SMART ENERGY - CARPATHIA"

I.1. *Problems to be solved*

One of the most important and urgent problems of the global development of the world community is the need for rapid change in approaches to energy policy in each country and each of the geographical macro-regions, regions, cities and rural settlements. The humanity and the governments of most developed countries need to face the following task: the transition from the outdated models of the energy sector, which is dominated by large producers of energy, fossil fuels (such as coal, oil, natural gas), inefficient energy networks functioning, deficient competitive energy market, to the new model. The radically changed new model creates a more competitive environment, equalises opportunities for development and minimises the dominance of one of the types of energy production, sources and methods of transportation (supply) of energy and energy resources. At the same time, there is an increasing preference for the use of energy from renewable and alternative energy sources (RES) from non-carbon-containing energy resources, as well as the increase of energy efficiency and reduction of energy consumption in technological production processes, housing and communal services. So, in fact, we are talking about a paradigm shift in the energy development of mankind.

The inevitability of the introduction of the new energy model is due to the urgent need for an accelerated transition to measures in order to prevent and adapt to climate changes (global warming). That is why, the new model is becoming one of the priorities of global energy development.

In the broader context, energy transition is the country's transition to sustainable economies through the introduction of renewable energy, energy efficiency and sustainable development of communities and areas (cities, towns, villages, and regions). The ultimate goal of the energy transition is the refusal to use coal and other non-renewable energy sources which when burned produce huge amounts of carbon dioxide CO2, the accumulation of which in the atmosphere as a "greenhouse gas" is one of the main mechanisms of global warming.

Often the realisation of this idea is called "Green Energy Transition". In general, RES include the usage of the following natural resources: wind, biomass, biogas (for example, landfill gas and wastewater gas), hydropower, solar energy (thermal and photovoltaic), geothermal energy, energy of sea waves and the ocean.

In our case, the target is a common, conditionally separated territory of the border regions of the Carpathian region of Ukraine, Romania, Hungary, and Slovakia. It should

be noted that this natural-geographical Ukrainian-Romanian-Hungarian-Slovak border area is part of the European Carpathian Mountains macroregion and it would be logical to immediately add to it the border areas of the neighbouring administrative-territorial unit of Poland, namely: Subcarpathian Voivodeship.

Thus, in addition to the general problem of global importance related to the need of undertaking coordinated measures and actions to implement the "Green Energy Transition" in the target natural-geographical border of 5 countries in the Carpathians, we identify **several other multilevel problems** as a way of ensuring the solution of the specified general problem:

1. Legal inconsistencies and differences between the participating countries in the legal framework for the implementation of energy policy, as well as technical assistance projects for RES (especially between Ukraine and the EU countries in the Carpathian region).

2. The need for constant and special consideration of environmental balance in the development of "Green Energy Transition" projects in the target border regions of the Carpathians. On the one hand, these regions have a unique complex of natural renewable energy resources (wind, hydropower, solar, hydrothermal, biomass, etc.), on the other hand, in accordance with the current international legal agreement (the so-called Carpathian Convention, ratified by all countries of the Carpathian macro-region), they have especially valuable natural resources for Europe and the world. That is why, the environment and ecosystems of the Carpathians are protected by both the Carpathian Convention and national environmental laws of 5 neighbouring Carpathian countries.

3. Lack of proper practices and experience of mutually coordinated and effective solutions of energy issues and in particular RES in the Carpathian macroregion.

I.2. *Value guidelines of the Joint Concept*

The common frame of reference of the Concept is as follows:

– establishing relationships under the scheme "global as a non-additive sum of processes and phenomena at the local (regional) level" for the new energy paradigm of mankind in terms of awareness and implementation of the new energy paradigm in the European Carpathian macroregion;

– establishing effective communication on issues related to energy and innovative energy solutions between interested and active public sectors (universities, local and national governments, business, startups, expert community and science, civil society organisations);

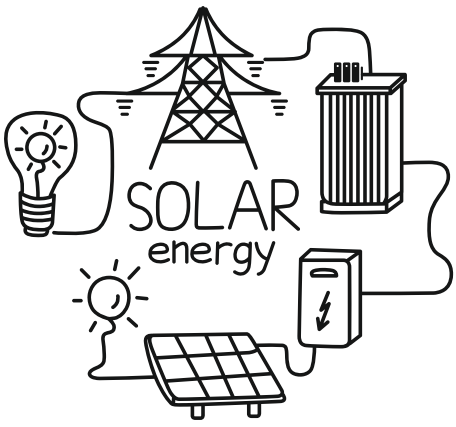
– stimulation of initiatives aimed at a systematic approach to the implementation of changes in the energy sector of the Carpathian macroregion while unconditionally ensuring the principles of sustainable (environmentally balanced) development;

– dissemination of successful and effective practices of "energy democracy" approaches and network institutions of innovative energy (in particular, hubs and clusters);

– initiating the wide implementation of the principles, approaches and content of the Concept in the strategic, programme and planning documents of the development of regions, cities, villages and communities of the cross-border Carpathian macro-region;

– creation of a methodological and conceptual platform for the initiation of research and development, formation of new and improvement of already existing educational and training programmes for professional training and development of officials of local councils in territorial communities;

– providing an ideological and innovative-technological basis for networks and associations of partnership and cooperation of local governments and civil society organisations in the field of sustainable energy development in the Carpathian macro-region.



I.3. *Purpose, basic principles, tasks and terms of realisation of the Joint Concept*

The **purpose** of the "Eco-Smart Energy - Carpathia" Concept is:

– to ensure comprehensive support on the ongoing basis for all target groups and interested parties (stakeholders) of the Carpathian region in achieving proper awareness, competence and professionalism in the development of methods, approaches and means of "smart" energy in the practical implementation of innovative and energy efficient solutions and projects in various life areas of the communities of towns and villages, as well as in the reduction of the greenhouse gas emissions, making local contributions to the implementation of the European Green Energy Transition tasks and solutions to global problems connected with the climate change caused by man-made anthropogenic human activities;

– to increase significantly the competitiveness of the Carpathian macro-region in Europe and the world through coordinated, intensive and modern cross-border energy development with unconditional adherence to the approaches of sustainable (environmentally balanced) development.

The **basic principles** of the " Eco-Smart Energy - Carpathia" Concept are the following:

a) Coherence and harmonisation with the 7 main strategic components of the European Strategic Concept of climate neutrality - 2050: energy efficiency; deployment of RES; transition to environmentally friendly transport; circular economics; "smart" networks and communications; bioenergy and technologies of natural carbon sequestration.

b) Compliance with the approaches of sustainable development of territories and communities, i.e. the practical compliance of balance (coherence, harmonisation) of economic, environmental and social components of their development.

c) Comprehensive (systemic) approach to the implementation of multifactor, systematic optimisational analysis and development of practical recommendations within the Joint Concept.

d) Providing pivotal position considering the adopted **5 EU evaluation criteria on the prospects of success and implementation of the Joint Concept, as a strategic document, namely relevance** (compliance); effectiveness; efficiency; influence; sustainability.

e) Ability to adapt (make adjustments and / or changes and additions) to the documents of regional strategic and spatial planning for the target border regions of Ukraine, Slovakia, Hungary, Romania, and Poland, as well as the Interregional Association "Carpathian Euroregion".

TASKS:

1. Achieving full coherence of the conceptual provisions and recommendations of the Joint Concept for the target cross-border area of the Carpathian macroregion and target groups with 7 strategic components of the European Strategic Concept of climate neutrality - 2050, on the one hand, and the ability of recommended approaches and practices of smart energy to adaptations (adjustments and changes) with documents of regional strategic and spatial planning for the target border areas of the Carpathian region, on the other hand.

2. Providing information and resource prerequisites, and focusing on the implementation of modern European innovative technical and technological solutions in the fields of energy and energy efficiency, and taking into account the positive experience and experience in the target border regions of the Carpathian region.

3. Focusing on the sectors with the largest share of energy consumption in the target border regions, as well as on the implementation of RES using available and affordable local energy resources, subject to unconditional adherence to the principle of sustainable development of the territory and/or community of the target Carpathian region, including the main provisions of the Carpathian Convention and national environmental legislation of each of the participating countries and beneficiaries of the Joint Concept.

4. Proposing a system of monitoring the achievement of the Goal and the implementation of the tasks of the Joint Concept in the Carpathian macroregion in a certain medium-term period until 2027.

5. Ensuring the use of the ideological and resource-informational potential of the Concept for the expected development on its basis of the draft Strategy for the Development of Smart Energy and Energy Efficiency in the Carpathian Macroregion.

6. Promoting (through the dissemination of information and implementation of the objectives of the Concept) the alignment of strong disparities in sustainable innovation and energy development of territories and communities of the Carpathian macro-region in the areas of: “cities - rural areas”; “lowland areas - foothills and mountainous areas”; “Western regions of Ukraine - Eastern regions of the EU countries, namely: Hungary, Slovakia, Romania, and Poland”.

7. Achieving (through the implementation of the Joint Concept) the establishment of universities, research and consulting organisations, expert NGOs and energy service companies (ESCOs) as a network of drivers of education and science, energy development and sustainable and smart energy, as well as hubs of energy efficiency and smart energy and grid production associations-clusters.

8. Turning the Joint Concept into one of the most important intellectual, educational, resource-informational and consulting platforms for the successful implementation and promotion of the European Green Energy Transition in the border areas of the Carpathian macroregion.

The terms of implementation of the Concept up to 2027 are determined by the relevant planning period both in the EU countries and the period of validity of the State Strategy for Regional Development of Ukraine for 2021-2027.

1.4. *Synthesis analysis of the situation in the partner countries and adjacent target border regions of the Carpathians*

The development and prospects for the implementation and realisation of the tasks of the Joint Concept **is a relevant and timely step given the following arguments, and factors:**

a) In recent years, as we can witness, there is a significant transformation of approaches to energy development in Europe and world in the areas of **greening and decarbonisation**, with special emphasis on combating and / or adapting to climate change and achieving global goals of sustainable development.

b) The signing of the Paris Agreement in 2015 outlined the new international obligations of the states in strengthening their climate policies. These transformations have a direct impact on the EU member states, including the EU's western neighbours of Ukraine, namely: Poland, Slovakia, Hungary and Romania, which are currently developing an updated common climate and energy policy.

c) In November 2018, the European Commission presented a long-term strategic concept for reducing greenhouse gas emissions (GHG), showing how the EU can pave the way for climate neutrality: i.e. economies with net zero GHG emissions by 2050. The European Strategic Concept - 2050 contains 7 **main strategic components:**

1. Maximising energy efficiency.
2. Maximum deployment of RES and electrification.
3. Transition to environmentally friendly transport.
4. Introduction of a circular economy.
5. Development of "smart" networks and communications.
6. Expansion of bioenergy and technologies of natural carbon sequestration.
7. Absorption of the remaining emissions CO_2 through technology acquisition, storage and reuse of carbon (carbon capture, storage and utilisation).

d) The goal announced by the European Commission of the EU's transition to climate neutral development by 2050, set out in the European Green Deal strategy, is already significantly accelerating energy transformations in the EU. Of course, energy transformations will effect (and have already effected) all spheres of the economy, a particular European country, as well as international economic cooperation with other countries in Europe and the world.

e) If in Slovakia, Hungary, Romania and Poland, that are the EU members (and at the same time Ukraine's neighbours), energy transformations take place within the framework of European approaches, principles and policy documents, then for Ukraine the above energy transformations have become both acute and challenging, and a great opportunity as for a state with an extremely ambitious Association Agreement with the EU and a party to the Treaty establishing the Energy Community.

f) In 2021 Ukrainian government developed a draft Concept of "green" energy transition of Ukraine until 2050 (hereinafter, the Energy Concept of Ukraine - 2050). In particular, the National Security and Defence Council of Ukraine recently decided on the need to revise the Energy Strategy of Ukraine until 2035 "Security, Efficiency, Competitiveness", approved by the order of the Cabinet of Ministers of Ukraine dated August 18, 2017 No.605-p, in connection with which the project Energy Concept of Ukraine - 2050 has been developed. Development of this important document sets the following main objectives in the Concept:

1. Ukraine is an energy-independent and security-resistant country.
2. Ukraine is a country where energy production and consumption are efficient, predictable, sustainable and affordable.
3. Ukraine is a country with a climate-neutral economy until 2070.

g) Even a concise and generalised analysis of the purpose, specific goals, ways and means of solving problems in the *European Strategic Concept - 2050* and the Ukrainian *Energy Concept - 2050* indicates a common vision and approaches to defining the problem area in energy development of the EU and Ukraine, as well as on the ways and means of their solution, including the use of "smart" energy approaches. There are yet some differences, for example, in the pace and timing of achieving carbon neutral economy (of course, with a delay in Ukraine).

Nevertheless, Smart Energy Concept in the Carpathian Region "Eco-Smart Energy - Carpathia" can be harmonised simultaneously with both the *European Strategic Concept - 2050* and the *Energy Concept of Ukraine - 2050*.

I.5. *Relationships and interaction of the Joint Concept with other areas of human activity*

The priority of developing a new appropriate and effective energy policy at both global and national levels of individual states is due not only to the severity of challenges and threats such as climate change and / or the exhaustibility of fossil hydrocarbons on the planet as flammable energy resources. The need for access to energy and the growth of energy consumption in the XX and early XXI century has invariably accompanied the development, scientific and technological progress in almost all areas of human activity. Of course, scientific and technological progress has affected the technical and technological development of energy itself in terms of finding and developing new energy sources, efficient and economical use or consumption. Today we are even talking about the concept of "smart" and "sustainable" energy, as well as the concept of "green" and "clean" energy.

Below you can find the diagram of the relationships and interactions of smart and sustainable energy with other areas of human activity. In our opinion, this generalised scheme is directly related to the implementation of the *European Strategic Concept of Climate Neutrality - 2050* and the draft *Concept of Green Energy Transition of Ukraine - 2050*, as well as to this Joint Concept of smart energy in the Carpathian region "Eco-Smart Energy - Carpathia". In other sections of the Concept the 12 directions of interrelations and mutual influences given in the scheme will be analysed in more detail.

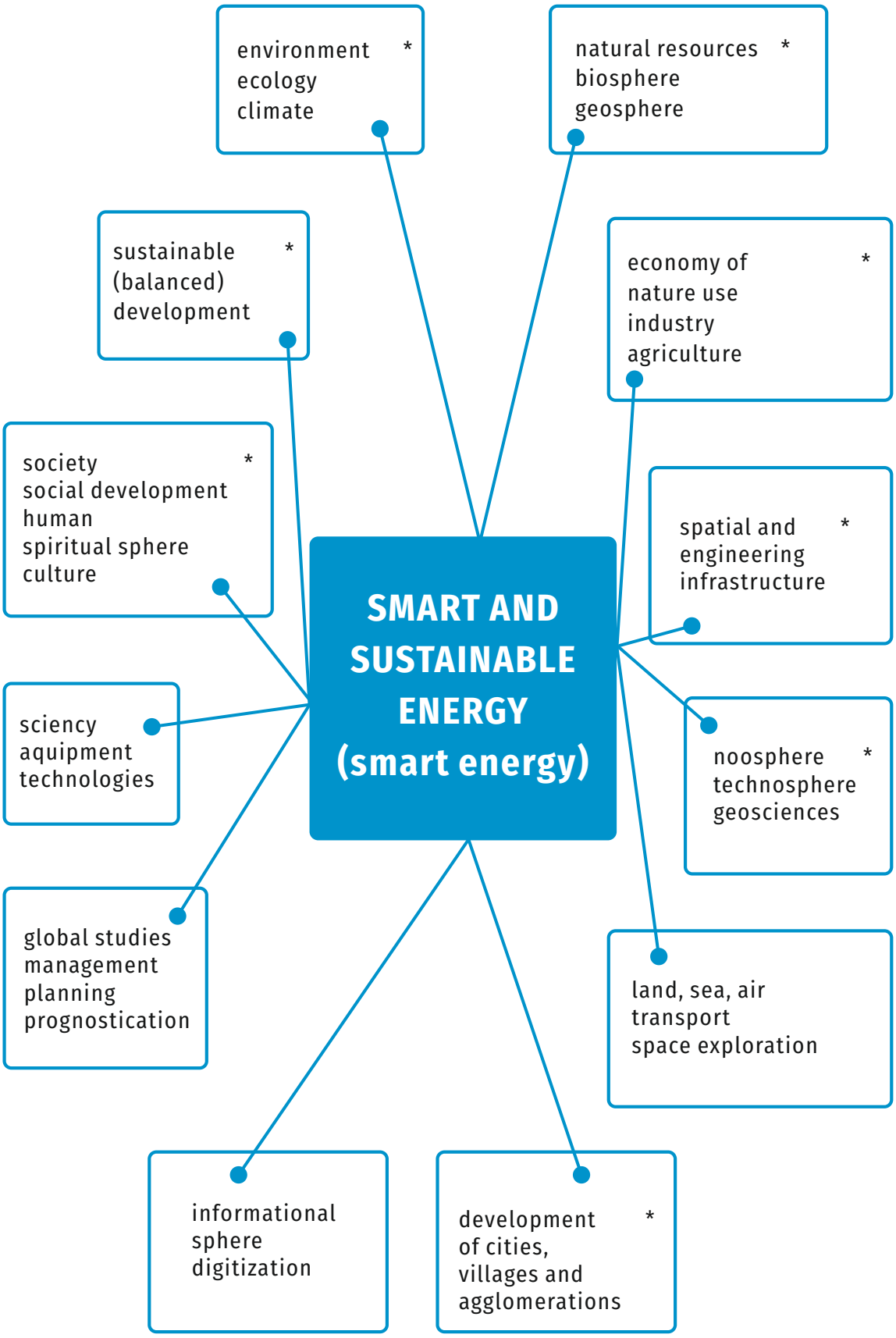
At the same time, we can say that for the target border Carpathian region, among 12 areas of interconnections and interactions with smart and sustainable energy mentioned in the scheme, at least 8 (marked with an asterisk) have a special and decisive impact on mountain and foothill territories of the Carpathian mega-region. And this is due, first of all, to the fact that the Carpathian megaregion has a significant natural resource energy potential of RES (hydro, wind, solar, geothermal, biomass, etc.). Thus, it is necessary to pay special attention to the following 8 areas of relationships and interactions:

– environment, ecology, climate;
– natural resources, biosphere, geosphere;
– economy, nature management, industry, agriculture;
– spatial and engineering infrastructure;
– society, social development of a human, culture, and spiritual development;
– noosphere, technosphere, geosciences;
– urban planning, development of cities and villages and agglomerations;
– sustainable (balanced) development.

Among other things, this special attention to the rational and efficient use of significant natural resource energy potential of the Carpathian macro-region is due to the fact that mountains, natural ecosystems and biodiversity of the Carpathians are much more sensitive to anthropogenic and man-made interventions than other lowland areas.

After all, as is well known from real practice, some of the planning technical, spatial-infrastructural and technological solutions for the placement of electricity facilities using RES (this especially applies to small hydroelectric power plants (SHEPP) on the mountain rivers of the Carpathians in their upper reaches, as well as to wind generators of large sizes and capacities, planned to be installed on the tops of mountains covered with alpine meadows) can predictably create serious risks and threats for mountain ecosystems and landscape and recreational resources of a specific natural subregion of the Carpathians.

Diagram of the relationships and interactions of smart and sustainable energy with other areas of human activity



Scheme 1.1

I.6. *Expected results of the Joint Concept implementation*

In short term (5-7 years) the implementation of the Joint Concept will contribute to the sustainable energy development of the target border Carpathian region and will provide an opportunity to **ensure**:

– equalisation of disparities in sustainable energy development between the mountainous border regions of the EU countries (Romania, Hungary, Slovakia, and Poland) and the western Carpathian regions of Ukraine;

– strengthening partnership cooperation and exchange of information between municipalities, state executive bodies, universities and scientific organisations, development and energy service institutions, companies and businesses on introduction of innovative smart energy in the target border of Carpathian mega-region;

– coordinated and consolidated approach in the development and implementation of energy projects based on the use of RES and the achievements of smart energy in order to protect the unique nature and ensure conservation of the environment and natural mountain ecosystems of the Carpathian region, strict compliance with the European and national environmental legislation acts in this field (Carpathian Convention, Berne Convention, etc., prevention of man-made disasters in the Carpathians);

– increase of the competitiveness of mountain border regions of the target Carpathian region due to the accelerated development of self-sufficiency from energy projects using RES and achievements of smart energy and on this basis in order to improve the living quality and standard of residents in the target Carpathian region;

– making a significant specific contribution to increasing the share of RES in electricity generation in Central and Eastern Europe and achieving the reduction of greenhouse gas emissions and ensuring a significant contribution to the implementation of the *European Strategy for Climate Neutrality - 2050* and the *Concept of Green Energy Transition of Ukraine - 2050* on this basis.

CHAPTER II:

ANALYTICAL DESCRIPTION AND SUBSTANTIATION OF THE JOINT CONCEPT

II.1. METHODOLOGICAL APPROACHES USED IN THE DEVELOPMENT OF THE JOINT CONCEPT

II.1.1. General remarks

When choosing methodological approaches to the development of the Concept, the generally accepted requirements for the methodology, such as the doctrine of structure, logic of organisation, methods and means of research (activity) on a particular problem were taken into account. In our case it is actually a coordinated smart energy development in the Carpathian macroregion using tools and mechanisms for cross-border cooperation (CBC) of communities, authorities, businesses and various non-governmental institutions and civil society organisations. In a narrow and focused understanding of the methodology, we define it as a logical and interconnected combination of conceptual presentation of goals, basic principles and objectives (see Chapter I), as well as components of multifaceted and intersectoral content on modern and optimised methods and approaches to the problem solutions with the help of which they receive: the maximum possible, objective and systematic information about the processes and phenomena associated with the use of smart energy, and predictably achieve practical results in this area.

It should be also noted that the specifics of the choice and application of methodological approaches to the development of a joint (coordinated, agreed) Concept of smart energy in the Carpathian region is largely determined by a set of different characteristics and features of the Carpathian macroregion. In particular, as a conditionally separated European mountainous natural-geographical territory, where natural complexes and administrative-territorial formations and settlements of 8 countries in Central and Eastern Europe, namely: Austria, Czech Republic, Slovakia, Poland, Hungary, Serbia, Ukraine, and Romania, are located.

Above (in subsection I.1) we have already noted that from the perspective of goals and objectives for the implementation of this Project HUSKROUA/1702/6.1/0014, only certain parts of the cross-border territories of 4 countries (Hungary, Slovakia, Romania, and Ukraine) in the Carpathian region are chosen as target regions, that are united by common borders and adjacent to the borders. It can be assumed that the targeted cross-border area of the Project defined in this way generally coincides with the territory of the Interregional Association of 5 countries "Carpathian Euroregion" (see the diagram in Figure 1).

At the same time, the generalised recommendations for the practical implementation of the Concept may well be relevant and effective for

implementation in a much larger area of the entire European Carpathian macroregion.

As in the following sections of Concept an integrated natural, infrastructural and energy resources potential of Carpathian macroregion is planned to be generalised (see Chapters 5 and 6), and below you can find a general description of only those specific characteristics and features of the Carpathian macroregion that have dictated the choice of methodological approaches and methods of analysis, research and forecasting for the development of smart energy.

Figure 1. Map of Interregional Associacion Carpathian Euroregion

II.1.2. Generalisation of specific features and characteristics of the Carpathian macroregion from the standpoint of RES use

A. Geographical location

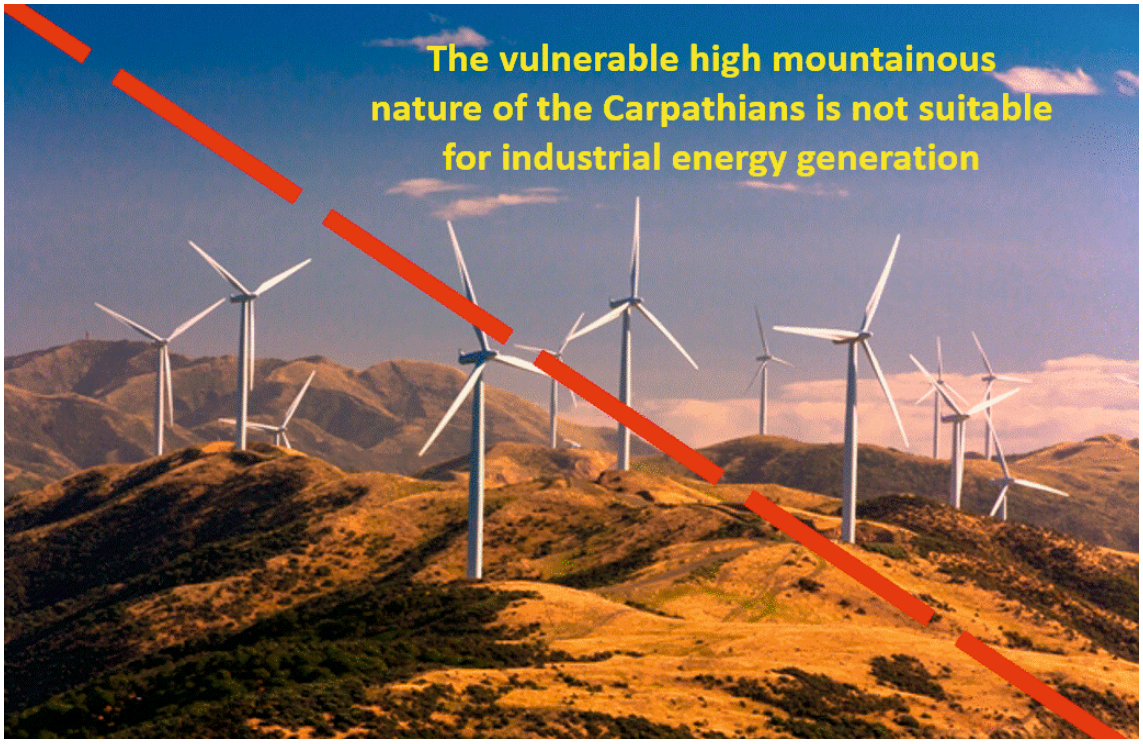
Carpathian macro-region is the largest mountainous system in the eastern part of Central Europe after the Alps, stretching through 8 countries, forming a giant convex arc over 1,500 km long, enclosing the Middle Danube Plain. The largest width of the mountain range is 430 km. The Carpathians are one of the main watersheds of Europe between the basins of the Black and Baltic Seas.

B. Natural resources as a fateful heritage

Carpathian macroregion is an exceptional natural heritage of mankind that needs to be preserved and multiplied. This is recognised by UNESCO, emphasised in many declarations and resolutions of international forums, enshrined in many international legal agreements ratified by the Carpathian countries. Carpathian macroregion is a source of clean water and clean air for the inhabitants of dozens of European countries,

a habitat for a third of the species of flora and fauna of the continent. Unique and endangered species of mountain plants and animals have been preserved in the Carpathians, which is a priceless asset in the conservation of biodiversity at both the regional and global levels.

The Carpathian World Wildlife Fund is included into the list of the 200 most important natural regions of the world. Preservation and enhancement of natural heritage is crucial for each of the countries of the Carpathian macroregion in their long-term development, as well as for the European continent in general, especially in the context of growing trends and threats of global climate change and other negative manifestations of globalisation. In addition, this should be considered due to the much higher sensitivity of mountainous nature to ecological imbalances and damage to ecosystems, biodiversity, mountain soils and watercourses (small rivers, streams and creeks), which are part of the unique and extensive networks in the Carpathian Mountains.



C. Energy potential of RES in the Carpathian macroregion

Estimates of RES energy potential in the Carpathian macroregion are mostly conducted in terms of individual countries and/or their regions. At the same time, almost all types of RES are quite acceptable and promising in the countries of the Carpathian macroregion: solar energy; hydropower and wind energy resources; geothermal water energy; biomass and biogas energy; thermal energy of the earth's interior (heat pumps).

At the same time, increased sensitivity of the ecosystems of mountain forests and alpine mountain meadows, wildlife, mountain soils, as well as drainage of small rivers and streams, natural mountain landscapes violations and irreversible man-made changes, reasonably limits the choice of the place in the planning processes, construction processes and location of alternative energy using renewable energy on mountainous areas including those areas on small rivers and streams.

So, on the one hand, we can observe a contradiction between uniqueness and vulnerability of the mountainous nature of the Carpathians, and, on the other hand, we can see potentially promising and attractive natural areas and watercourses in the Carpathian macroregion for implementation of renewable energy resource, This creates the need to find compromise space-planning decisions with the minimum possible damage to mountainous nature. It must be reflected in the methodological approaches to the development of the Concept. Moreover, minimising the negative consequences of the impact of this contradiction on the nature of the Carpathians is the core basis of all methodological approaches used in the development of the Concept.

For the sake of brevity and rationality of the statement below, we provide a generalisation table with the description of the methodological approaches used.

II.1.3. Methodological approaches and methods of research, analysis and forecasting

Table 2.1.

№	Methodological approach	Methodological bases and methods	Sources of information from the list included in the Concept
1.	**Methodology of management of sustainable development of complex spatial systems**	**1.1.** Studying the processes of integration of international interests of sustainable spatial development of regions and foreign experience in solving these issues with a focus on energy and energy supply in the processes of sustainable development of regions. **1.2.** Development of methodological bases for sustainable development management of complex spatial systems with a focus on harmonisation (balancing) of economic, social and environmental components of development. **1.3.** Using the following as methods of analysis and development: general provisions of systems theory and systems analysis;	**See:** [E1], [E5], [E30], [E31], [E32]

		methods of causal and comparative analysis; methods of regionalism; methods of problem-situational, statistical and technical-economic analysis and forecasting of economic-environmental processes.	
2.	**Systemic ecological approach**	**2.1.** Methods of studying (analysis, forecasting) the genesis and structural and functional features of urbanised and natural-ecosystem mountain, foothill and lowland zones of target cross-border regions. **2.2.** Methods of studying (analysis, forecasting) anthropogenic and man-made changes in natural ecosystems in the target cross-border regions as a result of the introduction of RES.	**See:** [E5], [E14], [E30], [E31], [E32]
3.	**Ecological and economic approach**	**3.1.** Methods of studying (analysing) the main types of production (economic) activities in relation to the state of the ecological potential of natural ecosystems in the target cross-border regions. **3.2.** Methods of studying (analysing, forecasting) the dynamics (trends) of changes in the main indicators of economic, social, demographic, environmental and infrastructural development in the target cross-border regions as a result of the introduction of RES.	**See:** [E5], [E14], [E30], [E31], [E32], [B26], [B28], [B29]

4.	**Geosociosystemic approach**	**4.1.** Methods of studying (analysis, forecasting) the genesis, structural construction, evolution and dynamics of geosocial systems in the target cross-border regions, which functionally combine natural, ecological, social and economic subsystems. **4.2.** Methods of studying (analysis, forecasting), taking into account the principles of self-regulation and management of geosocial systems processes in accordance with programmes and/or strategies of sustainable (environmentally balanced) development and/or programmes for sustainable and smart energy as a result of RES.	**See:** [E4], [E5], [E14], [E30], [E31], [B26], [B28], [B29], [B31], [B32]
5.	**Systematic optimizational approach**	**5.1.** System-optimisation method of analysis (forecasting) in the dimensions of international cooperation on sustainable development: focusing on mutually coordinated implementation of RES in target cross-border regions based on SOMARC (system-optimisation method of analysis of regional competitiveness), developed by the author), and transformed into SOMARCE (system-optimisation method of smart sustainable energy analysis), developed within the framework of this Concept). **5.2.** Methods of indexing, monitoring and optimising cross-border cooperation with the EU neighbours.	**See:** [E31], [B36], [B37], [B38], [B43] **See:** [E31], [E40], [E41].

II.1.4. *System-optimisation method of smart sustainable energy analysis (SOMARCE): application features for the target Carpathian region*

This section will be based on the approaches and provisions of our work [B37] on the systematic optimizational method of analysis of regional competitiveness, performed on the example of international cooperation on sustainable development in the Carpathian region.

In the framework of the proposed systematic optimizational method of analysis generally [B37] the following sequence of 6 analytical and development steps or algorithms were considered (in parentheses we will give a modification or transformation of systematic optimizational method of analysis of regional competitiveness for the use as a systematic optimizational method of analysis of smart sustainable energy):

1. Definition and analysis of conceptual functional spaces of the region with their interactions and interrelations (now in the context of systematic optimizational method of analysis).

2. Development of a structural scheme for formalising the tasks of system analysis of the development of the region (now in the context of systematic optimizational method of analysis of approaches and tasks).

3. Substantiation of the list of groups of indices and structuring comparative indicators, indices and rating assessments of the state and development trends of a specific region and/or group of regions (now also in the approaches and tasks of systematic optimizational method of analysis).

4. Classification of procedures for systematic analysis of regional development (now with a focus on the analysis of sustainable energy development using RES and smart energy approaches in the Carpathians).

5. The choice of specific methods and tools for system analysis, including programme, technical and adapted to the specifics of the proposed and formalised approaches to the Carpathian macroregion (now taking into account the goals and objectives of systematic optimizational method of analysis).

6. Implementation of step-by-step application model (pilot) testing of systematic optimizational method of analysis based on the practice of a specific region and features of CBC processes that take place in this region (we have chosen Zakarpattia oblast, Ukraine as a pilot and model region).

It should be noted that the choice of Zakarpattia oblast as a model (pilot) region in the practical approbation of systematic optimizational method of analysis is not accidental. This region is located in the geographical centre of the International Interregional Association “Carpathian Euroregion” (see Fig.1), the territory of which is situated closely to the cross-border area that is chosen in this Project. At the same time, in Zakarpattia oblast there are mountainous, foothill and lowland zoning areas, the

highest rate of forest cover, waters and protected areas, relatively high density of urban settlements. Thus, the practical application of systematic optimizational method of analysis approaches for Zakarpattia oblast is quite relevant and reasonable practical need of **"proactive strategic environmental and at the same time strategic energy analysis"** given the already cited contradiction between uniqueness and sensitivity of mountain nature in the Carpathians to violations of ecological balance, loss of biodiversity and high energy potential of territories and in particular the use of RES.

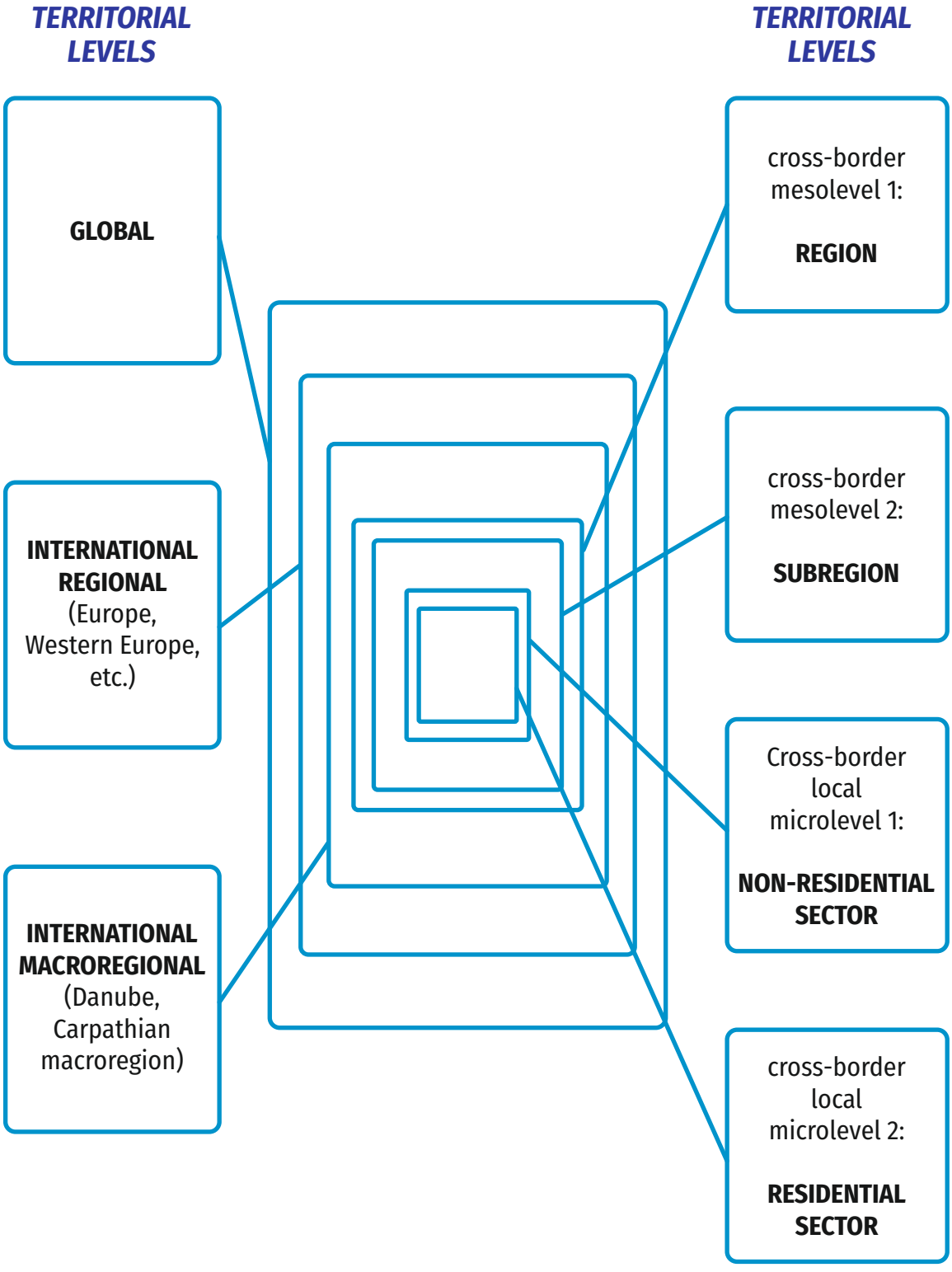


Figure 2. Scheme of the territorial levels selection in the approaches of the systematic optimizational method of smart energy analysis SOMARCE

It should also be noted that in the case of practical application of systematic optimizational method of analysis of regional competitiveness to analyse the dynamics of systemic characteristics of the competitiveness of the region, and in the case of using systematic optimizational method of analysis approaches to analyse the state and development of smart sustainable energy in a particular region, it is advisable to combine such analyses and research in different territorial levels: global, international regional (concerning groups of countries and supranational associations), international macro-regional (such as the Danube, Alpine, Balkan, Carpathian and other European macro-regions), cross-border meso-level 1 - regional (represented by the internal administrative regions of the countries of the target Carpathian macro-region), cross-border mesolevel 2 - subregional (represented not by administrative subregions of the Carpathian countries, but by subregional geographical territorial and economic zones; natural-geographical mountain, foothill and lowland), cross-border local micro-level 1 (represented by individual industrial and non-industrial non-residential enterprises, organisations, institutions and establishments), cross-border local micro-level 2 (represented by individual buildings and their components: apartments in apartment buildings, as well as individual households such as cottages, farmsteads, outbuildings, etc.), which generally represents the residential area of the target cross-border region.

The separation of territorial levels in the proposed SOMARCE (see Fig. 2) was analysed by us at each of the territorial levels in Table 2.2 from the perspective of expected CBC impacts, the nature of emerging relationships, and the degree of impact at the qualitative level: “weak”, “medium”, “strong”.

Note the most influential and distinctive position of the comparative-analytical Table 2.2 on the proposed methodological approach using SOMARCE: at local micro levels 1 and 2 we characterise the direct actors, energy relations in both non-residential (industrial and non-industrial) and residential sectors not only as energy consumers, but also **as producers of energy generated by RES within the framework of a new phenomenon in the last 10 years in developed countries and Europe i.e. scattered on local micro-level generation (production) of electricity and heat.**

Table 2.2

Multilevel influences, including CBC, in the system of global for the development of smart sustainable energy in the target cross-border macroregion of the Carpathians according to the approaches of SOMARCE

Territorial levels	Subjects	Effects of CBC	The nature of the relationship	Nature (degree) of effects: * – weak ** – average *** – strong
Global level	World community of states	• Non-additive integrated result of all effects of lower territorial levels. • Dissemination of innovations and energy technologies.	• Political • Socio-economic • Financial and economic • Responding to global crises	• Political (*). • Socio-economic (*). • Financial and economic (**). • Responding to global crises (*).
International regional level (Europe, Western Europe, etc.)	Non-governmental organisations and groups of countries (such as the EU, ASEAN, etc.)	• Non-additive integrated result of all effects of lower territorial levels. • Dissemination of innovations and energy technologies.	• Political • Socio-economic • Financial and economic • Responding to global crises	• Political (**). • Socio-economic (***). • Financial and economic (**). • Responding to regional conflicts and crises (**).
International macroregional level (Danube, Carpathian macroregion, etc.)	Entry of different nation states (such as the Danube Strategy, the Alpine Strategy).	• Non-additive integrated result of all effects of lower territorial levels. • Dissemination of innovations and energy technologies.	• Socio-economic • Financial and economic • Organisa-tional and technical • Institutional	• Socio-economic (**). • Financial and economic (*). • Organisa-tional and technical (**). • Institutional (*)

Mesolevel - 1: regional. Examples: - Zakarpattia (Ukraine) - Maramureș (Romania). - Suceava (Romania). - Satu Mare (Romania). - Szabolcs-Szatmár-Bereg (Hungary). - Košice Region (Slovakia)	• Internal administrative regions of countries. • Industries of the region. • Integral housing and communal services of the region. • Integral other buildings, facilities and energy consumers of the region in cities and villages.	• Non-additive integrated result of subregional (district) and zonal levels • Strong influence on all subjects • Accelerated spread of innovation and smart energy technologies.	• Organisational and technical (joint CBC projects and teams) • Institutional international organisations and network structures of CBC • Financial and economic mechanisms of CBC	• Organisational and technical (joint CBC projects and teams) (**) • Institutional international organisations and network structures of CBC (**) • Financial and economic mechanisms CBC (***)
Mesolevel - 2: subregional (non-administrative)	• Internal subregional geographical areas and zones of the region: economic; natural-geographical (mountain, foothill, lowland). • Integral large industrial and agro-industrial zones regions. • Integral housing and communal services of the subregion.	• Non-additive integrated result of local microlevels of different types. • Strong influence on all subjects • Accelerated dissemination of innovation and smart energy technologies	• Organisational and technical (joint CBC projects and teams) • Institutional international organisations and network structures of CBC • Financial and economic mechanisms of CBC	• Organisational and technical (joint CBC projects and teams) (**) • Institutional international organisations and network structures of CBC (**) • Financial and economic mechanisms CBC (***)

	• Integral other buildings, facilities and energy consumers of the subregion in cities and villages			
Cross-border local microlevel - 1 (non-residential industrial and non-industrial sectors)	• Some industrial and non-industrial enterprises, organisation, institutions and establish-ments in cities and villages of the region (subregion) • Integral energy consumption in the structural parts of the enterprise, organisation, institution, institution	• Non-additive integrated result of local energy consumption and local energy generation • **Strong dispersed influence of all subjects** • Direct bilateral and multilateral effects in CBC processes, including exchange of innovations and technologies of smart energy, Including on forms of energy generation in the framework of energy democracy	• Organisa-tional and technical bilateral and multilateral tools of CBC • Bilateral and multilateral agreements and joint CBC projects • Financial and economic mechanisms of CBC, including on the introduction of forms of energy generation in the framework of energy democracy	• Organisa-tional and technical bilateral and multilateral tools CBC (**) • Bilateral and multilateral agreements and joint CBC projects (**) • Financial and economic mechanisms of CBC, including on the introduction of forms of energy generation in the framework of energy democracy (***)
Cross-border Local microlevel - 2 (residential sector)	• Some residential buildings and their components (apartments) in apartment buildings in cities and villages of the region (subregion),	• Non-additive integrated result of local energy consumption and local energy generation • **Strong dispersed influence of all subjects**	• Organisa-tional and technical forms of CBC “people-to-people” • Joint CBC projects and initiatives in the form of “people-to-people” • Financial	• Organisa-tional and technical forms of CBC “people-to-people” (**) • Joint projects and initiatives of CBC in the form of “people-to-people” (**) • Financial

	as well as individual households (cottages, rural estates) • Integrated energy consumption in structural parts of a residential building (rooms, ancillary premises, common areas)	• Effectes in CBC processes in the form of **"people-to-people"** • Intensive exchange of innovations and technologies of smart energy, especially on **forms of energy generation in the framework of energy democracy**	and economic mechanisms of CBC, including on the coordinated implementation of forms of energy generation in the framework of energy democracy	and economic mechanisms of CBC, including on the coordinated implementation of forms of energy generation within the framework of energy democracy (***)

II.2. GLOBAL ENERGY DEVELOPMENT TRENDS OF THE XXI CENTURY

II.2.1 Briefly about energy, energetics and globalisation in the XXI century

The development of this Concept, as well as any other development or research, necessarily requires a common and accurate use of key definitions, which include energy and energetics. It should be noted that especially with regard to the definition of "energy" and "energetics" it is important to clearly distinguish them in this Concept from dozens of other semantic nuances in other types and forms of life of human communities, including in the fields of psychology, culture, art and even show business, etc. To this end, we turn to the Great Modern Encyclopaedia in 10 volumes, published in Ukraine in 2013.

"Energy (Greek "energia" - "action", "activity") is a scalar physical variable, the only measure of different forms of motion of matter and the degree of transition of motion of matter from one form into another. In physics, it refers to the ability to perform work, different physical processes, thermal, electromagnetic, gravitational, nuclear, etc.). Energy is measured in Joules (J).

"Energetics refers to economic and human activities for the production, distribution and use of energy resources of all kinds. The process of energy production often occurs in several stages: production and concentration of energy resources; transfer of resources to power plants; conversion of primary (natural) energy into secondary energy by power plants (for example, into electrical or thermal energy); transfer of secondary energy to consumers".

Of course, the given definition (interpretation) of the concept of "energetics", in our opinion, is too schematic, simplified, one-sided and generalised, and does not correspond to the level of development of science, technology and modern energy of the XXI century. However, this is the fate of many encyclopaedic definitions and concepts, they are rapidly ageing.

As this section will be focused on global energy development trends in the XXI century, it is important to provide an encyclopaedic definition of the globalisation process.

"Globalisation is a process of global economic, political and cultural integration and unification, the main consequence of which is the global division of labour, migration (worldwide) of capital, labour, productive resources, standardisation of legislation, economic and technological processes, convergence and merging of cultures countries. It may also refer to an objective process that is systemic in nature and covers all spheres of society, making the world more connected and dependent on all its actors".

The first sentence of this encyclopaedic definition of the process of globalisation, in our opinion, is outdated and incomplete in the XXI century, as evidenced by even the final following sentence of the above definition.

Our definition of the process of globalisation in the XXI century is illustrated in Figure 3 in the octahedral model of 8 directions (and facets) of globalisation processes of the present, namely the following directions: political; economic; information technology; social; environmental; demographic; security; cultural. In this model, the direction (and perpendicular to the facet) is associated with the intensity of globalisation, while the facet (plane) is a reflection of many manifestations of globalisation processes in one of the 8 directions, and their geographical distribution (dispersion) across continents and countries.

Figure 4 shows a diagram illustrating the system of interactions of the above 8 areas (facets) of modern globalisation processes for the period of global crisis caused by the pandemic - 2020 (COVID-19).

It should also be noted that, in general, the energy of the XXI century and its development cannot be considered in isolation from globalisation, which, even by encyclopaedic definition, is *"an objective process that is systemic and covers all spheres of society"*.

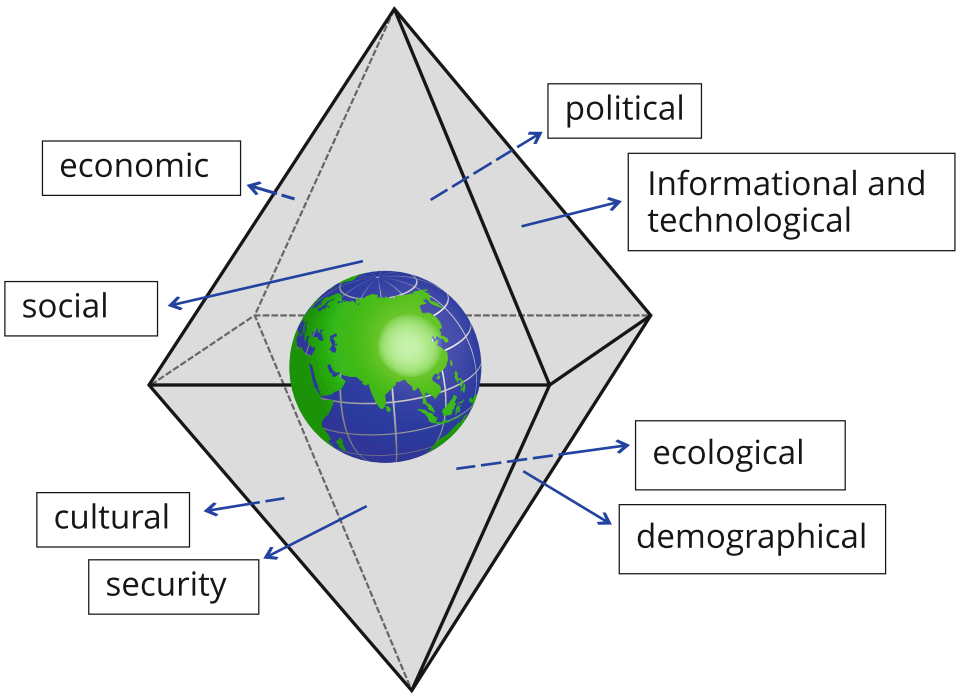


Figure 3. Eight directions (aspects, facets) of globalisation processes

Eight directions (facets, aspects) of globalisation processes (phenomena, transformations) sufficiently fully reflect the general course of globalisation on the planet.

In the monographs of foreign scientists only the first 7 areas of current globalisation processes are considered. In our opinion, such analysis and consideration lacks the separation of the 8th direction of globalisation processes and transformations. We are talking about the security direction, although its impact is present and considered in one form or another in the selected 7 areas. So, the list of following 8 directions (faces, aspects) of globalisation processes with a brief description of their content is provided below:

1. Political direction (aspect, facet)

In general, it includes the existing and planned for formation (reorganisation, improvement) system of political tools and international institutions that operate on a global scale and solve problems in which most countries of the global community are interested. The examples are the United Nations (UN), the World Health Organization (WHO), the World Trade Organization (WTO) and dozens of others. At the same time, in the future we may talk about institutions such as the World Government. Political direction (aspect, facet) is actually the only one that is directly determined (and used) by measuring the existing system of global governance (management) of global human development.

2. Information and technological direction (aspect, facet)

In general, it represents a huge variety of information resources and technologies that the global human community has developed and has mastered or is mastering. Of course, the globalisation of information resources and technologies is now being accelerated by the information and communication technologies (ICT). We are talking about virtually all areas of scientific, technical, environmental, cultural, spiritual and economic activities of human communities, **including the important field of energy generation, transportation, transformation and consumption.** This includes the growing global role of the Internet and social networks, information and hybrid wars, and more.

Of course, new types of energy technologies, such as laser thermonuclear synthesis (LTS), hydrogen energy and almost all RES, are also related to the 2nd direction of globalisation.

3. Economic direction (aspect, facet)

Generally speaking, this direction is represented by the functioning of the global economic and global financial system, in which the most striking example is multinational companies and corporations that accumulate huge property and financial capital along with the world-core international division of labour and aggregation of wealth. Energy, energy resources and energy technologies are a platform for economic development for most developed countries and for multinational companies and corporations.

4. Social direction (aspect, facet)

This direction is characterised by the formation of a global, supranational (global) social structure of the world population with its superclasses of super-rich people

(billionaires) and communities of poor people and those below the poverty line. It also covers global issues and challenges of the access of human communities to quality social services (education, health care, etc.), respect for universal human rights and freedoms, etc. Access to quality social services is in one way or another related to access to natural resources, including drinking water, as well as to energy resources and proper specific energy consumption. The distribution of such energy consumption in the context of the world is too uneven.

5. Ecological direction (aspect, facet)

This direction covers the problems, challenges and threats of global pollution, including the pollution of continents, oceans, seas, rivers and lakes, groundwater and air, as well as **anthropogenic** (caused by economic and domestic activities of human communities) and **man-made** (caused by both human activities and technological processes and machines, including obsolete energy technologies) global effects on the environment and human health. The examples are: global warming; irreversible extinction of species and forms of biodiversity in the living nature of the planet; large-scale deforestation with a global impact on the environment, degradation of fertile soils, irreversible disappearance of small rivers and streams from the water networks, lowering groundwater levels, catastrophic decline in access to clean drinking water, etc. The most significant feature of the globalisation processes of the **ecological** direction is that it is characterised by the widespread assertion of seemingly clear and logical and simple truth: **global processes (changes, transformations) are formed by the combined impact of environmentally harmful processes, changes, transformations) at the local level. At the same time, the mass awareness of this simple truth is still a long way off, as it is only taken care of by civil society. The environmental direction is directly related to energy technologies.**

6. Demographic direction (aspect, facet)

This direction unites the problems of demographic changes that are uncontrolled both by individual countries and humanity as a whole. In particular, this applies to rapid population growth in some countries and megaregions of the world with low or even negative indicators of economic and energy development, leading to poverty, low welfare and limited access to quality education and medicine, utilities, as well as mass international migration and more. The migration crises of recent years on the southern borders of the United States and on the borders of the EU only confirm the global importance of the demographic trend.

7. Cultural (both mindset and spiritual) direction (aspect, facet)

From the perspective of the analysis of global transformations, this direction covers the problems of the spread of "multiculturalism", on the one hand, and the disappearance of ancient and unique cultures and languages of small peoples, ethnic groups and subethnoses, on the other hand. The problem of deep contradictions between Western forms of mass culture, including the dubious values of mass culture of consumer societies, and traditional spiritual and cultural and national values of both "non-Western" peoples and the true, traditional culture of the West, are equally important. This also includes the problems of change in the worldview and spiritual basis of the human as well as human communities, and in ethics and value systems. Bioethics, the development of a culture of energy consumption, environmental ethics and religious movements for the preservation of Creation should also be attributed to the 7th direction of globalisation.

8. Security direction (aspect, facet)

This direction analyses the state of security issues of existence and development of Human and Nature and human communities, as well as ecosystems, natural landscapes, and geophysical parameters of life on planet Earth. It is considered to be conducted both in a wide range of meanings of the term "development security" and in its narrowed meanings, such as:

- safety of human life and human communities;
- international security and threats of war, terrorism, international crime, etc.;
- global environmental security;
- global public health security.

This is the direction that relates to a range of problems caused by the real global threat of the coronavirus pandemic-2020. This should also include the security of international air and sea transport and other security issues. These include new types of biotechnology, genetic engineering and genetically modified organisms, the unpredictable consequences of human cloning, chemical and bacteriological weapons of mass destruction and other security issues.

Undoubtedly, the problem of global and climate change on the planet is now at the forefront of security, largely due to human anthropogenic activities and, in particular, the burning of fossil hydrocarbons (coal, oil and gas) for human energy needs.

Figure 4 represents a diagram of sources of origin, impacts on and interactions of smart and sustainable energy of the XXI century with natural resources, geosphere and biosphere of the planet Earth and solar energy, and the main spheres of human life on the planet, none of which exists without energy generation, transportation and consumption.

The next section will describe the origins and causes of the current state of global civilisation of mankind, which was briefly called the "energy and environmental crisis".

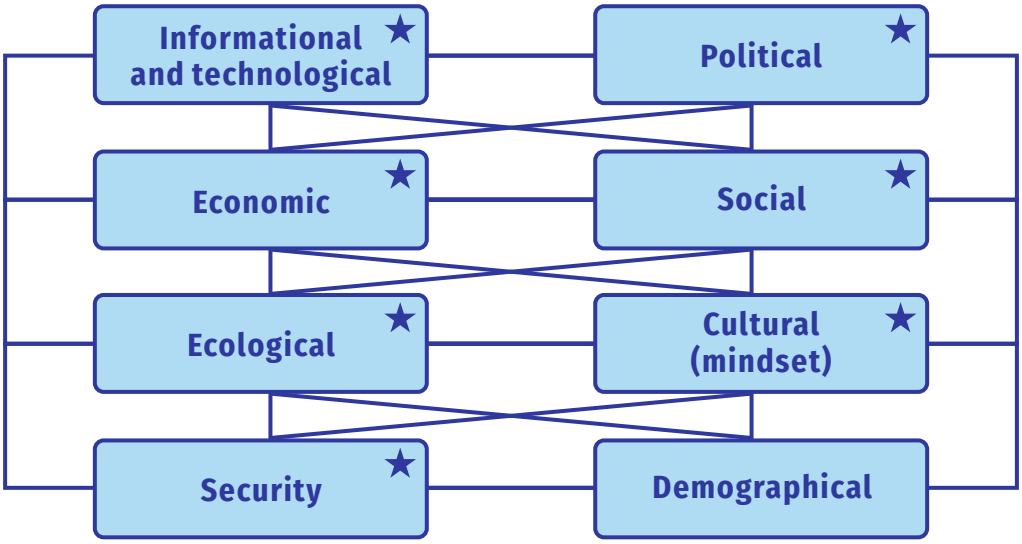


Figure 4. System of interactions and mutual influences of 8 directions (aspects, faces) of globalisation processes (changes, transformations)

Remark:** the global crisis caused by threats of climate change has affected all areas of globalisation, but 7 of them (highlighted with a star ★) have had the greatest impact and went into **"energy and environmental crisis".

II.2.2. *Global awareness of the ecological and energy crisis in the civilisational development of mankind*

At the end of the XX and in beginning of the XXI century it finally became clear for the world community that the model of development of today's civilisation, based on the mass use of energy from fossil hydrocarbons (coal, oil, gas, peat, wood), is an energy dead end, a kind of a trap for humanity. And we should and can find a way out of this dead end and avoid it as soon as possible in the direction of successful technical, economic and social development of RES (renewable energy sources), which in fact are always close to humans. At the same time, it is important to further develop and improve those new physical and technical and physical-technological energy developments, which in one way or another use the material and energy resources of RES (for example, laser thermonuclear synthesis, hydrogen energy, etc.).

Global awareness of the current environmental and energy crisis of mankind over the past 30-40 years has changed under the strong influence of a number of global problems and pessimistic forecasts and predictions. Here are just 3 of the main ones:

- changes in the environment and nature with irreversible losses in the biodiversity of the planet;

- global warming and climate change, which have catastrophic consequences for humanity;

- growing global energy needs while reducing the security of energy supply and increasing political dependence on energy resources and their uneven distribution between continents, macroregions and countries.

From 1950 to 2000, the annual energy use of the economy on a global scale grew by an average of 3.5% per year. World energy consumption has increased very unevenly. At the same time, most of the energy produced was used (and is used today) in industrialised, economically and infrastructurally developed countries. Thus, the average inhabitant of Western Europe consumes about 5.5 times more commercially produced energy than the average African.

And the average resident of the United States or Canada consumes 9 times more commercially produced energy than residents of India.

About 25% of the world population has no electricity at all, and 40% of countries, like all their previous history of development, rely mainly on bulky biomass with its combustion to meet basic energy needs.

It is forecasted that in 2030 another 1.4 billion people on the planet will still not have access to electricity.

Most global energy analysts expect that global energy consumption, despite all existing and projected challenges, will continue to grow.

The pessimistic “energy mood” gives a percentage of the increase in global energy consumption in 2000 to 2030. And even a more optimistic “environmental” scenario involves an increase in energy consumption by more than 50% (do not forget about the constant growth of the world population).

Fossil (mostly carbon) fuels (energy resources) are non-renewable energy resources. During combustion, they are converted into carbon dioxide, water vapour, sulphur dioxide and other substances that in the foreseeable future again do not react chemically to form fossil fuels.

Of course, it is important to promote the awareness of the global energy and environmental crisis in the governments and the public of all countries of the Carpathian macroregion, and in particular in Ukraine, Romania, Slovakia, Hungary, Poland. And awareness will be followed by joint actions, including within the framework of this Concept.

CHAPTER III.

RECOMMENDATIONS FOR THE PRACTICAL IMPLEMENTATION OF THE JOINT CONCEPT

III.1. *COMMENTS AND REMARKS ON THE AGREED UNDERSTANDING OF THE CONCEPT OF "SMART ENERGY" IN THE TARGET CARPATHIAN REGION. STAGES OF IMPLEMENTATION OF THE GREEN ENERGY TRANSITION*

III.1.1. *Who are the ideas and essence of the concept of "smart energy" aimed at?*

Agreed understanding of the basic concept of the Joint Concept of "smart energy" in the Carpathian region, above all, is important for all groups of stakeholders in the practical implementation of the goals and objectives of the Concept, namely:

- scientists, teachers and university students;
- research and implementation institutions;
- regional and local development agencies;
- energy service companies;
- business structures, farms, transport companies and business associations and financial institutions the economic and financial activities of which are related to the practical implementation of innovative and technical solutions and projects in various fields of modern energy, such as energy audit, energy monitoring and energy project management;
- bodies of state executive power and local self-government bodies of regional, subregional and local levels and their communal enterprises that provide municipal services of energy and heat supply, gas supply, water supply and sewerage, street lighting and traffic lights, etc.;
- residents of cities, towns and villages, that today are not only consumers of electricity, heat and resources (water, gas, hot water), for the delivery to homes and apartments of which electricity is mostly used, but also members of energy cooperatives and other forms "energy democracy", whose activities are aimed even at generating electricity or implementing other innovative technical solutions in the field of "smart energy" (for example, rooftop or outdoor solar mini-power plants and solar thermal collectors, etc.);
- public organisations and their associations and coalitions the activities of which are related to education, training services, dissemination of information or even the development and implementation of projects in the field of ecology and energy;
- it is expedient to point out design and survey bureaus and institutions of various

forms of ownership and construction companies and small construction and assembly enterprises, which actually implement in practice the chain **"development of design and estimate documentation (feasibility studies) with its state expertise for construction, reconstruction or capital (current) repair of a building or facility with new energy technical and technological solutions with "smart energy" approaches, corresponding to the existing level of national legislation in the field of energy and construction of each of the partner countries in the Carpathian macroregion".**

We have singled out the above groups of stakeholders and beneficiaries regarding the ideas and essence of the concept of smart energy in the target Carpathian region. And they were convinced that in fact in the societies (populations) of the Carpathian macroregion **there is no group or social stratum that is not directly interested in implementing measures and tools of smart energy both in their homes and in urban areas of cities, towns and villages, as well as at enterprises, institutions and organisations, in energy and transport, in the non-productive sphere.**

III.1.2. *It is important to interpret the concept of "smart energy" in a coherent way*

First, smart energy must be present in all components of the chain of "generation (production) of energy (heat) - transportation - consumption".

And this concept of smart energy must be the core of this chain.

In general, the definition (concept) of "smart" according to the definition of the "Great Modern Encyclopaedia" (Ukraine) is the following:

"...philosophical category that expresses the highest type of mental activity, the ability to think in general, analyse, distract and generalise; ability to think; high degree of development of mind, intelligence".

Thus, Human attitude to the use of energy resources for their living needs, in everyday life, transport, economic and other labour or creative and intellectual activities, can be called reasonable in the sense of the above concept "smart" only when it **is responsible and corresponding to the "highest type of mental activity" and the ability of Humans to "analyse", "generalise", "think".**

Responsible-1: from the perspective of knowledge about the physical and material sources of energy resources in the form of heat and electrical or radiant energy and the transition of this energy to other types, for example, in the mechanical energy of machines and mechanisms.

Responsible-2: from the perspective of knowledge about the limited energy resources of the so-called "traditional energy" based on the combustion of fossil hydrocarbons (coal, gas, oil), as well as knowledge about the existing threats to the Earth, human communities, ecosystems and all living things from the continued existence of "carbon energy" in the first half of the XXI century, through objectively

ongoing climate change processes (global warming) due to the accumulation of critical concentrations of greenhouse gases in the atmosphere of the Earth.

Responsible-3: regarding practical integration and personal and collective participation in the global movement of the Green Energy Transition, aimed at saving human civilisation from the real threats of climate change.

For its implementation, the new global energy paradigm of humanity requires supercritical accumulation of gradual and continuous local changes at all levels of potential influences in the system of global "matrioshka" of smart sustainable energy development, including at the international macro-regional level of Carpathian macroregion (see Table 2.2.). Gradual and continuous local changes at all levels of potential impacts in the system of global "matrioshka" of smart sustainable energy development are prudently stretched over time for several decades in the communities of the world and in Ukraine. After all, the traditional "fossil, carbon energy" has deep and strong economic, technological, technical and infrastructural and even political roots of its existence and can not be immediately "canceled" by any national or international acts and agreements. So, we really need an "energy transition", and therefore a reasonable amount of time to implement it in different countries. At the same time, a **responsible** attitude towards the new paradigm of global energy **(Green Energy Transition)** in human communities, society, public authorities and local governments, as well as in all other stakeholder groups, **should change not gradually but proactively and abruptly.**

The result of a coherent understanding of "smart energy" in the target Carpathian region in our Joint Concept is, first and foremost, a coherent understanding of the following components: consistency and interconnectivity, **as well as phasing of action for all stakeholder groups and beneficiaries,** namely:

Phase 1: formation of a **responsible attitude** to the new paradigm of global (as well as local and regional) energy through regulations at various levels, education, spreading innovation, coordinated adoption of strategies and programmes, etc., which in general will promote **advanced and abrupt public awareness** of the inevitability of active participation of all stakeholders in the Green Energy Transition. This phase 1 (public awareness) should not last too long (not more than a few years).

Phase 2: constant and sustainable increase of specific actions and projects on practical realisation of Green Energy Transition both in the urbanised territories of cities, towns and villages, and at the industrial enterprises, in establishments and the organisations of non-productive sphere, on the fields of transport and power, etc.

Along with this, let's not forget that the specific actions and projects of the new energy of the Green Energy Transition concern all components (areas) in the interconnected chain: "generation (production) of energy (heat) - transportation - energy consumption (heat)". Phase 2 has actually already begun. And it will continue continuously over time and with varying intensity across countries and continents until the Green Energy Transition is fully completed (approximately in 2050 in most EU countries).

III.2. HOW TO JOIN THE GREEN ENERGY TRANSITION?

III.2.1. Development of RES: sun, water, wind, geothermal waters

The basis for the development of RES in the target cross-border Carpathian region should be the development of **distributed generation**, which is an alternative to the current, generally resource-intensive energy, including carbon. The strategic perspective of energy development in the world, as noted in previous sections, is not to try to intensify traditional production processes of carbon and nuclear technologies (nuclear power plants - NPPs) for production and radial supply of electricity, but to support and accelerate the development of technologies of distributed generation and **smart self-regulated local networks**, equipped at local levels with storage capacity. The decisive factor in the energy of the future is the focus on inexhaustible and renewable energy resources, not localised as carbon and uranium raw materials in deposits, but ubiquitous, and converted into electricity by small (distributed) generation in each local power generation site and and power consumption site.

The basis of small (distributed) electricity generation is RES, namely: the sun, wind, water, geothermal water. According to the European Green Deal, the united Europe plans to completely switch to renewable electricity by 2050. Ukraine has also set itself an ambitious goal to achieve 30% of renewable electricity generation by 2030. In the future, Ukraine's plans are even more ambitious.

The Carpathian macro-region is an area with mainly foothill and mountainous terrain, which is characterised by scarcity of land, in the sense of agricultural land. At the same time, the Carpathian macroregion has sufficient insolation energy potential, considerable potential for air flows in the foothills and an extensive and powerful network of small mountain rivers (see annexes). However, resources for the construction of too **large RES power plants**, such as SPPs, WPPs or HPPs, with a capacity of more than 20 MW, are nevertheless limited. At the same time, the energy potential for the creation of a large number of local networks of small, mini- and micropower plants, which would cover the entire territory of the Carpathian macroregion in general, is quite large. In each community in the Carpathian macroregion, the total capacity can be up to 10-20 MW, relatively evenly distributed and located on the roofs of public and private buildings, along the directions of air flows, sewage and more.

With regard to small hydropower, we consider it appropriate to develop only small hydropower (up to 100 W) on small rivers of the Carpathian macroregion, with micro-hydropower plants operating in natural runoff without interfering with the hydrological regime of the river and without causing morphological changes. In general, the environmental and legal criteria for selecting sites for small and mini-hydropower plants on the mountain rivers of the Carpathians (developed by us for use in the Ukrainian Carpathians, but with an opportunity to be used in other countries of the Carpathian macroregions) are provided in the annexes to the Concept.

III.2.2. Bioenergy

Bioenergy also belongs to RES, but the basis of this type of energy is biomass and biogas, which are part of the biotic component of ecosystems. Due to its peculiarities, bioenergy needs separate consideration and analysis. Unfortunately, this component of RES in Ukraine is in particular the least developed. However, bioengineering is also of great interest for common solution of the problems of participation of communities in the border of the Carpathian macroregion in the Green Energy Transition through "smart energy" projects. Bioenergy in modern conditions is used for the following purposes:

- electricity generation;
- heat production;
- production of biofuels for internal combustion engines in vehicles.

The following components are used as a material energy resource in this process:

- **biomass** (wastes from agricultural and forestry production such as straw, dry stems, firewood, wood chips, briquettes; or cultivation of energy crops such as wood, grass);
- **biogas** (landfill methane collection at landfills, sewage treatment plants, anaerobic processing of livestock waste, food waste as a fraction of solid waste, waste from processing vegetable products (grape pulp) or actual processing of crops (rapeseed, corn), etc.

Biomass in the form of wood is still widely used in the communities in the Carpathian macro-region, as large areas are occupied by forests: from 30 to 80% of the area, depending on their location and levels of urbanisation. Many communities often do not even have heat sources other than burning firewood and wood waste. Therefore, diversification of biomass sources for energy needs is an important task for such communities. After all, with the growing demand for fuel wood, the richest and most valuable natural ecosystems may be affected, i.e. forests that best help us fight climate change, but at the same time are increasingly affected by human economic activity and urbanisation. In view of this, it is important to develop the direction of energy plantations of wood and grass energy crops, which will be able to replace firewood on the market and meet the growing needs for fuel wood in communities.

Biomass can be used for heat production or electricity generation at appropriate thermal power plants. The source of biomass can be forestry, woodworking enterprises, many of which are also located in the Carpathian macroregion, as well as agriculture and energy plantations of various forms of ownership.

Another important segment of bioenergy is biogas, the source of which can be landfills, septic tanks, waste from livestock farms, waste from processing plant products, food waste, which is a separate fraction of solid waste. Biogas production is focused on livestock farms, agricultural processing enterprises, public utilities, which take care of landfills and sewage treatment plants in communities. Biogas plants at such facilities allow the collection of methane, a greenhouse gas that will not enter the atmosphere, but will be used to produce heat or electricity. That is, biogas collection has a double positive climatic effect.

Enriched biomethane is no different from natural gas, so it can be transported and used with minimal infrastructure upgrades, unlike "green" hydrogen. Biomethane has the advantages of natural gas, while remaining carbon-neutral. A well-developed network of gas pipelines would allow connecting biogas plants focused on raw material sources and delivering energy to a significant number of consumers, regardless of the weather and season. All this makes biomethane quite an attractive energy resource compared to other environmental energy sources, such as wind or the sun.

Taking into account these features, bioenergy is a very important segment of RES. Unlike others, which are based on solar, wind and water energy, in bioenergy the generation of heat and electricity is continuous and it does not depend on the time of the day and weather. Thus, bioenergy is at the same time shunting power that flexibly responds to changes in electricity consumption. That is why, bioenergy is important in balancing the energy system of both local and general energy networks. **The larger the share of bioenergy in RES, the more stable the regional energy system.** Given this feature, we believe that bioenergy has significant prospects for development in the Carpathian region.

III.2.3. *Hydrogen energy and production of "green" hydrogen*

Hydrogen energy is another hope of the Green Energy Transition. The era of fossil fuels and carbon energy is coming to an end. And many experts are announcing the beginning of the era of hydrogen energy.

Hydrogen energy is a direction of energy production and consumption, which is based on the use of hydrogen as a means of accumulation, transportation and consumption of energy by the economy, population, vehicles and various production processes. Hydrogen has been chosen as the most abundant element on the Earth and in space. It has the highest energy consumption, and the product of its combustion is only water, which re-enters the natural cycle.

A variety of energy sources can be used to produce hydrogen: fossil fuels, nuclear energy and renewable energy technologies, such as solar, wind, hydro-, bio-, and geothermal energy. Thanks to such a variety of resources and technologies, hydrogen can be produced in all regions of the country and in the world in general. Today, the hydrogen produced is obtained by converting water vapour with natural gas. Hydrogen is also extracted from oil, coal and water.

In the nature, hydrogen occurs mainly in the gaseous state, and it is relatively "colourless". That is why, when we talk about "white hydrogen", we mean natural hydrogen, which can occasionally be found in underground deposits. Currently, there is no real strategy and technology for the use of these deposits, so different technological processes are used to obtain hydrogen artificially. Colours are used to denote them: each colour corresponds to a specific energy source and/or process used to produce hydrogen.

The oldest method of producing hydrogen is the conversion of coal into gas. Gasification processes convert organic or carbon-based materials based on fossil fuels into carbon monoxide, hydrogen and carbon dioxide. Gasification occurs at very high temperatures (above 700°C) without combustion, with a controlled amount of oxygen and/or steam. The gas formed as a result of coal gasification is called synthesis gas. It is possible to separate hydrogen from other elements in it, having applied adsorbers or special membranes. This hydrogen is known as "brown" or "black" depending on the type of coal used: brown (lignite) or black (bituminous) coal. The process of gasification of coal is accompanied by heavy pollution, as neither carbon dioxide nor carbon monoxide can be reused, and they are released into the atmosphere.

Today, most hydrogen comes from natural gas, where it is bound to carbon and can be separated by a process called "steam reforming", with excess carbon forming carbon dioxide. This hydrogen is called "grey" when excess carbon dioxide is not captured. Today, "grey" hydrogen makes up the bulk of production. Hydrogen is sometimes called "grey" to indicate that it is derived from fossil fuels without capturing greenhouse gases, and the difference from "brown" or "black" hydrogen is only that it produces less emissions.

Hydrogen is considered "blue" if the emissions from the steam reforming process are captured and stored underground by industrial carbon capture and storage (CCS) to prevent it from spreading into the atmosphere. However, a significant amount of carbon dioxide can not be captured, and the production of "blue" hydrogen requires a large amount of natural gas.

Hydrogen is called "pink" if it is the result of electrolysis using nuclear energy technology.

"Yellow" hydrogen is produced by electrolysis using mixed sources, depending on what is available: from RES to fossil fuels.

"Green" hydrogen is considered to be pure. It is produced using electricity from RES. Today, "green" hydrogen accounts for about 1% of total hydrogen production. The European Commission intends to change this and has developed a comprehensive strategy to support hydrogen production, highlighting its potential for a climate-neutral Europe and at the heart of the EU Green Agreement (and its budget). It is in the production of this "green" hydrogen that the EU, in particular Germany, sees Ukraine as its partner. By the end of 2021, the Ministry of Energy of Ukraine must present and approve the country's Hydrogen Strategy. Germany did it in 2020.

It is possible to produce "green" hydrogen where there is an excess of electricity produced by RES, namely the sun or wind. Therefore, four regions were selected for the production and transportation of green hydrogen in Ukraine: Zaporizhzhia, Kherson, Dnipropetrovsk and Odesa. This is the territory of the shelf of the Azov and the Black Seas, where you can place huge wind farms. Powerful WPPs and SPPs have already been put into operation and are functioning thanks to the state policy of stimulating the development of RES through the "green tariff".

Despite the fact that the Carpathian macro-region does not belong to the territories where there are large and powerful wind farms and power plants, the potential for production of "green" hydrogen for the needs of communities is available here. In the end, the experience of Germany proves it. Green hydrogen production is a way to diversify energy for public transport and heating buildings in communities, as well as to accumulate surplus electricity generated by RES facilities. For example, the grid may not always receive the entire amount of electricity generated by a SPP or a WPP. In order not to overload the grid and not to stop electricity generation, excess electricity is directed to the production of "green" hydrogen.

Today, hydrogen production is the least common and used area of smart energy for the Carpathian macroregion. Nevertheless, hydrogen energy deserves its place in the Joint Concept of smart energy in the Carpathian macroregion, as one of the most promising energy sectors in the European macroregion with extremely sensitive to human activities anthropogenic mountain forest nature.

III.3. FACTORS THAT CONTRIBUTE TO AND DO NOT CONTRIBUTE TO THE JOINT IMPLEMENTATION OF SMART ENERGY IN THE CARPATHIAN REGION

III.3.1. General remarks

As part of the analysis of the problem field of this Concept, we have already postulated (see 1.1.) the existence of 3 diverse and multilevel problems of practical implementation of measures and actions to implement the Green Energy Transition in the target natural-geographical border Carpathian macroregion of 5 countries (Romania, Slovakia, Poland, Hungary, and Ukraine). Below you can find a brief summarisation of this list of problems:

1. Legal disparities between the 5 participating countries regarding the joint and/or coordinated implementation and technical implementation of RES (especially between Ukraine and the EU neighbouring countries).

2. The need for constant and **particularly careful consideration of environmental balance,** especially in terms of informal coordination and coherence of RES projects that are expected to cause cross-border impacts: surface water bodies and groundwater; water collection systems and river basins; natural ecosystems and cross-border ecosystems, in particular forest ecosystems and virgin forests; foothill and mountain and alpine zonal natural ecosystems with especially valuable flora and fauna and natural mountain landscapes, etc.; nature reserves and protected areas of different levels of protection: from natural monuments of forest importance to forest reserves, regional landscape parks, biosphere reserves and reserves and national nature parks, etc.

3. Lack of good practices and experience of mutually coordinated, agreed and effective joint solution of RES issues and implementation of RES projects in the Carpathian macroregion. As of 2021, when all the above countries of the Carpathian macro-region are in roughly equal starting conditions for the development and mass implementation of RES projects for active participation in the Green Energy Transition, the lack of practices and experience of joint (or agreed) RES projects with cross-border component is totally clear. Moreover, almost all 5 countries of the Carpathian macroregion, as noted in the previous section (see III.2), will be in **phase 1** (building responsible public relations and realising the inevitability of active participation of all stakeholders in the global Green Energy Transition) **for several more years.**

4. However, our analysis would be clearly incomplete if we did not outline in general terms the main constraining factor of the global level for the implementation of the Green Energy Transition. This is an expressed in global financial and socio-economic consequences **price that the humanity will have to pay for the transition from the current "carbon" economy of many countries** (metallurgy, cement, chemical industry, production of building materials and fertilisers, transport on internal combustion engines, diesel and turbojet engines, etc.) to the complete decarbonisation of many economic sectors. This is summarised in the section below on EU countries.

III.3.2. *Who and how will pay for the decarbonisation of the economy in the EU?*

There is no doubt that the protection of the environment and the containment of the negative effects of global climate change after the international summit in Glasgow (2021) has become an unalterable global trend of improving the situation on the planet. At the same time, the Green Energy Transition is already perceived by the world community as the last chance to avert a global catastrophe for the Nature and the Human.

At the same time, the process of decarbonisation of many industrial technologies in developed countries, which make a huge contribution to the entry of greenhouse gases (especially carbon dioxide and methane) into the atmosphere, not only effects the strategic interests of multinational corporations in world markets, but also has strong influence on the consumers that will be forced to "feel" the socio-economic consequences of the "Green Energy Transition".

For example, in the EU, almost 80% of all industrial production for the Green Energy Transition will need significant modernisation. Experts on the EU economic development believe that their industrial policy until recently was exclusively "defensive" to competitors in the world economy and was not far-sighted. EU governments have often shied away from interventions that could harm competition between businesses already operating in domestic markets and have therefore lagged behind in industrial competition in foreign markets. At the same time, taxes on energy resources (which account for almost 60% of EU environmental taxes) for heavy industry remained low due to a number of complex preferential tariffs and benefits. And a wide range of grants, such as grants, investment support, research and development and innovation grants, were provided without clear conditions or early planning for the implementation of results.

However, stimulated by the non-alternative nature of the Green Energy Transition, the situation in the EU is beginning to change for the better. Thus, the Netherlands and Germany have recently announced a number of new climate goals and laws, including quantitative targets for industrial emissions. Until recently, the German "approach" to stimulating the Green Energy Transition was based on R&D funding (research and development) and investment in the development of new markets for environmentally friendly products.

The Netherlands opted for a combination of the so-called "whip and gingerbread" method. These include combined subsidies, rising CO_2 prices and the revision of government policies on the taxation of different types of energy produced and consumed. The adopted political and economic "bet" in the Netherlands and Germany is inclined to a compromise in which market adjustment in combination with indirect and direct measures of state support is expected to contribute to the "greening" of the economy.

Some countries, including Belgium, have relied on a full-scale industrial Green Energy Transition, and the country's only and major steel producer will receive significant government support to modernise production facilities.

In many EU countries, the rhetoric of public speaking has changed markedly in recent years, with top-level politicians and government officials ranging from perceiving global climate (and energy) challenges as a burden, a challenge and a danger, to promoting the benefits of their leadership in Green Energy Transition, including the modernisation of the economy and industrial production and energy. In fact, this is evidence that such countries and their political and business elites are successfully passing **Phase 1 (the formation of responsible public relations and awareness of the inevitability of the "Green Energy Transition"** (see subsection III.2)).

The EU already recognises that the economic approach, according to which private investment determines the direction of economic development without interfering with how and why plants and factories (and companies in general, including multinational corporations) produce goods, **is losing relevance.** Therefore, the public sector will have to formulate and consolidate the relevant legal acts with a clear and comprehensive view of sectoral climate goals with the subsequent inclusion of these goals in economic decision-making processes.

As we can see, the Green Energy Transition also stimulates the reformatting of relations between the state and the private (corporatised) economy in general in the direction of subordination to the goals of the new global energy paradigm of mankind.

In fact, the creation of new markets with the gradual closure of existing ones involves the development of transparent "rules of the game" for all economic players, including: approval of requirements for instruments and amounts of subsidies, taxation, licensing and regulatory procedures, R&D grants; development of new infrastructural solutions and mechanisms of state financing. Thus, EU governments, rather than "natural" markets, will have to take over: harmonisation of pricing mechanisms; development of principles for attracting investments related to the implementation of the Green Energy Transition; creation and implementation of uniform rules for regulating economic activity in the implementation of the new energy policy, etc.

According to European experts themselves, it is in the initial stages of **Phase 2 (sustainable and constant growth of specific actions and projects for the practical implementation of the Green Energy Transition)** that "demarcation lines" may emerge. These demarcation lines demonstrate the diversity of strategic planning at the EU level and the difficulty of bringing to a common denominator the proposed ways to implement green transition initiatives. Under such conditions, the determining factor in bringing the "common denominator" may be a combination of unifying factors and advantages not only at the national level (-s), but at the **international macroregional level** (see Table 2.2.), and in particular in the **Carpathian macroregion.** Indeed, the **unifying factors** for the cross-border areas of the 5 countries of the Carpathian macroregions are **much more influential** than the three multifaceted and multilevel issues of joint practical implementation of many Green Energy Transition approaches and projects listed above in Chapter III.3.

Below you can find a short list of such **unifying factors and benefits for the integrated natural-geographical Carpathian macroregion** (see the physical and administrative map of the macroregion below in this subsection):

1. Proximity of the set of spatial and territorial natural and infrastructural and urban features and characteristics of the Carpathian macroregion (see subsection II.1.2.) as a separate mountainous, foothill and lowland areas of the mountains of the Carpathian Arc in the centre of the European continent (forms the proximity and unity of approaches to environmentally sustainable implementation of measures and facilities of the Green Energy Transition, given that the Carpathian macroregion is an exceptional natural heritage for Europe and the world).

2. Sufficiently high energy potential of almost all types of RES in the entire Carpathian macroregion.

3. Absence in the Carpathian macro-region of large industrial complexes with intensive use of carbon energy (which to some extent equates the approaches of national policies of the Carpathian macroregion to the implementation of measures and actions of the Green Energy Transition in the Carpathian border areas), and allows over time to **move from a the joint concept to the Strategy for the development of smart energy in the Carpathian macroregion.**

4. Existence of more than 30-year old traditions, practices and experience of effective interregional, inter-municipal, scientific, business and humanitarian cross-border cooperation in the Carpathian macro-region both bilaterally and multilaterally (in particular, within many programmes of the European Neighbourhood Instrument and other donor funds, as well as the Interregional Association "Carpathian Euroregion" established in 1993 and the European Group of Territorial Cooperation "Tysa", etc.): see the map of the administrative regions of the 5 countries that are members of the Interregional Association "Carpathian Euroregion" at the end of this section.

5. The set of prerequisites necessary for the implementation of energy democracy and small (distributed) power generation approaches through the use of RES is currently available both in the EU countries and their regions bordering with Ukraine in the Carpathian macro-region, as well as after the completion in 2020 of the first

stage of decentralisation reform in Ukraine, including in the Carpathian border region, namely Zakarpattia, Lviv, Ivano-Frankivsk and Chernivtsi *(see the map of 64 territorial communities in Zakarpattia region).*

6. We should gradually but quickly overcome some lagging of Ukraine from the EU's neighbours in the legal field in terms of development and implementation and technical implementation of RES facilities, taking into account complex environmental laws and international legal agreements ratified by Ukraine. This is described in the next section below.

III.3.3. How is Ukraine harmonising its energy policy with the Green Energy Transition?

As of 2021, it is safe to say that over the past 5 years, the balance of power in Ukraine's energy sector has been constantly changing in favour of RES, namely the RES industry has changed radically. The turning point in the situation on the RES market was 2016, when investors in the RES industry really gained a foothold in Ukraine, and a number of relatively large manufacturers of solar panels and related equipment opened their offices in Ukraine.

In 2016-2019, the country had a favourable legislative framework and a guaranteed "green tariff", as well as RES financing programmes from both the European Bank for Reconstruction and Development (EBRD) and financial institutions of Ukraine. Owners of medium and large businesses have increased interest in the energy market through RES.

Lack of restrictions on the size of solar power plants (SPP) has also contributed to the growing interest in RES in Ukraine, and this fact acting in conjunction with other favourable factors, could not help but contribute to the rapid increase in capacity of solar energy.

Many Ukrainian experts in the field of energy development characterise the period of rapid growth of solar energy in 2016-2019 from a slightly different angle. It is noted that during this period in Ukraine the authorities, as well as permit and law enforcement agencies did not care much about such "trifles" as parity of interests, compliance with antitrust laws, transparency and equal access to land and other resources in investment design and construction of SPPs. The situation was and still is the same with a large share of investment projects in the promotion and construction of small hydropower plants (HPPs) and wind power plants (WPPs) in the Carpathians. Were they not too worried or habitually turning a blind eye to environmental laws and international legal acts on environmental protection, such as the Carpathian and Berne Conventions, contributing to the negative characterisation of the country as a corrupt territory? And in some cases, according to journalistic investigations, the technology of solar energy and other RES facilities has repeatedly been added to the "construction" of semi-criminal business models in the style of the 1990s, a phenomenon that often accompanied only the first 10 years of independence of Ukraine. Given these characteristics of 5 years of RES growth, including solar energy in Ukraine, the rhetorical question is whether such negative factors contribute to

cross-border cooperation in the Carpathian macroregion with the aim of joint implementation of RES within the Green Energy Transition? And can the confidence of the EU neighbours of Ukraine grow, given that the mountain ecosystems of the Carpathians are a common natural heritage for all 5 countries of the Carpathian macroregion? The Resolution of the Berne Convention on the Threats of the Emerald Network (Borzhavski Polonyny in Zakarpattia Region of Ukraine) from the construction of 34 wind farms with 34 windmills with a total capacity of 120 MW (contained in the annexes) is remarkable regarding this aspect of the cross-border problem of nature and environment protection.

In 2020-2021, the solar energy market of Ukraine and other Central and Eastern European countries is developing, despite the global crisis caused by the COVID-19 coronavirus pandemic, on the one hand, and a certain imbalance over the past 2 years of de facto public policy in Ukraine to inhibit the development of RES, on the other hand. The target border regions in the Carpathian macroregion, which covers the territories of 5 countries, including Slovakia, Poland, Romania, Hungary and Ukraine are characterised by the same trend in the construction and/or sustainable operation of electricity generation at SPPs.

In the table below in the context of the regions of Ukraine for comparison, the total installed capacity of SPPs only for households (as of April 1, 2021, in MW) is given in descending order of rating. While analysing the table, we can see that among 4 regions of the Ukrainian Carpathians, the rating location of the regions is as follows: **Zakarpattia region** - 66.6 MW (1st place, 3rd place in the overall ranking of regions); **Ivano-Frankivsk region** - 61.4 MW (2nd place, 4th place in the overall ranking of regions); **Chernivtsi region** - 39.2 MW (3rd place, 9th place in the overall ranking).

The total installed capacity of SPPs in households in 4 regions of the Ukrainian part of the Carpathian macro-region is 195.9 MW, which is a total of 23.46%, almost a quarter of the same figure throughout Ukraine. While the population in these 4 regions is 6077.0 thousand people, which is only 13.91% of the total number in Ukraine (no data on the Autonomous Republic of Crimea, the temporarily occupied territory of Ukraine). And Zakarpattia region, which ranks first among the 4 regions of the Ukrainian Carpathians, having 2.86% of the population of Ukraine, has installed and operating capacity of SPPs of 66.6 MW, which is almost 8% of the total capacity of SPP households in Ukraine. Of course, the correlation between the population of the region and the amount of SPP capacity established by households is indirect (conditional), because the potential capacity and investment activity of households depend on many factors. But in any case, it is obvious that the border regions of the Ukrainian Carpathians are much more active in investment in the practical implementation of SPP projects in their households than other regions of Ukraine (excluding the traditionally innovative Dnipropetrovsk region).

As for Zakarpattia region only, where Ukraine has state borders with Romania, Hungary, Slovakia and Poland, as of November 2021 there are 77 generating power plants with a total capacity of 295.5 MW. In particular, these are 14 hydropower plants, 2 biogas plants and 61 hydropower plants of various capacities.

Over the past 5 years, SPPs in the region have developed rapidly and they now dominate the production of electricity in the region. Historically, the first and oldest and longest-running power plants in the region were small hydropower plants (SHEPPs) built in Uzhorod (Uzh river) and on its derivation canal in the village Onokivtsi near the city are dated back to Czechoslovakia in the 1930s. In Soviet times, a relatively large hydroelectric power plant was built according to the original project from the Czechoslovak period on the waters of two rivers: Tereble-Ritska hydroelectric power station (27 MW). Much later, in different years, 5 small hydropower plants (9.03 MW) and 8 mini-hydropower plants (6.63 MW) were built. Among the SPPs built and put into operation relatively recently, there are 48 terrestrial SPPs (total capacity 245.71 MW) and 13 roof SPPs (total capacity 5.42 MW). If you add to this number of introduced SPP capacities those built in households (see table 3.1 above), it is quite obvious that among RES power plants in Zakarpattia **SPPs are out of competition in comparison with HPPs.** Meanwhile, the construction of the SHEPPs on the mountain rivers of the Carpathians poses the greatest environmental threats and challenges. At the same time, the occupation of small mountain rivers of the Ukrainian Carpathians by the "green tariff" developers-investors, despite the obvious benefits of SPPs, only intensifies, causing concern and opposition both in the environmental community and in local communities.

Table 3.1.

Distribution of SPP capacity of households in the regions of Ukraine State Energy Efficiency, as of April 1, 2021

Region	Rating	population, thous. people	% of total quantities in Ukraine	total capacity of SPP, MW	% of total capacity in Ukraine
Dnipropetrovsk	1	3320,3	7,60	122,3	14,65
Ternopil	2	1080,4	2,47	73,8	9,55
Zakarpattia (*)	**3**	**1250,7**	**2,86**	**66,6 (*)**	**7,98 (*)**
Ivano-Frankivsk (*)	**4**	**1380,1**	**3,16**	**61,4 (*)**	**7,35 (*)**
Kyiv	5	1719,5	3,94	53,5	6,40
Khmelnytskyi	6	1320,2	3,02	48,1	5,76
Kirovohrad	7	1002,4	2,29	47,5	5,68
Kherson	8	1083,4	2,48	44,7	5,35
Chernivtsi (*)	**9**	**905,3**	**2,07**	**39,2 (*)**	**4,69 (*)**
Odesa	10	2388,3	5,47	32,1	3,84
Vinnytsia	11	1634,2	3,74	28,7	3,44
Lviv (*)	**12**	**2540,9**	**5,81**	**28,7 (*)**	**3,44 (*)**
Volyn	13	1038,6	2,38	21,7	2,59
Mykolaiv	14	1178,2	2,70	21,4	2,56
Zhytomyr	15	1273,2	2,91	20,9	2,50
Cherkasy	16	1277,3	2,92	20,8	2,49
Donetsk	17	4403,2	10,08	18,7	2,24
Sumy	18	1152,3	2,64	17,8	2,13
Kharkiv	19	2742,2	6,28	16,4	1,96
Poltava	20	1477,2	3,38	15,1	1,80
Rivne	21	1154,3	2,64	14,6	1,74
Zaporizhzhia	22	1791,7	4,10	9,9	1,18
Chernihiv	23	1088,5	2,49	5,5	0,65
The city of Kyiv	24	2952,0	6,76	3,7	0,44
Luhansk	25	2272,7	5,20	2,2	0,26
Total in Ukraine *	26	43670,6	100*	835,0	100

*) There is no data on the Autonomous Republic of Crimea, the temporarily occupied territory of Ukraine

III.4. RECOMMENDATIONS FOR THE IMPLEMENTATION OF THE JOINT CONCEPT IN TERMS OF STAGES AND TASKS

III.4.1. Generalised recommendations for implementation within the two-stage process

In Section III.2 we postulated the need for a coherent understanding of such components of smart energy implementation (in the sense of joining the Green Energy Transition) as consistency, interconnectivity and phasing of action for all stakeholder groups in target border territories of the Carpathian region. In particular, the two-phase implementation processes were highlighted, namely:

Phase 1: formation of a **responsible attitude** to the new paradigm of global (as well as local and regional) energy through regulations at various levels, education, diffusion of innovation, coordinated adoption of strategies and programmes, etc., which in general will promote **advanced and abrupt public awareness** of the inevitability of active participation of all stakeholders in the Green Energy Transition. This phase 1 (public awareness) should not last too long (not more than a few years).

Phase 2: constant and sustainable increase of specific actions and projects on practical realisation of Green Energy Transition both in the urbanised territories of cities, towns and villages, and at the industrial enterprises, in establishments and the organisations of non-productive sphere, on the fields of transport and power, etc.

It is especially pointed out that specific actions and projects of the new energy of the Green Energy Transition concern all constituent components (areas) in the interconnected chain: “generation (production) of energy (heat) - transportation - energy consumption (heat)”. Phase 2 has actually already begun. And it will continue continuously over time and with varying intensity across countries and continents until the Green Energy Transition is fully completed (approximately in 2050 in most EU countries).

In a sense, Phase 1 can be considered as one that requires more intellectual effort (and “soft” projects) of:

- structures of legislative and executive power at the central level (new laws and regulations, government decisions, bylaws, state planning documents such as strategies, programmes, etc.); at the regional and subregional levels, including local governments at these levels; basic bodies of local self-government of territorial communities of cities (towns), settlements and villages;
- sectoral ministries and departments;
- scientific and educational organisations and institutions, including universities, academic and branch institutes, research and implementation organisations of various forms of ownership, etc.;
- civil society sectors of development, as well as scientific, technical, information and resource, environmental activities, etc.;
- business circles and business associations and enterprises in the fields of energy and energy consumption.

Phase 2 is represented by already specific projects and practical steps and actions for their implementation in the framework of innovative project management.

It is obvious that both the implementation of the tasks and projects of Phase 1 and Phase 2 will require sources of funding and state support, as well as financial support from the International Technical Assistance Programme (ITAP) and national governments of the Carpathian macroregion.

Coordination of coordinated activities planning for the implementation of the Joint Concept of Smart Energy in the Carpathian macroregion can take place within the existing institutions of cross-border cooperation (Danube Strategy and the relevant Danube Danube Transnational Programme; Interregional European Association "Carpathian Euroregion", European Group of Territorial Cooperation "Tysa", Visegrad Fund etc.) and through the **establishment of new cross-border stakeholder network structures** (for example, Danube Energy Regional Hub; Memorandum on Cooperation of Territorial Communities within the NESiCA Project - see Annexes).

It should be noted that both in the time interval of Phase 1 and Phase 2, the design and intellectual efforts must also be based on the **platform of values of the Joint Concept** (see subsection I.2).

III.4.2. *Recommendations for practical implementation of the Joint Concept within the framework of the goals and objectives*

The objectives, seven basic principles and 8 tasks of the Joint Concept of Smart Energy in the Carpathian Region are so large, significant and important that at the end of the Concept text and analysis of recommendations we consider it appropriate and necessary to fully reproduce them.

The **purpose** of the "Eco-Smart Energy - Carpathia" Concept is:

- to ensure comprehensive support on the ongoing basis for all target groups and interested parties (stakeholders) of the Carpathian macroregion in achieving proper awareness, competence and professionalism in the development of methods, approaches and means of "smart" energy in the practical implementation of innovative and energy efficient solutions and projects in various life areas of the communities of towns and villages, as well as in the reduction of the greenhouse gas emissions, making local contributions to the implementation of the European Green Energy Transition tasks and solutions to global problems connected with the climate change caused by man-made anthropogenic human activities;

- to increase significantly the competitiveness of the Carpathian macroregion in Europe and the world through coordinated, intensive and modern cross-border energy development with unconditional adherence to the approaches of sustainable (environmentally balanced) development.

The **basic principles** of the "Eco-Smart Energy - Carpathia" Concept are the following:

a) Coherence and harmonisation with the 7 main strategic components of the European Strategic Concept of climate neutrality - 2050: energy efficiency; deployment of RES; transition to environmentally friendly transport; circular economics; "smart" networks and communications; bioenergy and technologies of natural carbon sequestration.

b) Compliance with the approaches of sustainable development of territories and communities, i.e. the practical compliance of balance (coherence, harmonisation) of economic, environmental and social components of their development.

c) Comprehensive (systemic) approach to the implementation of multi-factor, systematic optimizational analysis and development of practical recommendations within the Joint Concept.

d) Providing pivotal position considering the adopted **5 EU evaluation criteria on the prospects of success and implementation of the Joint Concept, as a strategic document, namely relevance** (compliance); **effectiveness; efficiency; influence; sustainability.**

e) Ability to adapt (make adjustments and / or changes and additions) to the documents of regional strategic and spatial planning for the target border regions of Ukraine, Slovakia, Hungary, Romania, and Poland, as well as the Interregional Association "Carpathian Euroregion".

Below you can find the generalised recommendations for each of the 8 tasks of the Joint Concept for their practical implementation:

TASK 1:

Achieving full coherence of the conceptual provisions and recommendations of the Joint Concept for the target cross-border area of the Carpathian region and target groups with 7 strategic components of the European Strategic Concept of climate neutrality - 2050, on the one hand, and the ability of recommended approaches and practices of smart energy to adaptations (adjustments and changes) with documents of regional strategic and spatial planning for the target border areas of the Carpathian macroregion, on the other hand.

Such a large-scale task, in our opinion, can be completed in Phase 1 in 3-4 years, taking into account tens and hundreds of regions and administrative-territorial units of subregional and basic levels of cities, towns and villages in the Carpathian macro-region. Nevertheless, the leading and guiding role should be the development and coordination of the ***Strategy for the Development of Smart Energy and Energy Efficiency in the Carpathian macroregion*** *(provided for in task 5 of this Concept) with the 5 countries of the Carpathian macroregion. However, without waiting for this planned Strategy, it is advisable to implement the ideas and provisions and objectives of this Concept in the development of Strategies for development of territories of individual regions, subregions, cities and communities (see the annexes for standard recommendations for strategic planning for the development of territorial communities in Zakarpattia region, Ukraine, in the format of a separate operational goal and operational objectives of the Community Development Strategy).*

TASK 2:

Providing information and resource prerequisites and focus on the implementation of modern European innovative technical and technological solutions in the fields of energy and energy efficiency, and taking into account the positive experience and experience in the target border regions of the Carpathian region.

It should be noted that in order to form dynamically changing and up-to-date information and resource and open to public access databases, it is advisable to develop a separate major project, involving even several professional organisations (consortium) working in various fields of energy information and resource provision, as well as ESCOs (energy service companies). With regard to "positive experiences and developments in the target border regions", this important task can be successfully implemented as an analytical and descriptive part planned for the development of the **Smart Energy Development Strategy in the Carpathian macroregion** (provided for in Task 5 of this Concept).

TASK 3:

Focusing on the sectors with the largest share of energy consumption in the target border regions, as well as on the implementation of RES using available and affordable local energy resources, subject to unconditional adherence to the principle of sustainable development of the territory and / or community of the target Carpathian macroregion, including the main provisions of the Carpathian Convention and national environmental legislation of each of the participating countries and beneficiaries of the Joint Concept.

Ecological and conservation balance of energy development of communities and territories of the Carpathian macroregion is too important and fateful for the Nature and the Human and their future to be entrusted only to business circles and investors in the field of energy development at RES. Especially in terms of stimulating the implementation of energy projects "green tariff" and cheap loans and more. Therefore, Task 3 is recommended for the implementation of environmental orientation by universities, research institutions, regional development agencies and civil society organisations.

TASK 4:

Proposing a system of monitoring the achievement of the Goal and the implementation of the tasks of the Joint Concept in a certain medium-term period until 2027 in the Carpathian region.

In our opinion, it would be expedient to combine the system of monitoring the implementation of both the developed Concept and the one planned for the development of the Strategy for the Development of Smart Energy and Energy Efficiency in the Carpathian Macro-region (see Task 5).

TASK 5:

Ensuring the use of the ideological and resource-information potential of the Concept for the expected development on its basis of the draft Strategy for the Development of Smart Energy and Energy Efficiency in the Carpathian Macroregion.

To develop this draft Strategy, it is advisable to use the organisational experience of the Carpathian Euroregion - 2020 Development Strategy in 2013-2014: with the establishment of an international (5 countries of the Carpathian region) working group to involve experts in energy, spatial and strategic planning, ecology and nature protection.

TASK 6:

Promoting (through the dissemination of information and implementation of the objectives of the Concept) the alignment of strong disparities in sustainable innovation and energy development of territories and communities of the Carpathian macro-region in the areas of: "cities - rural areas"; "lowland areas - foothills and mountainous areas"; "Western regions of Ukraine - Eastern regions of the EU countries, namely: Hungary, Slovakia, Romania, and Poland".

In order to set and implement this task, it is advisable to analyse and summarise the experience of each of the 5 countries of the Carpathian macroregion in these issues (as part of a separate project), explore and summarise the experience of other mountainous regions in Europe and the world, as well as to identify these problems (equalisation of disparities in energy and regional and local development of mountainous and foothill areas with lowlands) within a separate strategic goal (operational goal) proposed for the development of the Strategy for Smart Energy Development and Energy Efficiency of the Carpathian Macroregion.

TASK 7:

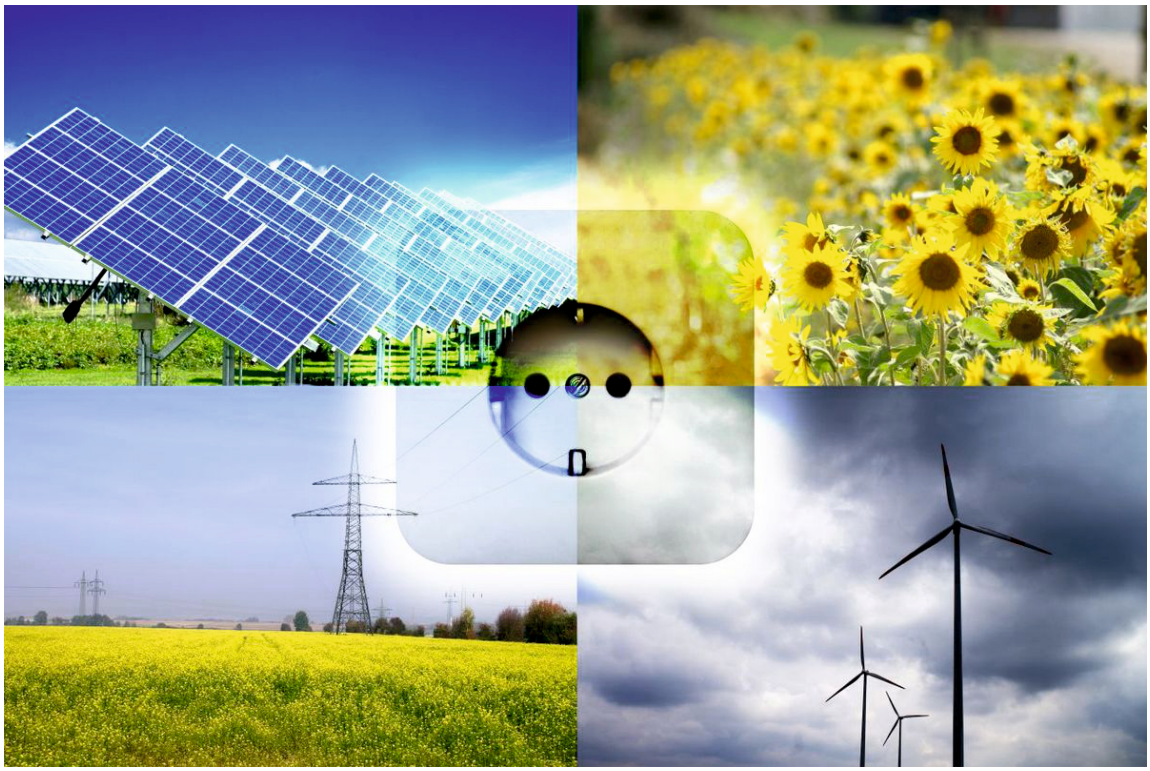
Achieving (through the implementation of the Joint Concept) the establishment of universities, research and consulting organisations, expert NGOs and energy service companies (ESCOs) as a network of drivers of education and science, energy development and sustainable and smart energy, as well as hubs of energy efficiency and smart energy and grid production associations-clusters.

It should be noted that, on the one hand, "universities, research and consulting, expert public and energy companies and ESCOs" seem to have no competitors in these areas, but, on the other hand, it is these organisations and institutions and companies, that having proper intellectual potential and information and human resources, rarely combine their efforts (especially through international and cross-border cooperation) and/or take initiative in the field of energy using RES or other promising technologies of the Green Energy Transition. We need more active efforts, intensification of partnership, introduction of new, more effective forms of cross-border scientific and business cooperation, formation of effective cross-border partnership networks.

TASK 8:

Turning the Joint Concept into one of the most important intellectual, educational, information-resource and consulting platforms for the successful implementation and promotion of the European Green Energy Transition in the border areas of the Carpathian region.

In our opinion, it is expedient to separately form information and communication pillars and foundations of this platform, using the full arsenal of modern approaches and methods of digitalisation and opportunities of social networks and television and radio, national and international forums, exhibitions and fairs, development and implementation of various educational and training programmes, trainings, distance courses, etc. A separate component of this platform should be media support for the active participation of communities and citizens, local authorities and other stakeholders in the implementation of the Green Energy Transition in the Carpathian macroregion. The branding of green energy in the Carpathians is also in demand, as well as the formation of the exceptional prestige of business and public activity in solving the tasks of the Joint Concept of Smart Energy in the Carpathian region.



CHAPTER IV.

THE IMPACT OF GLOBAL CHANGES ASSOCIATED WITH THE FULL-SCALE AGGRESSIVE WAR OF RUSSIA AGAINST UKRAINE IN 2022 ON THE DEVELOPMENT OF SMART ENERGY IN THE CARPATHIAN REGION

IV.1. *GENERAL REMARKS: FROM GLOBAL TO REGIONAL AND LOCAL IN THE ANALYSIS OF WORLD CHANGES*

Sections I-III of this Concept were developed and discussed and approved by the partner expert cross-border community of the Project "New Energy Solutions in Carpathian area (NESiCA)" back in 2021, i.e. before the start of the full-scale invasion of military occupation forces of the Russian Federation (RF) on the territory of the independent and sovereign state of Ukraine on February 24th, 2022. Now, after a year of Russia's aggressive and brutal war against Ukraine, we consider it necessary within the framework of this section IV to carry out certain generalizations and adjustments and clarifications to sections I-III of this Concept with the sole purpose: **to reflect the impact of global changes associated with Russia's war against of Ukraine, on the most likely development of energy in the Carpathian region in general and on the possibility of implementing those recommendations on smart energy that were developed within the framework of this Concept.**

Below in the table IV.1.1. there is a list of new factors of significant changes that in a relatively short annual period from February 2022 until March 2023 took place in all 8 directions of globalization processes (see fig. 3 of section II.2 "Global energy development trends of the XXI century" of this Concept). In particular, we are talking about the following 8 directions (aspects, faces) of globalization processes: **political; economic; information technology; ecological; safe; social; demographic; cultural.**

Of course, in our concise table, it is impossible to reflect the entire spectrum of changes in globalization processes in the world, therefore, these changes are **analyzed more from the standpoint of their impact on the field of energy and energy development of developed countries.**

Table 4.1.1.

Distribution of SPP capacity of households in the regions of Ukraine State Energy Efficiency, as of April 1, 2021

Direction and list of changes	Outcome and impact
1. POLITICAL DIRECTION	
1.1. According to world politicians and experts the full-scale invasion of the troops of the Russian Federation (RF)	**1.1.** The beginning of a large-scale war of the Russian Federation against Ukraine after 8 years of a hybrid war in

into Ukraine on February 24, 2022 (after more than a year of war) as of March 2023 **became the biggest geopolitical event after the end of World War II in 1945.** The war is still ongoing, but it is potentially able to change the course of world history due to the possible restructuring of the global international security system into a more effective and fair one (in the case of the victory of Ukraine and the democratic West).	Donbas and the annexation of Crimea became a symbol of the collapse of the irresponsible and dishonorable policy of "appeasement of Russia" on the part of Western countries, which finally actually recognized their strategic mistakes regarding relations with neo-imperial Russia throughout the entire period after World War II. The sanctions policy against Russia was launched and is being strengthened, Ukraine constantly receives humanitarian, financial and military aid from the democratic countries of Europe and the world.
1.2. Or, on the contrary, in the case of a temporary victory of Russia, for the first time in world history and geopolitics, an aggressive and large-scale genocidal war will continue the stage of actual extermination of the independent Ukrainian state and Ukrainians as a nation in front of the developed and democratic countries of the West. In any case, such a scenario is very unlikely, because Ukrainians, as a people and a nation, will under no circumstances submit to the aggressor and occupier and will continue to fight for Freedom and the European choice of development.	**1.2.** The current strategy of the West regarding neo-imperial and dictatorial Russia, although it has changed, still suffers from a significant flaw: the political goals that the democratic West continues to follow do not adequately correspond to the aggressive ambitions of the Russian Federation to destroy even the existing fragile international legal order under the leadership of the UN.
1.3. The political (and geopolitical) changes that began in February 2022 significantly and systematically affect the other 7 directions - economic; social; information technology; safe; ecological; demographic; cultural.	**1.3.** A brief summary of new interactions between 8 directions of globalization processes (with emphasis on the field of energy and energy development) will be provided below.
1.4. In the political direction of globalization processes, the changes associated with Russia's war against Ukraine most affect the following levels (see Table 2.2 of the Concept): **global; international regional level (Europe).**	**1.4.** The importance of the international Carpathian macroregion, where the rear 4 regions of Western Ukraine have state borders with the EU countries (Poland, Slovakia, Hungary, and Romania) during the war between

At the international level of the the **Carpathian macroregio**n targeted by the Concept, including 4 regions of Western Ukraine, which are rear regions, there are no changes in **regional policies** (in contrast to the regions of Eastern, Southern and North-Eastern Ukraine, which were or are still occupied by Russian troops). Of course, in case such changes do not include the **significant intensification of all aspects of cross-border processes.**	Russia and Ukraine, is huge from many positions related to cross-border processes: **military and humanitarian aid and trade; flows of refugees and migrants; transportation of energy resources; business relocation and attracting and implementing investments; ensuring stability of energy systems, etc.**
1.5. As of March 2023 (a year after Russia's full-scale invasion of Ukraine), the developed democratic countries of the West gradually, but eventually **irreversibly and radically reduced the policy regarding the supply of most economically important energy resources from Russia** (natural gas, oil, coal, fuel for nuclear power plants, etc.), with the exception of only a small number of countries that need longer terms to reorient their economies and energy sectors to other energy markets. At the same time, we are talking not only about the temporary policy of sanctions, but also about complete energy independence from Russia for the long term.	**1.5.** The new energy paradigm of the development of the democratic West and Ukraine is accompanied not only by a reorientation to other markets for the supply of traditional (fossil, carbon) energy resources, but also by the **adoption of political decisions on speeding up processes related to the large-scale implementation of the "Green Energy Transition" on the basis of wide implementation RES and smart energy in general.**
2. ECONOMIC DIRECTION	
2.1. Russia's full-scale war against Ukraine caused colossal **economic losses** over the course of 1 year, which manifested themselves and continue in the future, primarily and most of all, in Ukraine itself. In general, the economic indicators have deteriorated somewhat for many other developed democratic countries of the world, of course, not as catastrophically as in Ukraine.	**2.1. The economic consequences of Russia's invasion of Ukraine after a year of war** (analyzed by Forbes magazine, February-March 2023): - decrease in GDP: **30.4%**; - decrease in exports relative to 2021: **29.9%**; - decrease in imports relative to 2021: **3.9%**;

It is worth noting that, in general, the global economy at the beginning of 2022 has not yet recovered from the crisis impact of the COVID-19 pandemic and from the negative impacts of other global factors, in particular such as climate change and the need for the fastest possible introduction of carbon-free energy on a global scale in order to slow down and prevent the negative consequences of the global warming.	- decrease in the exchange rate of the national currency to the US dollar: **25.4%**; - decrease in the volume of international currency reserves: **25.4%**; - decrease in the amount of international currency reserves: **7.9%**; - direct economic losses from the war: **USD 349 bln**; - dead civilians: **28,826 people**; - the number of citizens who left Ukraine: **about 8 million people**; - volume of international financial assistance: **USD 32 billion dollars (not counting humanitarian and military aid)**; - volume of direct foreign investments: **about USD 31 million dollars (much lower than in previous years)**.
2.2. The governments and leaders of the democratic countries of the West are gradually realizing that the common **European and world economy, with Russia's participation in it, has changed fundamentally and irrevocably** not only during the war with Ukraine and the sanctions policy, but **for a long time in the foreseeable future**. And this is due to the fact that Russia needs not only to be defeated in the current military confrontation, but also peaceful coexistence with it in the future needs to be ensured, and the solution to this task may take decades.	**2.2.** In the coming years, a period of intensive **formation of new cooperation and new economic ties is coming for the European and a significant part of the world economy, which will change the economic face, first of all, of developed democratic Europe.** Experts even predict the formation of a **new axis of economic cooperation in Europe from north to south**, as an axis of logistics, new capital investments and new forms and volumes of economic cooperation. Noting at the same time that **only thanks to the intensification of such cooperation, it is possible to compensate for the losses that European countries have from changing directions of economic activity and foreign trade.**

	For the European Carpathian macro-region, which includes 4 regions of the Ukrainian Carpathians, as well as the southern voivodships of Poland, most of the regions of Slovakia, many regions of Hungary and Romania, some regions of the Czech Republic, Serbia and Austria, **the idea of forming a north-south axis** (from the Baltic to the Balkans and Andriatica) **has not only been discussed for about 10-15 years, but is also considered from the perspective of the construction of a new trans-European highway through the Carpathians from north to south.**
2.3. The energy sector of the European and world economy has changed unprecedentedly quickly and radically during the year of Russia's war against Ukraine in that part of it, which is related to the sources and trade routes of the supply of traditional (fossil, carbon) energy resources (oil, natural gas, coal). Of course, we are talking about partial or complete rejection of similar types of trade with Russia.	**2.3.** Relevant decisions were adopted in an unprecedentedly short time both in the structures of the European Union (despite the need for consensus during voting) and in individual European countries. The global and European trade arteries of the energy sector of the world economy seem to have irreversibly changed for decades and longer periods not in favor of the aggressor Russia.
3. INFORMATIONAL TECHNOLOGY DIRECTION *(covers in fact all fields of scientific and technical, economic, energy, cultural and spiritual, transport, environmental and social and communication and media activities of human communities, which to one extent or another need information and communication technologies (ICT) for working with accumulated and constantly enriched human civilizations with informational resources; of course, also with informational resources regarding the areas of energy generation, its transportation, transformation and consumption, including all types of RES).*	
3.1. Russia's aggressive full-scale war against Ukraine is aimed to carry out faster subjugation, genocide and colonization of the people of Ukraine, **to carry out large-scale destruction of the critical infrastructure of life and, first of all, the facilities of the United Energy System of Ukraine** (UESU).	**3.1.** For Ukraine, severe and large-scale destruction of the facilities of the UESU, including centralized systems and facilities for the distribution and regulation of electricity transportation to consumer regions, caused throughout autumn 2022 - winter 2023 frequent power outages in the vast

Also, starting from October 2022, taking into account the approach of the autumn-winter cold period of the year, the objects of the UESU **became priority aims** for massive attacks from the air for many months (attacks by cruise missiles, kamikaze drones, artillery and mortars, aerial bombs).	majority of cities, towns and villages (blackouts). As a result of the specified energy crisis period in the work of the UESU, the experts, politicians and leadership of Ukraine increasingly raised and initiated the issue not only of the restoration of the centralized UESU, but also of the **gradual transition to a centralized, more flexible and resistant to military and terrorist threats distributed generation of electricity in the local territories of communities.** The change of the energy paradigm from the centralized UESU to the decentralized energy system of Ukraine of distributed generation (DESURG) is fully consistent with both the European "Green Energy Transition" and the "Energy Concept of Ukraine - 2050", developed and approved by the Government of Ukraine even before the war (see 1.4). Of course, the platform for the implementation of DESURG will be various types of RES and innovative achievements in energy in general.
4. ECOLOGICAL DIRECTION *(covers anthropogenic and technogenic changes at various levels: from local microlevels and sub-regional mesolevels, regional and macroregional levels to international levels and the global, planetary level: see Table 2.2. of this Concept)*	
4.1. The longer Russia's full-scale war against Ukraine lasts, **the greater and more diverse in terms of consequences and territories (levels) the damage it causes to the environment, the more negative and long-term consequences we will have in the future both for the physical and mental health of people, and for the environment.** e.g. soils, water bodies (surface and underground), plant and animal world, air pool.	**4.1.** According to preliminary calculations and assessments of the Ministry of Environment (made, including by experts of public and scientific organizations of Ukraine), we already have the following **long-term negative consequences as of the beginning of 2023:** - the troops of the aggressor (Russia), are conducting combat operations in the vast territories of the East, South

The following leads to such negative consequences:

- movement of heavy tracked and wheeled machinery;
- construction of fortifications, including with using commercial wood;
- destruction of forests and valuable natural objects;
- numerous explosions of rockets, shells and mines;
- laying of roads, pontoon crossings or construction of military infrastructure;
- heating and cooking in the troops;
- soil and water pollution by fuel materials and petroleum products;
- destruction and burning of residential and non-residential buildings, which turns them into construction debris and ruins;
- military equipment broken in battles, rusting in the open air;
- unutilized solid household waste in front-line areas;
- improperly carried out burials of people who died as a result of hostilities;
- damage or destruction of objects in communal enterprises of water supply and drainage.

and North of Ukraine; in these territories, only the area of protected zones of the nature reserve fund is more than 12,400 sq. km, which is a third of the entire nature reserve fund of Ukraine;
- intense **chemical contamination** of residential, non-residential, agricultural and natural territories with highly toxic inorganic and organic substances and products of chemical reactions (carbon monoxide, brown gas, nitrous oxide, formaldehyde, cyanic acid vapors, sulfur and nitrogen oxides, etc.) occurred and continues; they not only chemically pollute the environment, but also cause acid rain, which negatively affects soils and vegetation, migrates into groundwater, ends up in food chains and affects animals and people;
- significant areas of natural and agricultural lands (millions of hectares) as a result of mining and chemical pollution and pollution by petroleum products have actually been removed from agro-industrial production and/or use as natural areas of protected areas, forests or recreational and health zones;
- the consequences of fires at relatively large industrial or commercial warehouse facilities cause additional pollution of air, soil, and surface and underground water with toxic substances;
- there are dozens of examples of damage (failure, destruction) of operational water supply and drainage facilities, which creates the threat of the spread of epidemics, pollution of water bodies with untreated effluents, and the cessation of clean drinking water production processes in the cities of the pre-front-line and front-line zones.

4.2. In cities with a high level of centralization of communal services, the disruption of water, gas, heat and electricity supply systems as a result of hostilities and/or remote missile attacks directly causes a **humanitarian and man-made ecological disaster**. This type of waging a genocidal war by Russia against Ukraine is rightly called **ecocide**.	**4.2.** Starting from February 24, 2022, the ecocidal actions and destruction of communal infrastructure by the troops of the Russian Federation are observed in almost all large, medium and small cities of Ukraine, which were subjected and are subjected to this day (at the beginning of April 2023) to massive missile or artillery attacks or with the participation kamikaze drones shelling: Mariupol, Kherson, Kharkiv, Kupiansk, Zaporizhzhia, Kryvyi Rih, Pavlohrad, Dnipro, Chernihiv, Sumy, Shostka, Okhtyrka, Kramatorsk, Pokrovsk, Bakhmut, Severodonetsk and other cities of Ukraine.
4.3. For the first time in recent world history, despite a bunch of international legal agreements signed by the aggressor of the Russian Federation, the occupation troops of Russia were not only stationed with military equipment and weapons on the territories and in the buildings of nuclear power plants (NPP) (at the Zaporizhzhia NPP and the Chornobyl NPP in the Chernobyl zone, which are objects of increased environmental danger for the global and all lower levels), but also **carried out shelling, provocative, dangerous and unprofessional military actions and threats, subjected the technical staff of the nuclear power plant to psychological pressure, rudely and dangerously interfered with technological regulations**. And in general, with this complex of criminal actions, they blackmailed not only Ukraine, but also the countries and governments of the entire world community.	**4.3.** The occupying forces of the Russian Federation have created and are still creating real threats to global environmental security with severe and long-lasting consequences of radiation pollution from the accident or destruction of the Zaporizhzhia NPP (the largest nuclear power plant in Europe) for tens and even hundreds of millions of people, **which is not only a war crime, but also a crime against humanity.** At the same time, criminal and provocative actions and ignoring the requirements of the IAEA and the UN regarding the cessation of military intervention in the operation of objects of increased ecological danger (nuclear power plants) were deliberately and purposefully carried out by Russia, while at the same time being a permanent member of the UN Security Council! Such actions and other war crimes and crimes against humanity directly raised the question of Russia's membership in the UN Security Council and the radical change of the entire system of global security and peace in order to maintain the world order.

5. SECURITY DIRECTION *(generally includes the following components of the systemic concept of "development security": security of human life and human communities; international security and threats of wars, terrorism, international crime, etc.; global economic security; energy security; global public health security; information security; cyber security and etc.)*	
5.1. In section II. 2.2 “Global awareness of the ecological and energy crisis in the civilisational development of mankind” of this Concept **generalizations of global** trends regarding energy and environmental crises, the consequences of which worry mankind, are made. In particular, the most important of them should be singled out: - about 25% of the world's population, i.e. 1.4 billion inhabitants, do not have access to electricity at all, and 40% of countries, as in the entire previous history of mankind, continue to rely on carbon-containing biomass; - most global energy analysts predict that despite the existing challenges and **dangers of global warming with its catastrophic consequences, energy consumption in the world will continue to grow**; even an optimistic "ecological" scenario predicts an increase in energy consumption in the world from 2000 to 2030 by more than 50% (taking into account the constant increase in the number of the planet's population); - before Russia's full-scale war against Ukraine, which began on February 24, 2022, the Russian Federation was one of the main commercial suppliers of carbon-containing (fossil) energy resources to the world market (oil, natural gas, coal, wood); therefore, neither the loss of its share in the world market of carbon-containing (fossil) energy resources, nor the acceleration of processes related to the implementation of the "Green Energy Transition" plans with the use of RES were disadvantageous to Russia;	**5.1.** As already noted in the previous subsections, the energy sector of the European and global economy in 2022-beginning of 2023 changed very quickly and radically in the part related to sources and trade routes of supply of traditional (fossil) carbon-containing energy resources. From the point of view of global environmental security from the consequences of global warming, the "replacement" of some sources and trade routes of the supply of carbon energy resources **does not reduce** the levels of negative consequences and threats from global warming. At the same time, it was Russia's full-scale war against Ukraine that served as a trigger for new progressive decisions by the EU structures to **accelerate and facilitate the processes of systematic implementation of the means, systems and technologies of the "Green Energy Transition" at least in European countries.** Similar decisions at the EU level lie both in the permitting and legal sphere, and in the motivational sphere for business and scientific-implementation and scientific-innovative structures regarding the further development and dissemination of achievements and innovations of green and smart energy in all spheres and industries: from housing and transport to communal services, business and industrial production.

- the Russian-Ukrainian war of 2022 significantly and dramatically changed the situation on the world market of carbon-containing (fossil) energy resources as a result of the long-term and large-scale sanctions policy of the countries of the democratic west against the aggressor country Russia.	
5.2. For the first time in the history of world wars, starting from October 2022, Russia carried out the **destruction of energy infrastructure in the cities** of Ukraine, conducting remote attacks with cruise missiles, kamikaze drones, aerial bombs and artillery in a purposeful and large-scale manner and during many months of 2022-2023. The purpose of energy terror on the part of the Russian Federation was to sow panic and discontent among the civilian population; to disorganize and paralyze social life and economic processes; negatively affect management systems and the information sphere; to cause acceleration of the mood of defeat and surrender in war, etc.	**5.2. None of the goals** of the massive energy terror against peaceful settlements in the cities of Ukraine, which Russia carried out in 2022-2023, **was achieved**, although separate and significant destruction of the energy and communal infrastructure in the cities took place, causing emergency and "planned" power outages in fact in all regions of Ukraine. In general, the following joint actions and factors worked systematically and gave a synergistic effect: - the technical and professional actions of air defense systems have increased significantly; - quick and highly professional decisions and actions of all managers and technicians and paramilitary structures of emergency services and energy workers; - the unity and will to win despite all the difficulties of the vast majority of residents of communities in the cities of Ukraine.
6. SOCIAL DIRECTION *(covers global, national and local problems and challenges of access of human communities and residents of urban and rural communities to high-quality social services, i.e. education, health care, social protection, culture and sports and recreation, as well as this direction is related to observance of human rights and freedoms)*	
6.1. Access to quality social services is somehow related to access to natural resources with adequate (sufficient) specific energy consumption.	**6.1.** As a result of the military operations of the occupying army of the Russian Federation, significant territories of the East, North and

Russia's full-scale war against Ukraine has negatively and significantly affected both access to quality social services and the ability of relevant national and local systems and institutions to provide such services.	South of Ukraine temporarily found themselves in one or alternately in different statuses: - occupied zones; - combat zones; de-occupied territories; frontline territories; support areas; rear regions and territories. Neither the state nor the local self-government had and does not have the ability to provide social services in the occupied, de-occupied and front-line territories; as for the support and rear areas, **the following factors do not contribute to the provision of quality social services here:** - frequent air alarms; - disconnection of power supply systems as a result of shelling and destruction; - changes in the structure and composition of the population of cities, towns and villages as a result of the intensification of migration processes with the presence of a significant number of forcibly displaced persons, including to a greater extent children and women, which may affect the excess number of students in school classes; a similar problem is the provision of quality medical services, as well as social protection services and assistance to citizens in need.
6.2. Practically in all countries of the Carpathian region, as well as in other EU countries, as well as in Ukraine, **buildings of the social sphere** (education, hospitals, health care, social protection, culture, sports, rest and recreation, libraries, provision of administrative services, other public buildings), as well as the **housing and**	

public transport together make up the lion's share of the energy consumption of cities and villages.

At the same time, among the 5 countries of the Carpathian region (Poland, Slovakia, Hungary, Romania, and Ukraine), it is the decentralized local self-government of basic territorial communities in Ukraine that has **the largest area of authority and responsibility for the energy sector of social buildings and housing and communal services**, including apartment buildings and public buildings of trade and services.

And especially in Ukraine, as a result of intensive rocket and artillery fire during the military operations of Russia, starting from February 2022, hundreds and thousands of buildings were subjected to ruining and destruction in the social, residential and communal, industrial, commercial, domestic and public spheres of cities and settlements (a separate goal i.e. energy infrastructure, was already discussed in subsection 3 of this Table).

Of course, the largest number of buildings were completely or partially destroyed by the Russians in the following zones: occupied, combat zones, de-occupied, front-line zones.

7. DEMOGRAPHIC DIRECTION

*(covers the problems **of rapid population growth** from the global level to individual continents or megaregions of the planet and even individual overpopulated countries with low or negative indicators of economic, energy and environmental development and non-reproduction or depletion of a limited number of natural resources, which predictably leads to a **deterioration of indicators of the level and quality of life** and is the main cause of mass international migration; another important reason for the phenomena of mass international migration is the long-term unresolved acute **security problems** for the inhabitants of cities and rural areas such as natural and man-made disasters and/or local or even international regional or macroregional **military conflicts and full-scale wars**, as is currently the case on the European continent as a result of **Russia's aggressive war against Ukraine**, which has been ongoing since 2014, and in an active offensive phase since 2022)*

7.1. In this subsection, we will only talk about the brief statistical data of those demographic changes and trends that affect Ukraine more since 2000, and so on the energy and related sectors of the country's development.	**7.1.** Demographic changes under the conditions of their scale (in particular, related to the processes of mass international migration) can significantly affect all other directions of change at different territorial levels, in particular, the economic and information technology (energy) and social and even security directions. After all, we are talking about the most valuable human resource.
7.2. According to the statistical data base of the UN European Economic Commission (EEC), the population of Ukraine in the period 2000-2013 decreased from 48.9 million people (2000) to 45.3 million people (2013). Statistical data for 2014 (42.8 million people) and for 2015 (42.7 million people) for Ukraine as a result of the first years of Russia's hybrid war could be obtained only without taking into account the occupied territories of the Crimea and the city of Sevastopol, and in the following years also without taking into account the occupied territories of Donetsk and Luhansk regions.	

7.3. In other countries of the European Carpathian region for the same period of 2000-2015 there was also a tendency to decrease the size of the permanent population, the largest was observed in Romania (from 22.4 to 19.8 million people), a smaller one in Poland (from 38.3 to 38.0 million people) and Hungary (from 10.2 to 9.8 million people), and it practically remained at the same level in Slovakia (5.4 million people).

IV.2. *CONCLUSION: A STRATEGIC VISION OF THE EFFECTIVE IMPLEMENTATION OF THE JOINT CONCEPT OF SMART ENERGY IN THE CARPATHIAN REGION "ECO-SMART ENERGY - CARPATHIA" IN THE CONDITIONS OF GLOBAL, REGIONAL, AND LOCAL CHANGES CAUSED BY RUSSIA'S WAR AGAINST UKRAINE.*

As we can see from our brief analysis in the previous subsection IV.1, the full-scale war of Russia against Ukraine in 2022, which was a continuation of the hybrid war that began in 2014 with the annexation of Crimea by the Russian Federation and the direct military and political support of illegal separatist groups in Donbas, led to **fundamental changes and rethinking** by the world community of the democratic countries of the West of conceptual approaches both to ensuring the security and defense of the countries of the European continent, and to the development of new approaches and priorities of foreign policy in a wide range of its directions and problems (see the analysis of the previous subsection within the framework of 8 directions globalization changes). Similar targeted and topical analysis can now be found in the research of many leading analytical centers.

In Ukraine, for example, the National Institute of Strategic Studies (a state institution), the Razumkov Center (a non-governmental organization) and other scientific and analytical centers and organizations conduct similar studies.

The most important indirect but expected conclusion of the majority of modern studies of leading analytical and scientific centers regarding the current systemic crisis situation in the world, including in the context of solving global (and local) problems of energy and ecological development of mankind, is finally a seemingly convincing **collective awareness and understanding** of even political leaders and governments of most developed and democratic countries of the world that all global problems are only a collection of problems of lower territorial levels down to regional and local, that they are all interconnected and mutually influencing, that postponement in time, ignoring or a distorted perception of challenges and threats under the influence of long and large-scale information wars, which have never stopped from the forces of global evil, **only intensify the solution of such problems and significantly increase the price that humanity is forced to pay for averting the catastrophic consequences of challenges and threats.**

So, let's briefly summarize under what **new global conditions**, which will affect all lower territorial levels down to the local level, the implementation of our Joint Concept of Smart Energy in the Carpathian region will take place in 2023 and in the following years.

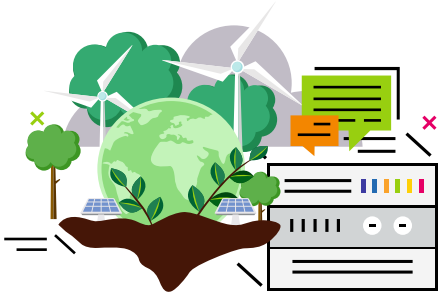
1. Russia's aggressive, unjust, brutal and full-scale war against Ukraine as the largest military conflict on the European continent since World War II radically and unambiguously affected both expert and analytical assessments in the fields of security and foreign policy, as well as awareness of changes and the need for decisive actions in these policies on the part of the developed democratic countries of the West.

If earlier the community of European countries, the USA and Canada focused on preventing conflicts, maintaining peace under all external international circumstances and destructive actions of Russia and other autocratic or dictatorial regimes, then as of the beginning of 2023, the focus of attention has shifted to new security issues: the lack of an alternative to the transatlantic system defense and NATO; peculiarities of the organization of defense taking into account the lessons of Russia's war against Ukraine in 2022; definition and assessment of the global consequences of Russian aggression; reviewing and strengthening the defense capacity of the EU and NATO with its real expansion to the East in the near future (Sweden, Finland, Ukraine, Moldova, Georgia).

2. The global shock from the armed invasion of the Russian Federation into Ukraine in 2022 also marked the sudden end of the 30-year imagined "peaceful" period of "globalization and international cooperation", which was followed by the most acute security crisis in Europe and the world since World War II, but already in the conditions of the 21st century. The consequences of this large-scale war, which is still ongoing, will definitely lead to the creation of stronger and more stable foundations for a new order both in Europe and in the world.

3. The platform for renewing the European security architecture should be the key elements of the peace formula of Ukraine - the unconditional and unconditional restoration of the territorial integrity of the state within the borders of 1991, ensuring its inviolability in the future; fair punishment of the aggressor for war crimes and crimes against humanity and for the unprovoked aggression with entirely far-fetched and genocidal goals; forcing the aggressor to fully compensate large-scale losses.

Experts of the Royal Institute of International Affairs (Chatham House, The Royal Institute of International Affairs) in February 2023 represented the study “Seven ways in which Russia's war against Ukraine changed the world”. This study thoroughly analyzes changes in geopolitical alliances, security and defense configurations, **global energy prospects, and changes in global supply chains**. Regarding the last of these global changes, here are the annotated results of the Royal Institute of International Relations.



Russia and Ukraine are global suppliers of energy, food, and mineral fertilizers, so the war caused significant disruptions and changes in the supply chains of these goods.

The most decisive and important step was that the community of European countries decided **to get rid of dependence on Russian fossil energy carriers**. By diversifying sources and ways of supply, the community of European countries simultaneously decided to accelerate all measures and actions related to the "Green Energy Transition", that is, accelerating the transition to renewable energy (RES).

The plans and programs of the EU for the period up to 2030-2035 actually refer to the complete decarbonization of the energy sector.

Similar plans of the community of European countries have somewhat unexpected geopolitical consequences. In particular, African countries suddenly turned out to be "attractive" for the West, and dependence on China for the introduction of RES based on solar panels (up to 70% of the market belongs to the PRC) led to the adoption of a number of political decisions, and in particular the Industrial Plan of the EU "Green Deal", the Law on Reduction inflation in the USA, etc., which should contribute to the expansion of own production of materials, means and devices for RES.

Of course, in the real economic and energy policy of each of the EU and non-EU European countries, as well as in other countries of the democratic West, the rates of getting rid of dependence on fossil energy resources (decarbonization), in particular, and primarily of Russian origin, are quite different. Currently, we are talking about radical and irreversible global changes in the energy sector and at the level of adopted consolidated decisions, and in new trends, and in practical actions at the levels of industry and business, municipalities and communities, transport, utility companies and energy companies, state authorities, scientific and innovative and implementing institutions, etc.

Therefore, the request for a **strategic vision of the effective implementation of the Joint Concept of smart energy in the Carpathian region in the new conditions of systemic global changes caused by Russia's war against Ukraine appears to be extremely relevant** and logical.

If to sections I, II and III of our Joint Concept "Eco-Smart Energy - Carpathia" (according to their thematic content; generalizations about problems and value orientations; expected results from implementation; new methodological approaches in the analysis of problems, in particular, approaches of the proposed **"systematic optimization method for the analysis of smart sustainable energy"** (SOMARCE); in accordance with the implementation recommendations, etc.) the keywords would be: **"energy efficiency", "environmental friendliness", "system approach", "optimality", "compliance with the principles of sustainable (balanced) development", "vulnerability of the nature of mountainous areas", "active participation in the Green Energy Transition",** then, taking into account the new thematic content and content of Section IV, new keywords are added to the indicated keywords, in particular **"acceleration", "intensification", "active implementation of innovations", "priority", "involvement of all development sectors of society", "distributed generation", "energy security".**

One of the possible variants of the strategic **vision of the effective introduction of smart energy in the Carpathian region as of 2030** (in conditions of irreversible positive global changes caused by Russia's war against Ukraine) **may have the following wording:**

"Decarbonized energy of the international Carpathian region continues to develop intensively as one of the most priority and nature-friendly modern industries, which unites coordinated and complementary efforts of science, innovation and business and entrepreneurial spheres, forms and supports effective institutions of cross-border innovation and investment cooperation and cooperation between countries in the Carpathian region".

It is worth noting that it is for the sake of the development of new decarbonized energy and other innovative and scientific fields, that on March 27, 2023, in the city of Košice (Slovakia), at the initiative of the National Science and Technology Association of Ukraine, a Joint Protocol on the creation of the Ukrainian-Slovak International Center for Innovation and Technologies Transfer was signed. The protocol was signed by the rectors of the Uzhhorod National University and the Technical University in Košice (the largest technical university in Slovakia).

It is also about the beginning of the implementation of another institutional and innovative initiative in the international cooperation of Ukraine and Slovakia in the spheres of decarbonized energy development, i.e. the formation of 7 sectoral cross-border innovative cluster structures (see appendices).

CONCLUSIONS

1) Joint Concept of Smart Energy in the Carpathian Region "Eco-Smart Energy - Carpathia" (Concept) has been developed on the basis of the proposed system-optimization method of smart sustainable energy (SOMARCE), taking into account the specifics of the target Carpathian macroregion, mutual influences of territorial levels from global to local, in-depth analysis of changes in globalization processes in the world and on the European continent in 2022-2023, which are taking place under the influence of Russia's full-scale war against Ukraine.

2) During the development of the Concept the results of efforts of teams of scientists, engineers, experts and practitioners of leading universities, public and energy service organizations, and the cross-border network of involved pilot territorial communities of the target border areas of Ukraine, Romania, Hungary, and Slovakia, have been considered.

3) Innovative and methodological approaches, ideological and conceptual content of the Concept, as well as the best practices of energy solutions of pilot territorial communities *(appendices to the Concept)* should be urgently extended to the entire natural and geographical territory of the Carpathian macroregion, in particular to the Carpathian territories of Poland, Austria, and the Czech Republic and Serbia with the involvement of leading universities and scientific and innovative organizations and institutions of these countries.

4) The practical approval of the provisions and recommendations of the Concept was carried out in selected 12 pilot territorial communities (3 communities from each of the border countries of Ukraine, Romania, Hungary and Slovakia) with the participation of consultants, experts and specialists of energy service companies; and the results have been summarized and described in the collection **"Best energy solutions in the Carpathian region"** as an electronic appendix to the Concept with the possibility of wide access to the best practices of the entire community of territorial communities of the Carpathian macroregion.

5) Taking into account the conceptual and innovative content and practical recommendations of the Concept, thanks to active and purposeful communications and working trips and meetings of the Project's cross-border partners, the International Consortium **"Sustainable and Smart Energy of the Carpathian Macroregion"** has been formed on the basis of voluntarism and horizontal relationships between partners and involved co-partner organizations region.

6) Due to the active participation of the leading universities of the border regions of Ukraine, Romania, Hungary and Slovakia, as well as and the creation of specialized research and implementation **"Laboratories of Smart Energy"** in them, the International Consortium "Sustainable and Smart Energy of the Carpathian Macroregion" formed a reliable and stable platform for measuring and expert consulting support of project implementations in the areas of the introduction of renewable energy and energy efficiency and energy monitoring projects in municipal energy and in the economic and social spheres in general.

7) Recommendations developed in the Concept for its implementation within the framework of the 2-stage process and the formulated Goal and 8 tasks, the introduction of basic principles and 5 European evaluation criteria of the strategic documents

developed within the Concept (see section III.4), the Vision of the effective implementation of smart energy in the Carpathian region by 2030 (see section IV.2) formulated in the Concept, make it possible to use the Concept as an **ideological, substantive and methodological platform for the rapid development of the Strategy for the development of smart energy in the Carpathian macroregion and the Action Plan from its implementation until 2030.**

8) The unique importance of the developed Concept is fully confirmed by the fact that its provisions, ideological and innovative content and focus on the rapid achievement of energy efficiency and accelerated implementation of electricity generation projects of carbon-free energy from renewable energy sources in the cross-border Carpathian macroregion are **fully consistent and harmonized** with the political decisions that during 2022 and in the spring of 2023, were actively discussed by the world community of developed and democratic countries and finally adopted both at the European (the EU structures) and at the global level (the G7 community of world leaders).

9) Thus, in April 2023, the G7 countries at the summit in the Japanese city of Sapporo achieved the recognition of **"new major goals for the development of solar and wind energy in the world"** with agreements on a global movement in the direction of a faster abandonment of carbon-containing fossil fuels and, accordingly, accelerated development of all types of RES. It is especially noted in the decisions of the G7 countries that RES and energy security issues have acquired a qualitatively new relevance in the world precisely as a result of the full-scale and aggressive phase of Russia's war against Ukraine since February 2022 and the use of the strategy of energy terror against the civilian population by the Russian Federation in this war since October 2022. At the same time, it is emphasized, and it is extremely important, that both actions in the field of energy to avert the global climate catastrophe, and actions on the energy security of countries and territories are **non-controversial, so they can be carried out simultaneously.**

10) In conclusion, the developed Concept proposed that one of the possible variants of the strategic **Vision of the effective implementation of smart energy in the Carpathian region by 2030** (under the conditions of irreversible positive global changes caused by Russia's war against Ukraine) could have the following wording: **"Decarbonized energy of the international Carpathian region continues to develop intensively as one of the most priority and nature-friendly modern industries, which unites coordinated and complementary efforts of science, innovation and business and entrepreneurial spheres, forms and supports effective institutions of cross-border innovation and investment cooperation between countries in the Carpathian region".**

11) Of course, in the detailed and meaningfully structured processes of developing the project of the Strategy for the Development of Smart Energy in the Carpathian Macroregion and the Action Plan for its Implementation for the Period Until 2030, the above formulation of the Vision can be changed and supplemented, but the essence and directions and value guidelines of the development of smart energy remain unchanged.

12) An in-depth analysis of the information sources developed and used and provided in the Concept allowed to separately highlight and summarize practical recommendations for implementing the provisions and developments of the Concept for local councils of territorial communities and regional (territorial) state authorities and other actors in the field of energy development in the Cross-border Macroregion (given lower).

PRACTICAL RECOMMENDATIONS REGARDING THE IMPLEMENTATION OF THE JOINT CONCEPT OF SMART ENERGY IN THE CARPATHIAN REGION "ECO-SMART ENERGY - CARPATHIA"

- for local self-government bodies of territorial communities and communal enterprises providing services in the fields of energy and energy supply;

- for state executive bodies of regions and subregions (districts, counties);

- for universities and scientific, innovative implementation and consulting organizations and institutions;

- for public and non-governmental development organizations and development agencies working in the fields of energy saving and energy efficiency; ecologically balanced (sustainable) development of communities and territories; nature and environment protection; project management, etc.

- for energy service companies (ESCOs) and small and medium-sized businesses and private entrepreneurs working in the fields of design, business planning and implementation of projects in the energy sector, including projects using RES.

1. Energy policy and planning

1.1. Energy policy at all territorial government levels (from global, international and national to regional and local levels) has become a priority in recent years due to many factors of the development of human civilization, among which the main are the challenges and threats caused by climate consequences for living nature and man, as well as the constant growth of energy consumption in the world.

1.2. The transition to carbon-free, "green" energy, decarbonization of economies (and housing and utilities), improvement of energy efficiency and development of energy based on renewable energy sources is the only alternative to the current energy in the world, which still largely depends on the burning of fossil hydrocarbons (hard coal, oil and natural gas, etc.)

1.3. The EU countries have set themselves the goal of achieving a state of "climate neutrality" by 2050. Ukraine has set itself the goal of achieving climate neutrality by 2070. Radical changes in global energy policy, caused by Russia's full-scale war against Ukraine, actualized the discussion and decision-making about accelerating the energy transition to carbon-free energy in Europe and the world.

1.4. The above, as well as the content of the Conclusions to the Concept *(see above)*, convincingly testify that in the next 30-40 years for the list of interested parties and power structures of all territorial levels (region, subregion, territorial community), as well as for interregional and intermunicipal levels of cross-border cooperation in the Carpathian region, **the issue of energy development planning of the region (subregion), territorial community or border territories of 2 or more neighbouring countries of the Carpathians will constantly be in the focus of attention of both national governments and international and intergovernmental territorial development programs.**

1.5. Thus, the issues of new energy development of territories in one or another variant or form should be presented in relevant documents in the processes of:

- spatial and land planning;
- strategic planning of the development of territories (regions, subregions) and communities;
- targeted program and branch planning for the development of territories and communities;
- budget planning;
- strategic environmental assessment of the above-mentioned planning documents.

2. Assessment of the energy potential of RES development of the territories of regions (subregions), communities and neighbouring territories of the border of the Carpathian region

2.1. In general, the mountainous and foothill territories of the Carpathian region have a higher natural energy potential for RES development than, for example, the flat territories of Ukraine, Romania, Hungary, Slovakia and Poland (small hydropower, wind power, solar power, biomass, geothermal water reserves, etc.).

2.2. In most cases (especially for the territories of the Ukrainian Carpathians), the issue of assessments of the energy potential of RES development **has not been sufficiently investigated.** And in the existing studies, nature protection and ecological restrictions and risks from the implementation of RES projects in the environment of the vulnerable mountain nature of the Carpathians are not properly taken into account.

2.3. In order to objectively assess the energy potential of RES development, territorial communities of the border of the target Carpathian region should order specialized and professional (expert) organizations to carry out a study on a **comprehensive assessment of the existing energy potential of RES development in their territory** and only on the basis of the results of these studies they should develop relevant strategies or programs.

3. For the effective implementation of the Joint Concept of Smart Energy in the Carpathian Region "Eco-Smart Energy - Carpathia", we recommend for the level of territorial communities and/or their inter-municipal level, including the level of cross-border cooperation, to focus managerial attention, first of all, on solving the following issues:

3.1. Carrying out a comprehensive analysis of the **energy efficiency** of all types of energy consumption and buildings in the community (including energy audits of public buildings in the fields of education, health care, social protection, culture, sports, etc.) and, on this basis, carrying out a basic analysis of greenhouse gas emissions.

3.2. Carrying out a comprehensive analysis of the needs of the territorial community in electricity and thermal energy for heating and hot water supply, as well as for the needs of street lighting. For the territorial communities of the Ukrainian Carpathians, we recommend taking into account the contingent of forcibly displaced persons, as well as the existing and estimated needs of relocated business enterprises.c

3.3. We also recommend conducting a study of the needs for heat energy and electricity, taking into account the branch affiliation and forms of ownership of energy consumers in the territorial community (at least in order to carry out an assessment of the annual needs for the budget of the community, public and private sectors of consumers).

4. We recommend studying the needs of raw materials for the development of promising bioenergy in the Carpathian region for the following industries:

A. Forestry (ability of forestry enterprises to provide fuelwood);

B. Forest processing industry (volumes of waste from such woodworking);

C. Land resources (areas for growing energy crops);

D. Municipal economy (% of landfills suitable for methane collection and which ones are suitable for this, the potential of treatment facilities, "green" waste, food waste);

E. Farms (waste from animal husbandry, plant crops);

F. Food processing industry (waste from the processing of grapes, fruits, vegetables).

5. Territorial communities can become important players in the Energy Transition process by developing their own networks of distributed renewable energy power generation facilities that will evenly cover the entire territory of the target border of the Carpathians. *If the energy independence of communities increases, the quality and reliability of electricity supply will also increase, which will make the local energy system more stable and flexible.*

6. The recommended development of bioenergy in the territory of the target border of the Carpathians *will improve the quality of the environment (in case of installation of biogas plants at landfills and sedimentation facilities of sewage treatment plants) and will create an additional and high-quality source of heat and electricity supply that does not depend on environmental conditions and time of day. Bioenergy is an effective resource for balancing the entire energy system.*

7. The recommended production of "green" hydrogen on the territory of the target border of the Carpathians is possible locally and in those places where there is overproduction of electricity using RES.

8. The main recommendation for territorial communities in the implementation of the Joint Concept in the Carpathian region is that participation in the Green Energy Transition will be successful and accelerated when, in parallel with **the implementation of carbon-free energy projects using promising and available renewable resources in the given territory, the projects to improve the energy efficiency of all energy-consuming facilities and buildings are implemented no less intensively.**

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ANNEXES (in electronic format)

1. BEST SOLUTIONS IN CARPATHIAN REGION in English

2. BEST SOLUTIONS IN CARPATHIAN REGION in Ukrainian

3. Electronic version of the map NESiCA

4. Electronic version of the Joint Concept "Eco-Smart Energy-Carpathia" in English

4. Electronic version of the Joint Concept "Eco-Smart Energy-Carpathia" in Ukrainian

Project name:
New Energy Solutions in Carpathian Area (NESiCA)
Lead partner: Uzhhorod National University (Ukraine)

Partners:
- Self-Government of Szabolcs-Szatmár-Bereg County (Hungary)
- Ştefan cel Mare University of Suceava (Romania)
- NGO European Initiatives Centre (Ukraine)
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The Member States of the European Union have decided to link together their know-how, resources and destinies. Together, they have built a zone of stability, democracy and sustainable development whilst maintaining cultural diversity, tolerance and individual freedoms. The European Union is committed to sharing its achievements and its values with countries and peoples beyond its borders

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