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## Development capacity and perspectives of the renewable energy in the Carpathian region of Ukraine

**Abstract.** The Carpathian region of Ukraine is characterised by high potential of renewable energy, in particular relating to small hydropower and geothermal energy in Ukraine. The technically feasible capacity of renewable energy of the region is 10.4% of the total capacity of Ukraine. According to the Ukraine - European Union Association Agreement, Ukraine is obliged to develop renewable energy and stimulate its growth through legislative, financial and institutional mechanisms. Therefore, it is important to use the capacity of the renewable energy sources in all regions of Ukraine. *The purpose* of the research is to reveal the possibilities of renewable energy development on the basis of determination of the level, prospects and tools to enhance the use of renewable energy sources in the Carpathian region of Ukraine. *Results.* It has been established that the Carpathian region is characterised by different levels of exploitation of renewable energy by areas and sources. In general, the share of renewable energy used in the region is low, with the exception of wood biomass, which is somewhat higher. The perspectives for increasing of the industrial energy production in the region should be based on the use of wind, solar, geothermal energy, mainly using existing oil and gas wells available in the region, and small hydropower in compliance with environmental requirements. It has been determined that the renewable energy in the Carpathian region of Ukraine grows mostly at the expense of private investments and requires incentives for its development at both the national and regional levels. Efficient use of the renewable energy in the region is impossible without a strategic approach. The structure, the objectives and the tasks of the regional renewable energy development strategies (RSDFE) are outlined in the article. Public-private partnership mechanisms, such as the energy cluster, green public procurement, auctions of projects for the construction of renewable energy objects, etc., are suggested. *Conclusions.* The conducted research has shown that the significant amount of unused renewable energy in the Carpathian region of Ukraine creates preconditions for active development of renewable energy, which may also become a new driver for regional development. At the same time, capacity development requires additional organisational and economic measures to be taken by the regional authorities aimed at planning and supporting renewable energy by establishing cooperation with the business environment, facilitating the implementation of renewable energy investment projects.

**Keywords:** Renewable Energy; Carpathian Region; Capacity; Perspectives; Energy Cluster; Green Public Procurement

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**Потенціал та перспективи розвитку відновлюваної енергетики в Карпатському регіоні України**

**Анотація.** У статті розглянуто рівень і перспективи використання потенціалу відновлюваної енергетики Карпатського регіону України. Встановлено, що потенціал відновлюваних джерел енергії в регіоні використовується в незначній мірі. Визначено, що відновлювана енергетика зростає здебільшого за рахунок приватних інвесторів і потребує стимулів для розвитку як на рівні держави, так і регіону. Вказано на необхідність стратегічного системного підходу й запропоновано структуру, цілі та завдання регіональних стратегій розвитку відновлюваної енергетики. Серед них – використання механізмів публічно-приватного партнерства, таких як енергетичний кластер, зелені державні закупівлі, аукціонні торги готовими проектами з будівництва об'єктів відновлюваної енергетики тощо.

**Ключові слова:** відновлювана енергетика; Карпатський регіон; потенціал; перспективи; енергетичний кластер; зелені державні закупівлі.

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**Потенциал и перспективы развития возобновляемой энергетики в Карпатском регионе Украины**

**Аннотация.** В статье рассмотрены вопросы, касающиеся уровня и перспектив использования потенциала возобновляемой энергетики Карпатского региона Украины. Было установлено, что степень использования потенциала возобновляемых источников энергии в регионе является незначительной. Определено, что возобновляемая энергетика развивается в основном за счет частных инвесторов и требует внедрения стимулов для своего развития как на государственном, так и на региональном уровнях. Авторы статьи указывают на необходимость стратегического системного подхода, а также предлагают структуру, цели и задачи региональных стратегий развития возобновляемой энергетики. Среди них – использование механизмов публично-частного партнерства, таких как энергетический кластер, зеленые государственные закупки, аукционные торги готовыми проектами строительства объектов возобновляемой энергетики и др.

**Ключевые слова:** возобновляемая энергетика; Карпатский регион; потенциал; перспективы; энергетический кластер; зеленые государственные закупки.

**1. Introduction**

Starting from 2015, the global renewable energy capacities have exceeded the traditional ones. Moreover, investments in the production of fossil energy resources lag behind investments in renewable energy projects.

China, the European Union member states, the USA and Brazil are the leaders in the development of renewable energy. The EU pursues its policy of increasing the share of consumption of energy from renewable sources up to 20% as early as 2020. Taking into account the current trends in the growth of renewable energy capacities in the EU member states, it can be argued that the percentage will not only be achieved but also exceeded. The EU member states have agreed to decrease the greenhouse gas emissions by 40% by 2030, if compared to 1990, by increasing the share of renewable energy sources (RES) in the final energy consumption to 27%. The Energy Roadmap 2015 stipulates growth of the share of RES to 55-75% in the overall structure of energy production and to 59-83% in the energy generation [1]. Eurostat data show that the share of RES in the gross energy final consumption increased in all 28 EU member states in the period from 2004 to 2014. The largest increase among the European countries in the period was observed in Sweden (from 38.7% in 2004 to 51% in 2012), Denmark (from 14.5% to 26%), Austria (from 22.7% to 32.1%), Greece (from 7.2% to 15.1%) and Italy (from 5.7% to 13.5%) [2]. Estonia, Bulgaria and Sweden reached their 2020 goals in 2012 and they plan to increase RES capacities.

Renewable energy is one of the priority directions of the development of the energy branch in Ukraine. The goals of the growth of renewable energy capacities in Ukraine are outlined by international obligations undertaken by our country according to the Ukraine - European Union Association Agreement and the country's membership in the Energy Community.

The 2020 National Action Plan for Renewable Energy was developed and adopted in 2014 in correspondence with the EU requirements [3]. One of its tasks stipulates the increase of the share of renewable energy sources in the final energy consumption up to 11% in 2020. The share of RES in Ukraine's energy balance for the period between 2015 and 2016 was planned to be increased to 6.7% and 7.4%, respectively. However the percentage was not achieved.

**2. Brief Literature Review**

Issues relating to renewable energy development and exploitation of renewable energy sources in Ukraine have been

in the research focus of a number of institutions and scientists. The International Energy Agency, organisational and analytical structures of the Energy Community, the Ukrainian Association of Renewable Energy, the Institute of Renewable Energy of the NAS of Ukraine, etc. are among them. A considerable contribution to the elaboration of theoretical and methodological, as well as scientific and practical foundations of renewable energy development has been made by the following domestic and foreign researchers: I. Andriichuk [4], H. Heletuha [5], H. Denysenko [6], S. Kudria [7], A. Prokip [8], G. Boyle [9], B. Vries and D. Vuuren [10], M. Jacobson and M. Delucchi [11], etc. Nevertheless, issues relevant to the active exploitation of renewable energy capacities in terms of the regional aspect require further research.

**3. Purpose**

The purpose of the article is to reveal opportunities for renewable energy development by defining the level, perspectives and tools to enhance the exploitation of renewable energy sources in the Carpathian region of Ukraine.

**4. Research**

The Carpathian region of Ukraine is characterised by high potential of renewable energy sources. The aggregate technically feasible capacity of renewable energy of the region amounts to 10.3 million tonnes of fuel equivalent per year, which is 10.4% of the total capacity of Ukraine (Table 1).

**Tab. 1: Technically feasible capacity of renewable energy sources in the Carpathian region of Ukraine in millions of tonnes of fuel equivalent per year**

Region	By energy sources, million tonnes of fuel equivalent per year					Total
	solar	small hydropower plants	wind	geothermal	biomass	
Zakarpattia (Transcarpathian)	0.14	1.11	0.3	0.85	0.87	3.27
Ivano-Frankivsk	0.13	0.10	0.27	0.18	0.95	1.63
Lviv	0.22	0.44	1.27	0.79	1.12	3.84
Chernivtsi	0.09	0.22	0.3	0.07	0.85	1.53
Total	0.58	1.87	2.14	1.89	3.79	10.27

Source: [12]

The National Action Plan for Renewable Energy in Ukraine and stipulates active development of solar and wind energy. The planned growth of new capacities of solar energy objects in the Carpathian region of Ukraine is outlined in Table 2.

Most of the planned parameters of the growth of solar energy capacity in the region were not achieved, mostly due to the lack of financial resources to implement the developed projects. However, in 2017 three new solar power plants (SPP) were commissioned. They are Zakarpattia (Transcarpathian) «Huta-2» with its capacity of 3.5 MW

(Zakarpattya, or Transcarpathian, region), SPP «Ozer-na» with its capacity of 10 MW and one SPP at the village of Tyhlyash, with its capacity of 21.5 MW (Lviv region).

It has been planned to build several new solar power plants in 2018: four SPPs in Zakarpattya (Transcarpathian) region, three - in Lviv region, three - in Ivano-Frankivsk region and two in Chernivtsi region.

Meanwhile, installation of solar modules on the roofs of private houses is becoming increasingly common. In the nearest future, such modules, in terms of their aggregate capacity, will compete with more powerful SPPs designated for industrial energy production.

The growth of wind power plants (WPP) capacity in the region is shown in Table 3.

However, wind energy in the Carpathian region of Ukraine, except for Lviv region, is underdeveloped. Nowadays, only two wind power plants operate near Staryi Sambir, i.e. «Staryi Sambir-1» with its capacity of 13.2 MW and «Staryi Sambir-2» with its capacity of 20.7 MW. For 2018-2019 It has been planned to construct three more wind power plants in Lviv region, which are WPP «Karpatska» with its capacity of 36.3 MW in Turkyivskiy district, WPP «Smerechanska» with its capacity of 33 MW in Staryi Sambir district and WPP «Orivska» with its capacity of 46 MW in Skolivskiy district.

Bioenergy is developing much faster in the region, in particular the one based on wood biomass. However, bioenergy capacities maintain mostly the local needs of certain enterprises and social facilities in thermal energy.

In 2017, the overall capacity of renewable energy objects in all the regions of the Carpathian region of Ukraine is estimated at the level of 324.05 MW (Table 4).

It is worth mentioning that the Carpathian region of Ukraine is characterised by high capacity in terms of substituting traditional energy sources with the renewable ones. Nowadays, Zakarpattya (Transcarpathian) region (the substitution ratio of which is 2.2) and Chernivtsi region (the substitution ratio of which is 1.2) have the highest perspectives relating to the substitution of organic fuel with the renewable energy sources (Figure 1).

According to our data, the available capacity of possible RES use in the region is implemented to a small extent and has significant reserves (Table 5). Therefore, the natural RES capacity in the region is a major factor in promoting rather than restricting perspective development of renewable energy.

We believe that the perspectives of energy production in industrial scale in the region should be mostly attributed to the use of the capacity of wind, solar and geothermal (predominantly with the use of oil and gas wells available in the region) energy, as well as small hydropower.

The use of solar energy and all types of biomass has great perspectives in the case of local exploitation (residential sector, public utilities, social facilities, tourism, etc).

Active use of renewable energy sources is not only one of the major tasks of state and regional authorities that stems from their liabilities, but also a way to avoid energy dependence and to promote innovative development.

An efficient use of the RES capacity in the region requires a strategic approach. Defining the renewable energy as a priority direction of regional sustainable development strategies is an important method of promoting renewable energy. Taking into account the increasing role of renewable energy, it is natural to distinguish another component which is the Regional Strategy for Renewable Energy Development (RSRES). The objective of the strategy is to improve the energy efficiency of all economic sectors in the region through the use of RES capacity. The main goals of the strategy are to reduce the use of traditional fuel and energy resources, to improve environmental protection, to

Tab. 2: Planned growth of the capacity of solar energy objects in the Carpathian region of Ukraine

Region	Installed capacity, MW/year					
	Total	2016	2017	2018	2019	2020
Zakarpattya (Transcarpathian)	31.0	6.0	4.6	6.0	7.2	7.2
Ivano-Frankivsk	29.0	5.6	4.6	5.6	6.6	6.6
Lviv	47.0	9.0	7.2	9.0	10.9	10.9
Chernivtsi	21.0	4.0	3.2	4.0	4.9	4.9
Total	128	24.6	19.6	24.6	29.6	29.6

Source: Developed by the authors based on [13]

Tab. 3: Planned growth of the capacity of wind energy objects in the Carpathian region of Ukraine

Region	Installed capacity, MW/year					
	Total	2016	2017	2018	2019	2020
Zakarpattya (Transcarpathian)	86.8	23.8	20.4	17.0	13.5	12.2
Ivano-Frankivsk	111.5	30.6	26.1	21.7	17.5	15.6
Lviv	79.9	21.9	18.7	15.6	12.6	11.2
Chernivtsi	87.6	23.9	20.5	17.1	13.7	12.4
Total	365.8	100.2	85.7	71.4	57.3	51.4

Source: Developed by the authors based on [13]

Tab. 4: Installed capacity of renewable energy objects in the Carpathian region of Ukraine, 2017

Regions	Solar energy, MW	Wind energy, MW	Small hydropower, MW	Geothermal energy, MW	Biomass energy, MW	Total
Zakarpattya (Transcarpathian)	48.05	0.05	37.06	1.2	10.8	97.16
Ivano-Frankivsk	20.4	0.02	3.3	0.1	75.6	99.42
Lviv	23.6	34.0	0.62	0.16	54.3	112.68
Chernivtsi	1.05	0.02	—	0.02	13.7	14.79
Total	93.1	34.09	40.98	1.48	154.4	324.05

Source: Compiled by the authors

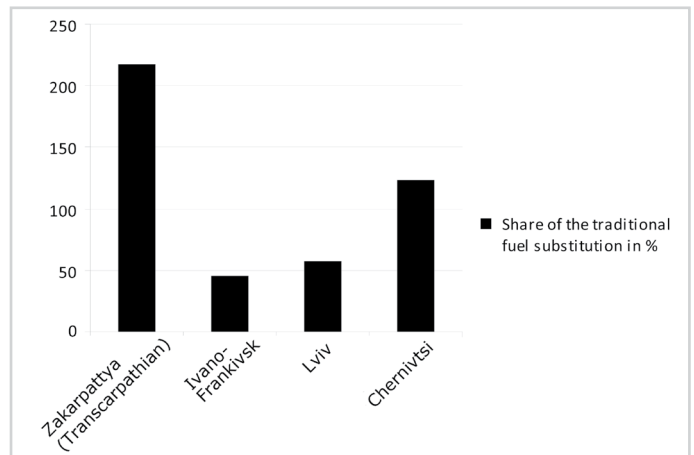


Fig. 1: Possibility to substitute organic fuel with renewable energy sources in the Carpathian regions of Ukraine

Source: Developed by the authors based on [14]

Tab. 5: Level of exploitation of technically feasible renewable energy capacity in the Carpathian region of Ukraine, 2017

Region	Solar energy	Wind energy	Small hydropower	Geothermal energy	Biomass energy *
Zakarpattya (Transcarpathian)	5.6%	less than 0.1%	4.86%	1.68%	8.5%
Ivano-Frankivsk	1.7%	less than 0.1%	2.72%	less than 0.1%	23.5%
Lviv	2.03%	1.08%	0.46%	less than 0.1%	5.7%
Chernivtsi	0.42%	less than 0.1%	0%	0%	6.5%

Note: \* - wood biomass

Source: Compiled by the authors



develop new production and services related to renewable energy (Table 6).

Based on the above tasks, it may be appropriate to elaborate targeted complex programs or special targeted programs which will include all organisational, economic and technical mechanisms of introduction of RES.

Implementation of tasks related to renewable energy development requires establishment of close cooperation between authorities and businesses, development of forms and mechanisms of public-private partnership in the field of renewable energy at the regional level. The following concepts are viewed to be of particular importance.

1. Energy cluster

The efficient functioning of the relevant public-private partnership mechanism for the development of renewable energy has been proved by the Renewable Energy Hamburg Cluster, the Energy Cluster of Western Finland, the Basque

Energy Cluster, the Upper Austria Green Energy Cluster, the Polish Renewable Energy Cluster, etc.

Regional authorities are recommended to take the initiative of creation of renewable energy clusters composed of active economic entities with the experience of implementation of projects in the field of renewable energy. It is appropriate to encourage local self-governing bodies, relevant scientific and research establishments in the region, enterprises engaged in renewable energy, construction and other adjacent branches, IT-companies, public organisations and financial institutions to participate in such a cluster.

2. Green public procurement

Implementation of green public procurement (GPP) or sustainable public procurement in the region is considered to be one of the most efficient mechanisms of cooperation between the state, local self-governmental bodies and economic entities in the field of RES.

Tab. 6: Objectives and tasks of 2030 regional strategies for renewable energy development the Carpathian region of Ukraine

Strategic goals	Operational objectives	Tasks		
1. Substitution of traditional energy resources with renewable ones	1.1. Regulation of the processes of allocation of RE facilities	1.1.1. Evaluation and creation of an atlas of the natural potential of renewable energy 1.1.2. Development and adoption of the territorial scheme of RE objects allocation of RE objects 1.1.3. Establishment of approval procedures for RE projects by authorities and society		
	1.2. RE maintenance and development planning	1.2.1. Development of efficient organisational forms of entities' cooperation in the field of RE; creation of regional renewable energy clusters		
		1.2.2. Development of a regional RE development program		
		1.2.3. Assistance in passing the authorisation procedures for RE projects		
	1.3. Assistance and development incentives	1.3.1. Budget assistance to RE projects 1.3.2. Introduction of green public procurement of RE products and services 1.3.3. Development and auction sales of the Project of Creation of the Renewable Energy facility product 1.3.4. Creation of the «Renewable Energy» regional information portal 1.3.5. Promotion of renewable energy via mass media, etc.		
			1.4. Scientific support and technical innovations	1.4.1. Development of regional program of scientific-productive cooperation in the field of RE 1.4.2. Establishment of a regional competition for the best scientific development in the field of RE 1.4.3. Support of innovative developments in the field of RE
				1.5. Capacity growth
1.6. Sectoral promotion				
			2. Energy greening	
2.2. Ecological rehabilitation of areas	2.2.1. Recultivation and rehabilitation of lands under TPP slag collectors and slurry pits. 2.2.2. Reassignment of traditional energy facilities and related land plots			
3. Solution of social and economic problems of structural transformation of the energy sector	3.1. Economic restructuring	3.1.1. Development of schemes of structural transformation of the economy of the territories with big facilities relating to traditional energy 3.1.2. Introduction of investment incentives for structural transformation of the economy of the territories with big facilities relating to traditional energy		
	3.2. Prevention of unemployment and solution of problems relating to social protection of employees	3.2.1. Development of a new job creation program for employees who resign from work at traditional energy facilities 3.2.2. Professional retraining of employees who resign from work at traditional energy 3.2.3. Introduction of elements of additional social protection for employees who resign from work at traditional energy facilities		

Source: Compiled by the authors

According to the definition given by the European Commission, in the Communication (COM (2008) 400) «Public procurement for a better environment», GPP is «a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured». Green public procurement can have a significant impact, because social facilities funded from budget and public utility companies are major consumers of energy.

The introduction of a green procurement mechanism is stipulated by the Strategy of National Ecological Policy of Ukraine until 2020. Furthermore, the customer is entitled to apply ecological criteria as technical specifications during a competitive bidding process on procurement of goods or services at the expense of budgetary funds.

To practically embody GPP in the region, regional authorities are suggested to decide on the transition to GPP, with the share of green public procurement of renewable energy production and services gradually increasing over a period of time.

### 3. Elimination of authorisation obstacles

An extremely long and complicated authorisation procedure to agree on construction of objects operating with the use of RES, and their further connection to the public power grid remains the main drawback of the existing renewable energy development mechanism.

Public, regional and local authorities have an important task before them, which is not to create constraints for investors who are ready to invest in renewable energy projects. Therefore, the coordination of issues related to the implementation of projects in the field of renewable energy requires simplification in order to improve their competitiveness and investment attractiveness.

### 4. Project tendering

The implementation of public-private partnership through the development and project tendering on renewable energy has proved its efficiency in a range of countries. Dozens of countries globally apply the practice of public tenders for new projects on renewable energy.

The development and implementation of projects on exploitation of RES at the regional level of region (oblast) is to be introduced according to the following:

1. Introduction of a project, along with its feasibility study, by an implementing body, fulfillment of permitting requirements, holding of public hearings; addressing the issues relating to the allocation of land, drafting agreements and accompanying documents which are to be submitted to relevant Ministries, profile agencies and commissions, i.e. the National Commission for State Regulation of Energy and Public Utilities of Ukraine, the State Agency on Energy Efficiency and Energy Saving of Ukraine, etc., the connect the potential object to the public power grid and to obtain a green electricity tariff.
2. Submission of the final project to the Department of Renewable Energy Sources and Alternative Fuels of the State Agency on Energy Efficiency and Energy Saving of Ukraine with the request to obtain authorization to hold open tendering for prospective investors; once the project has been approved, a comprehensive advertising campaign is to be launched to attract domestic and foreign investors.
3. Organisation and conduct of an auction.

The outlined forms of public-private partnership at the regional level will create favourable conditions for the development of renewable energy and provide efficient momentum to enhance regional economy.

### 5. Conclusions

Strategic tasks relating to the substitution of traditional energy sources with the renewable ones require decisive action to develop renewable energy at the national, regional and local levels. The conducted research shows that the significant, yet underexploited, potential of renewable energy sources in the Carpathian region of Ukraine creates preconditions for active development of renewable energy in the region. Consequently, it can become a driver of regional development. Along with that, capacity implementation it is required to conduct additional organisational and economic activities on part of regional authorities, aimed at developing renewable energy, establishing cooperation with business environment, thus implementing investment projects in the field of RES. The authors suggest a range of organisational and economic tools to accelerate the development of renewable energy in the region. They are elaboration of regional targeted strategies of exploitation of RES, formation of renewable energy clusters, implementation of green public procurement, development and auctioning of projects on the construction of renewable energy facilities, etc.

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