

REVIEW PAPER

Renewable Energy Sources as a Key Focus of Ukraine's Energy Policy Amid Military Threats: Geographical and Economic Dimensions

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ABSTRACT

The article describes the main renewable energy sources and their geographical use, which is dictated by energy policy. According to forecasts, the world's population is expected to grow from the current 7 billion people to 9-10 billion by the middle of the XXI century. Estimates show that global energy consumption will have increased several times by that time. Such an increase in energy consumption on the planet needs to be provided with energy raw materials sources. The solution to this problem should be started today since the widespread introduction of new technologies in energy generation will take more than a decade. This study allowed us to identify the main factors influencing the solution of energy supply and energy consumption problems as conditions for sustainable and proportional development of regional economies. In this regard, regional energy consumption strategies should be based on the implementation of recommendations for energy conservation, fuel, and energy resource saving, and the policy of energy substitution with alternative energy.

HIGHLIGHTS

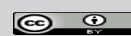
- ❶ The capacity of renewable energy sources is much higher than the total consumption of fuel and energy resources. However, the possibilities of their exploitation depend not only on the level of technical solutions implementation, terrain features, and climate conditions but also on economic feasibility. Self-renewable energy sources are diffused over large areas.
- ❷ Potential of biofuels can be utilised for consumers whose needs are met by small energy hubs. This type of alternative energy has a clear regional orientation and defined market directions. According to the European Commission's plans, bioenergy will reach two-thirds of all renewable energy by 2030, which is fully in line with current trends.

Keywords: Energy policy, renewable sources, geographical dimension, renewable energy sources, gas market restructuring

According to the Statistical Review of World Energy 2024 data, the world's proven oil reserves reached 239.8 billion tons (1700.1 billion barrels) at the end of 2023. This is enough for approximately 52 years

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of global production (R/P), taking into account the constant growth of global energy consumption. The world's proven gas reserves at the end of 2023 totaled 186.9 trillion cubic meters, which is enough to ensure 55 years of global production. In 2023, the world's coal reserves were 892 billion tons, which is enough to ensure 114 years of global output, and today, it has the largest reserves of all fossil fuels. Therefore, alternative energy is the key to solving the issues of resource depletion (Ma *et al.* 2018).

One of the areas of geothermal energy is the use of low-potential energy from the earth, featuring low source temperatures (3-30 °C). This energy cannot be used directly in power supply systems. Such energy can be utilised by devices called heat pumps. In other countries, heat pumps are becoming more widely used in residential heating systems. In Canada and the United States, heat pumps comprise 45% of the market for heating systems. The European Union plans to provide more than 50% of its heat supply through heat pumps in the coming years.

The conversion of solar energy into thermal energy is ensured by the ability of matter atoms to absorb electromagnetic radiation. In this case, the energy of electromagnetic radiation is converted into the kinetic energy of atoms and molecules of the matter, i.e., thermal energy. As can be seen from Fig. 1, an intensive use of concentrated solar radiation began in the second decade of this century. The installed load of this type of power plant worldwide was 4.8 GW at the end of 2016.

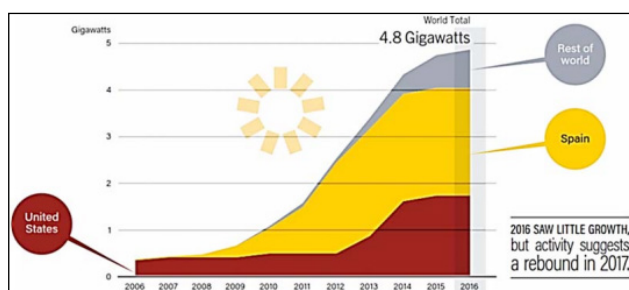


Fig. 1: Dynamics of using concentrated solar radiation globally

The advantage of heating using solar rays is the high speed of the process, exceeding 1000 K/s. The molten material does not get contaminated with foreign inclusions, as the narrow beam melts it in the form of the same material. An oxidising or reducing atmosphere can be created in the working chamber.

Several dozen solar furnaces have been built worldwide. They are located in the USA, France, Japan, Algeria, Uzbekistan, Armenia, and other countries. The capacity of the installations varies from 5-10 kW to 1000-5500 kW. The largest solar concentrator in the world is built in Uzbekistan near Tashkent (see Fig. 2). The mirror area is 1840 m² (12090 mirrors). The maximum temperature in the working zone is 2000 °C.



Fig. 2: General view of the world's largest solar concentrator (Uzbekistan)

In addition to visualising the state of the development of alternative energy sources (in general and by type), the corresponding features of the regions can be obtained based on either relative or synthetic indicators (Sáez-Martínez *et al.* 2016; Ang, *et al.* 2022). Regional profiles can be formed by any set of indicators selected for analysis purposes. The choice of the best value with subsequent comparison with regional indicators will allow for comparing the selected indicators and ranking regions based on these estimates.

Hydrogen energy has significant potential. The global hydrogen energy market could reach \$2 billion per year by 2025. Burning hydrogen produces lower greenhouse gas emissions (50% less compared to petrol-powered cars). When hydrogen is produced from renewable raw materials, it has a high energy density and generates only water as the primary emission source (Khoja *et al.* 2020; Mehrjerdi, 2020). However, hydrogen is highly explosive, has a low liquefaction temperature, and low density in its gaseous state, which causes several issues related to its storage and accumulation. The

achievement of the set goals is planned through the creation and implementation of state support measures in the fields of hydrogen production, storage, transportation, and storage (Ahmed *et al.* 2020).

The combustion of biomass for energy production has been practised for a long time. However, this process causes environmental pollution and is not very efficient, as the full potential of biomass as an energy source is not utilised (Yang *et al.* 2015; Xia *et al.* 2022). Currently, biomass meets only about 10% of global energy demand, which allows hydrogen to be one of the leaders among all renewable energy sources (Ampah *et al.* 2022). Large-scale industrial hydrogen production is carried out through natural gas reforming (via conversion into synthesis gas) with an efficiency of about 70-75%, or through coal gasification, which has an efficiency of about 45-65% with a concomitantly high level of CO₂ emissions (Mazhar *et al.* 2021).

Hydrogen technologies do not compete with traditional methods of generating electricity and heat but rather with decarbonisation systems of the energy system: carbon capture and storage, bioenergy, and heat pumps (Abbasi *et al.* 2020; Rej *et al.* 2022). Hydrogen has proven itself well in specific niches, for example, serial production of cars that run on alternative engine sources is already underway. Storage and transportation of hydrogen in cylinders is associated with increased danger due to its high volatility and explosiveness when in contact with air (Amrouche *et al.* 2016). This explains the extremely high material intensity of such transportation methods – a container weighing approximately 20 kg for every 1 kg of transported hydrogen, which, accordingly, negatively affects transportation costs.

LITERATURE REVIEW

Alternative energy sources include geothermal, hydrothermal, aerothermal energy, biomass energy, biogases (gas from organic waste, sewage treatment plants), and secondary energy resources, which contain blast furnace and coke oven gases, coal seam degasification, and the conversion of waste energy potential from technological processes (Salem *et al.* 2022).

The research of legal, economic, organisational, and technical problems related to the use of alternative

energy sources is reflected in the studies by both Ukrainian and foreign scholars.

Anwar *et al.* (2021) described the efficiency of photovoltaic converters, which ranges from 12% to 24%, depending on the design and semiconductor materials used (see Fig. 3).

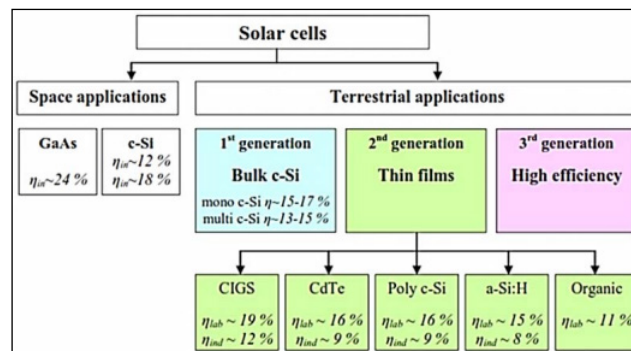


Fig. 3: Materials for manufacturing photovoltaic converters

Zappa *et al.* (2019) claimed that in 2016, the total capacity of photovoltaic installations worldwide reached 303 GW, sufficient to cover 1% of the world's total electricity demand (see Fig. 4). China, Germany, and Japan took the leading positions in the global arena of solar energy production at that time (Annual Energy Outlook, 2012; China 2030, 2012; Australian Energy Resource Assessment, 2014).

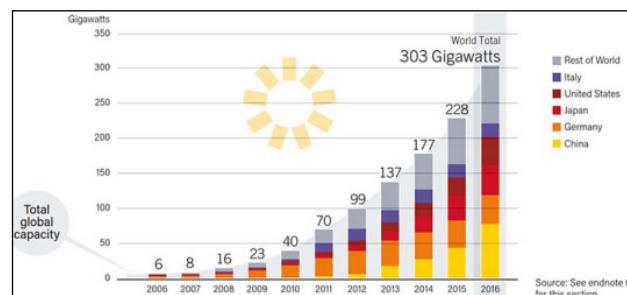


Fig. 4: World's solar photovoltaic power plants

Having subjected seaweed to fermentation, Parrado *et al.* (2016) obtained ethanol. They can also be composted to produce biogas. Seaweed can also be dried and subsequently burned for energy purposes.

Adams *et al.* (2018) list four main methods of converting wave energy into electricity (see Fig. 5):

- ♦ the principle of "oscillating water column" (OWC);
- ♦ attenuators;

- ♦ the principle of “body oscillation” (point absorber);
- ♦ the principle of “overflow” (overtopping).

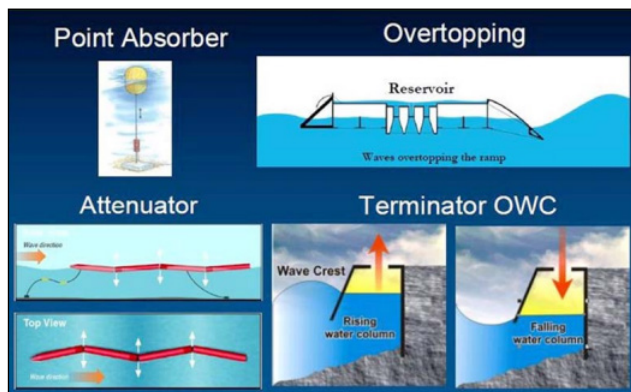


Fig. 5: Methods of using energy from waves

At present, systems for energy storage from renewable sources using fuel cells have been developed (Ikegami & Wang, 2016) and are being implemented. As shown in Fig. 6, electrical energy generated by solar panels (or wind turbines) is used to produce hydrogen (via electrolysis), which is stored in special containers and supplied to fuel cells to generate electrical energy during periods of peak energy consumption (or at night when solar radiation is absent).

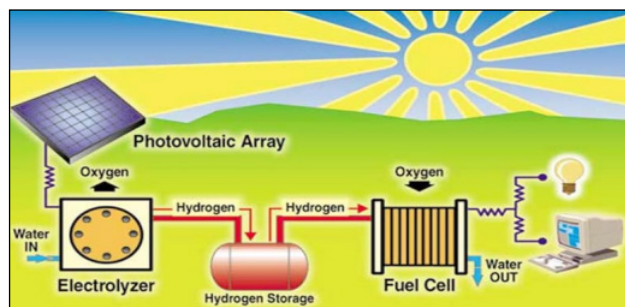


Fig. 6: Principle of Accumulation and Use of Solar Energy: photovoltaic array; hydrogen storage; oxygen; fuel cell

This study aims to analyse the use and justify the prospects for the development of renewable energy sources. The paper seeks to analyse engineering and technical approaches for the implementation of energy policy strategy.

METHODS

Geographical dimension, which is a major factor in the development of renewable energy sources in different parts of the world, became the subject of this research. We conducted a retrospective analysis

of using various renewable energy strategies. The study was conducted on the engineering and technical specifications, usage efficiency and prospects for the development of wind and solar power plants.

In this study, we employed the methods of historical and logical analysis and comparison, expert opinions, system analysis and forecasting. The research materials included energy devices that allowed converting the energy of nature into light energy with maximum efficiency and their application in different countries of the world.

RESULTS

At present, the following types of organic biofuels are used for transportation:

- ♦ bioethanol (mainly made from sugarcane and corn);
- ♦ biomethanol (from marine phytoplankton);
- ♦ biobutanol ($C_4H_{10}O$ - butyl alcohol, from sugarcane, beets, corn, wheat, etc.);
- ♦ dimethyl ether (from coal, natural gas, cellulose-paper production waste, and biomass).
- ♦ biodiesel (made from animal, vegetable, and microbial fats, as well as products of their esterification (rapeseed, soybean, palm, coconut oil) (Doppalapudi *et al.* 2021; Doppalapudi *et al.* 2023).
- ♦ second-generation biofuel (different fuel obtained by biomass pyrolysis, algae, etc.).

Biodiesel – methyl ester, which possesses fuel properties and is obtained as a result of a chemical reaction from plant fats, finds the broadest application in many countries (Sotnyk *et al.* 2023). In the world (2021), 185 trillion liters of biofuel were produced, of which about 125 trillion liters account for fuel ethanol (74%). The main world producers of biofuels are the USA and Brazil.

Swiss company Clean Hydrogen Producers (CHP) has developed a technology for hydrogen production from water using parabolic solar concentrators. The area of the installation's mirrors is 93 m². At the concentrator's focus, the temperature reaches 2200°C. Water begins to split into hydrogen and oxygen at temperatures above 1700°C. Hydrogen production amounts to 3800 kg per year (about 10.4 kg per day).

According to the information resource of the international network of renewable energy (REN21), the contribution of Renewable Energy Sources (RES) to gross energy consumption is 21.5% (see Fig. 7). The largest share is traditional biomass utilisation (7.8%) (Ziegler et al., 2019).

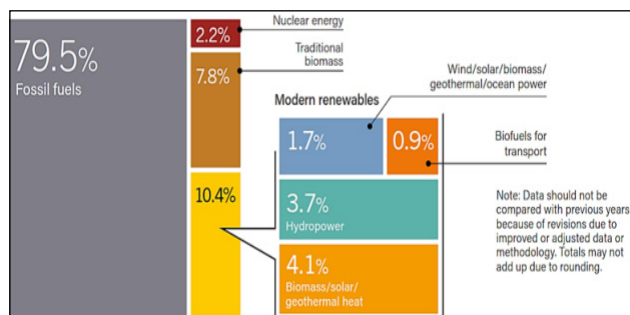


Fig. 7: RES contribution to World Gross Energy Consumption (2023)

The share of RES in global electricity consumption is somewhat higher and amounts to 24.5%. The maximum contribution to electricity consumption comes from hydropower (16.6%). As of 2023, China, the United States, and Germany have the largest installed RES capacity (see Fig. 8). It is worth noting the intensive development of renewable energy in China in recent years and wind and solar energy in Germany. Considering that Germany consumes much less per capita compared to China, it ranks first in the global ranking.

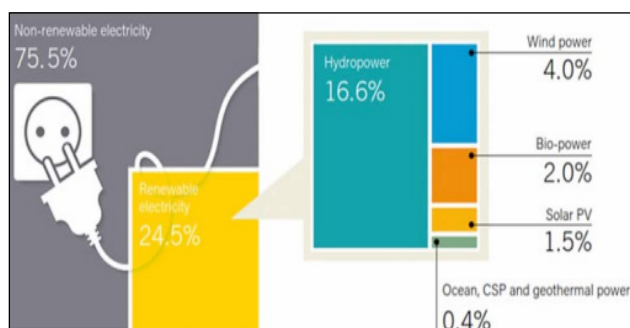


Fig. 8: RES contribution to the global electricity consumption

Significant achievements in the development of renewable energy are evident in the countries of the European Union (300 GW of installed capacity). When considering the percentage contribution of RES to the energy consumption of EU countries, significant achievements of Scandinavian countries and Latvia can be noted (see Fig. 9). The success of Europe in this field is driven by state support and incentives for the use of RES.

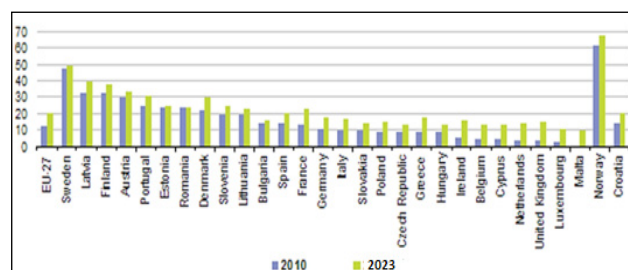


Fig. 9: RES development trends in the EU countries

In the long-term perspective of the world energy development by 2100, the consumption of hydrocarbon energy is planned to be reduced by 30-35% by replacing it with renewable energy sources (see Fig. 10).

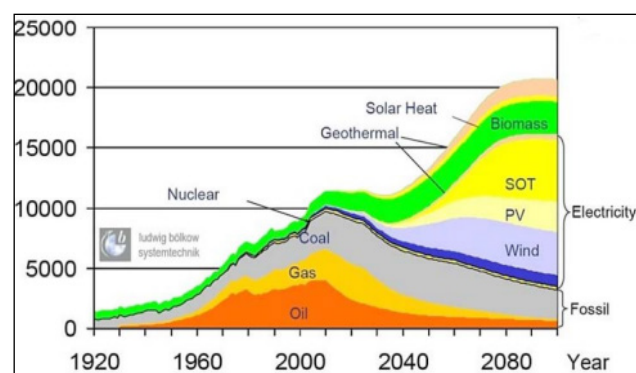


Fig. 10: Scenario of the world energy development

In Ukraine, as in the rest of the world, the largest contribution to renewable energy comes from wood fuel sources (firewood, wood chips, wood waste). The country has recently commissioned new photovoltaic, wind, and hydroelectric power plants in recent years.

Suppose solar radiation in the Sahara was used by 10%. It would be possible to produce the current world energy demand in an area of approximately 700 km by 700 km (see Fig. 11). However, with the current state of technology and engineering, it is not possible to cost-effectively transmit energy to consumers in different parts of the world. In terms of geographic latitude, solar radiation in Ukraine is much lower than in the Sahara: the country receives up to 1200 kWh/m² of radiation per year. This corresponds to the amount of energy contained in 60 liters of oil. In general, the annual solar radiation throughout the territory of Ukraine represents an amount of energy that exceeds the gas requirement for energy production by 15 times.

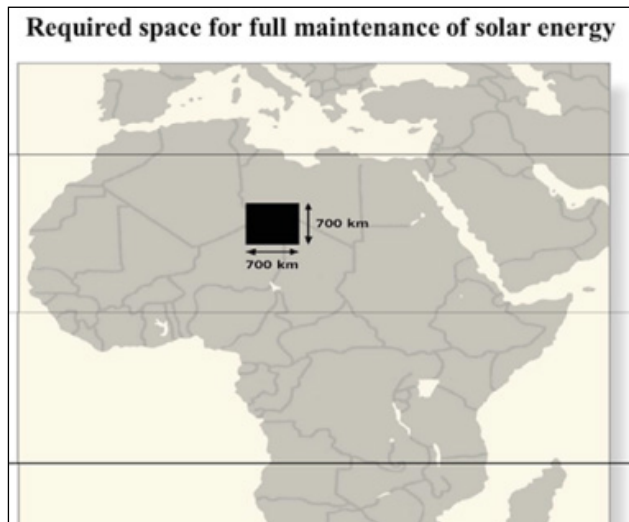


Fig. 11: The potential for solar energy use in the Sahara Desert

The largest solar power plant is located in Morocco (Sahara Desert) (see Fig. 12). Its capacity equals 500 MW.



Fig. 12: Overview of the largest solar power plant (Morocco)

Along with industrial electricity production, solar modules have been used in recent years to create new environmentally friendly vehicles (hybrid cars, airplanes, dirigibles, etc.).

As can be seen from Fig. 13, wind power is on the rise globally. The total installed capacity of wind power in 2021 reached 487 GW. The highest growth rate is observed in China (+23%). The top 5 countries in wind energy development include China, the United States, Germany, India, and Spain. Considering the size of the countries, Germany has the greatest success in the development of wind energy (Azad *et al.*, 2015; Azad *et al.* 2019).

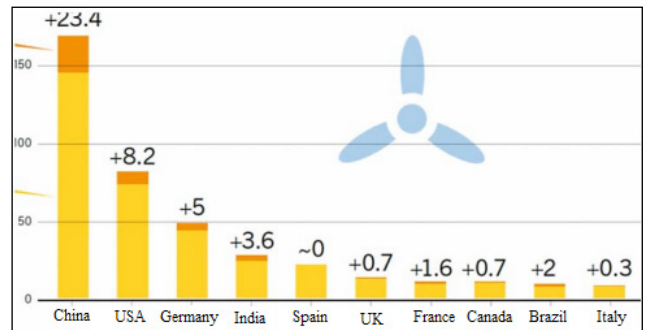


Fig. 13: Top 10 countries in the global wind energy development

Geothermal power plants can be effectively used for both heating and electricity generation. As can be seen from Fig. 14, geothermal power plants are most widely used in the United States, the Philippines, and Indonesia. For example, in the United States, the registered capacity of geothermal power plants is more than 3.5 GW.

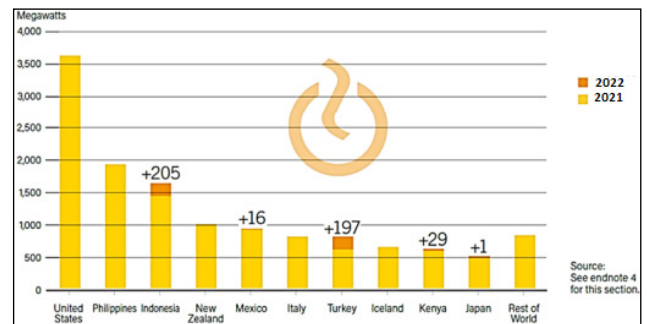


Fig. 14: World leaders in geothermal energy use

Global hydropower generation in 2022 reached 1064 GW. As can be seen from Fig. 15, the top 10 countries of the world's hydropower producers include China (about 28% of global production), Brazil, the United States, Canada, and other countries.

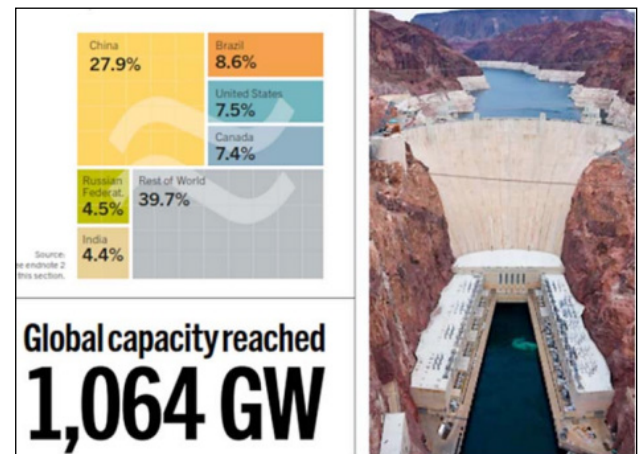


Fig. 15: Hydropower generation by the world's leading producers (2022)

Incineration of municipal solid waste - this technology is used in many European countries (see Fig. 16). For example, on the outskirts of Vienna (Austria), 4 thermal power plants have been set up that run on industrial and municipal waste (including toxic and medical waste) and provide thermal energy to the city.

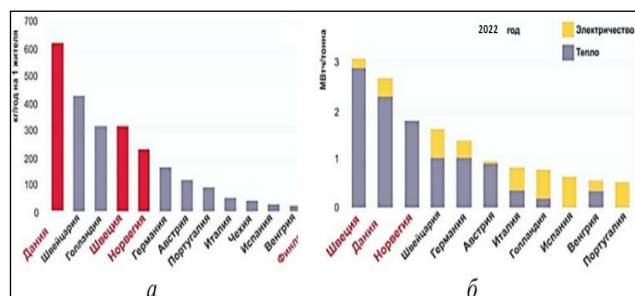


Fig. 16: Amount of waste incinerated per capita (a); amount of energy used per ton of waste (b)

DISCUSSION

In the context of the formulated results of regional energy policy, it is necessary to focus on the accelerating rates of economic growth in regions and the growth of energy efficiency in regions compared to the primary energy resource consumption rates (Gurieiev *et al.* 2020). The factor of energy security of the region through alternative energy sources is one of the most important characteristics of their development. The choice of appropriate assessment criteria and their quantitative values will allow for the creation of appropriate scorecards of alternative energy potential and the degree of its development (Atstaja *et al.* 2022).

One of the progressive and still unexplored alternative energy sources is tidal energy, which occurs in shallow waters, ranging from 1-3 TW. The technical potential of tidal currents is 48 TWh/year (0.17 EJ) in Europe and 30 TWh/year (0.11 EJ/year) in China. Ocean currents also have significant energy potential. For example, the Gulf Stream has a technical potential for generating 25 GW of energy equivalent. The potential of ocean thermal energy is 44,000 TWh/year (159 EJ/year) (see Fig. 17). As shown in the figure, this type of energy has the maximum value in equatorial regions.

The peculiarity of the political orientation in solving optimisation problems based on smart networks includes the application of artificial intelligence and neural network elements.

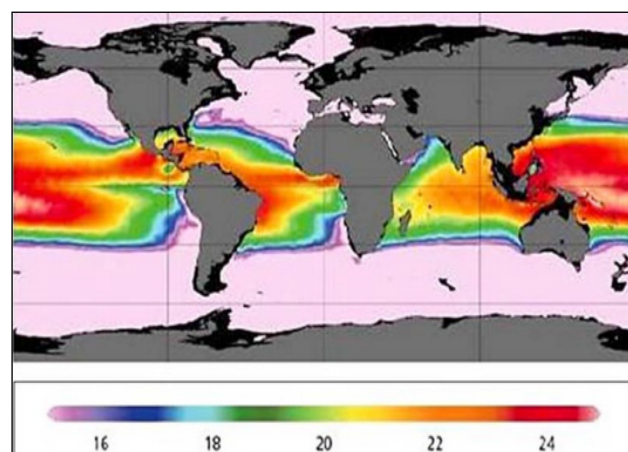


Fig. 17: Global distribution of oceans' thermal energy

The latter are used to search for the most optimal solutions to the problems using previous experience of similar issues and the experience of leading experts in energy policy. It should be noted that decision-making using “smart grids” can be carried out online, using all modern operational types of communication (Internet, cellular, and radio communications) (see Fig. 18).

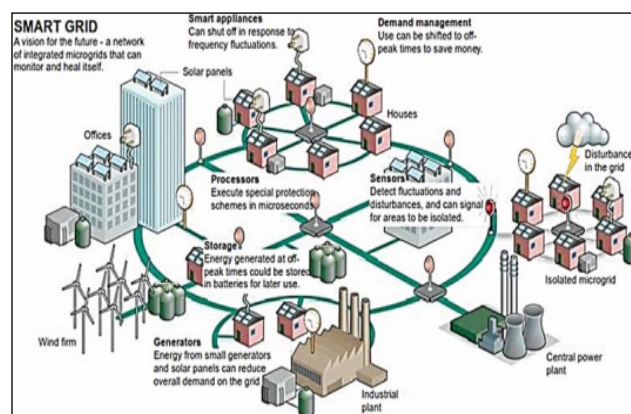


Fig. 18: Conceptual structure of “smart grids” for renewable energy

CONCLUSION

The main challenges for the development of the energy sector in Ukraine compared to the European countries are as follows:

- growing demand for energy resources against the backdrop of declining reserves of traditional energy resources and rising prices;
- growing dependence on energy imports;
- the need to protect the environment;
- the need for significant investments in the energy sector.

The priority areas of energy development in our country include:

- ♦ improvement and diversification of the fuel and energy balance;
- ♦ maximum involvement of domestic energy resources, including renewable, unconventional, and secondary energy sources;
- ♦ reconstruction and modernisation of existing facilities and replacement of retired facilities with the introduction of new scientifically based energy efficient technologies;
- ♦ reduction of fuel consumption for electricity and heat generation.

REFERENCES

- Abbasi, K., Lv, K., Nadeem, M.A., Khan, A. and Shaheen, R. 2020. Agricultural and manufacturing sector determinants of electricity consumption, price, and real GDP from Pakistan. *North American Academic Research*, **3**: 21–44. <https://doi.org/10.5281/zenodo.3604943>. Last Accessed on 9th June, 2024.
- Adams, S., Klobodu, E.K.M. and Apio, A. 2018. Renewable and non-renewable energy, regime type and economic growth. *Renew Energy*, **125**: 755–767. <https://doi.org/10.1016/j.renene.2018.02.135>. Last Accessed on 19th June, 2024.
- Ahmed, K., Farrok, O., Rahman, M.M., Ali, M.S., Haque, M.M. and Azad, A.K. 2020. Proton Exchange Membrane Hydrogen Fuel Cell as the Grid Connected Power Generator. *Energies*, **13**: 6679. <https://doi.org/10.3390/en13246679>. Last Accessed on 9th June, 2024.
- Ampah, J.D., Afrane, S., Agyekum, E.B., Adun, H., Yusuf, A.A., and Bamisile, O. 2022. Electric vehicles development in Sub-Saharan Africa: Performance assessment of standalone renewable energy systems for hydrogen refueling and electricity charging stations (HRECS). *J. Cleaner Production*, **376**: 134–238. <https://doi.org/10.1016/j.jclepro.2022.134238>. Last Accessed on 9th June, 2024.
- Amrouche, S.O., Rekioua, D., Rekioua, T. and Bacha, S. 2016. Overview of energy storage in renewable energy systems. *Int. J. Hydrogen Energy*, **41**: 20914–20927. <https://doi.org/10.1016/j.ijhydene.2016.06.243>
- Ang, T. *et al.* 2022. A comprehensive study of renewable energy sources: Classifications, challenges and suggestions. *Energy Strategy Reviews*, **43**: 100939. <https://doi.org/10.1016/j.esr.2022.100939>. Last Accessed on 9th June, 2024.
- Anwar, A., Siddique, M., Eyup, D. and Sharif, A. 2021. The moderating role of renewable and non-renewable energy in environment income nexus for ASEAN countries: evidence from Method of Moments Quantile Regression. *Renewable Energy*, **164**: 956–967. <https://doi.org/10.1016/j.renene.2020.09.128>
- Atstaja, D., Koval, V., Grasis, J., Kalina, I., Kryshtal, H. and Mikhno, I. 2022. Sharing model in circular economy towards rational use in sustainable production. *Energies*, **15**(3). <https://doi.org/10.3390/en15030939>
- Azad, A., Rasul, M., Islam, R. and Shishir, I.R. 2015. Analysis of Wind Energy Prospect for Power Generation by Three Weibull Distribution Methods. *Energy Procedia*, **75**: 722–727. <https://doi.org/10.1016/j.egypro.2015.07.499>
- Azad, K., Rasul, M., Halder, P. and Sutariya, J. 2019. Assessment of Wind Energy Prospect by Weibull Distribution for Prospective Wind Sites in Australia. *Energy Procedia*, **160**: 348–355.
- Doppalapudi, A., Azad, A. and Khan, M. 2021. Combustion chamber modifications to improve diesel engine performance and reduce emissions: A review. *Renewable and Sustainable Energy Reviews*, **152**: 111683. <https://doi.org/10.1016/j.rser.2021.111683>. Last Accessed on 8th January, 2024.
- Doppalapudi, A., Azad, A. and Khan, M. 2023. Advanced strategies to reduce harmful nitrogen-oxide emissions from biodiesel fueled engine. *Renewable and Sustainable Energy Reviews*, **174**: 113123. <https://doi.org/10.1016/j.rser.2022.113123>. Last Accessed on 8th January, 2024.
- Gurieiev, V., Kutsan, Y., Iatsyshyn, A., Artemchuk, V. and Popov, O. 2020. Simulating systems for advanced training and professional development of energy specialists in power sector. *CEUR Workshop Proceedings*, **2732**: 693–708. <https://doi.org/10.31812/123456789/4456>. Last Accessed on 8th January, 2024.
- Ikegami, M. and Wang, Z. 2016. The long-run causal relationship between electricity consumption and real GDP: evidence from Japan and Germany. *J. Policy Model*, **38**: 767–784. <https://doi.org/10.1016/j.jpolmod.2016.10.007>. Last Accessed on 18th January, 2024.
- Khoja, A., Azad, A., Saleem, F., Khan, B., Naqvi, S., Mehran, M. and Amin, N. 2020. Hydrogen Production from Methane Cracking in Dielectric Barrier Discharge Catalytic Plasma Reactor Using a Nanocatalyst. *Energies*, **13**: 5921. <https://doi.org/10.3390/en13225921>. Last Accessed on 18th January, 2024.
- Ma, Y., Zhang, J., Huang, Y. and Cao, J. 2018. A novel process combined with flue-gas desulfurisation technology to reduce lead dioxide from spent lead-acid batteries. *Hydrometallurgy*, **178**: 146–150. <https://doi.org/10.1016/j.hydromet.2018.04.006>
- Mazhar, A., Khoja, A., Azad, A., Mushtaq, F., Naqvi, S., Shakir, S., Hassan, M., Liaquat, R. and Anwar, M. 2021. Performance Analysis of TiO₂-Modified Co/MgAl₂O₄ Catalyst for Dry Reforming of Methane in a Fixed Bed Reactor for Syngas (H₂, CO) Production. *Energies*, **14**: 5921. <https://doi.org/10.3390/en14113347>. Last Accessed on 8th January, 2024.
- Mehrjerdi, H. 2020. Modeling and optimisation of an island water-energy nexus powered by a hybrid solar-wind renewable system. *Energy*, **197**: 117–217. <https://doi.org/10.1016/j.energy.2020.117217>. Last Accessed on 8th January, 2024.

- Rej, S., Bandyopadhyay, A., Murshed, M., Mahmood, H. and Razzaq, A. 2022. Pathways to decarbonisation in India: the role of environmentally friendly tourism development. *Environ. Sci. Pollut. Res.*, **29**: 50281–50302. <https://doi.org/10.1007/s11356-022-19239-2>
- Sáez-Martínez, F.J., Lefebvre, G., Hernández, J.J. and Clark, J.H. 2016. Drivers of sustainable cleaner production and sustainable energy options. *J. Clean. Prod.*, **138**: 1, 1–7. <https://doi.org/10.1016/j.jclepro.2016.08.094>. Last Accessed on 8th January, 2024.
- Sotnyk, I., Kurbatova, T., Trypolska, G., Sokhan, I. and Koshel, V. 2023. Research trends on development of energy efficiency and renewable energy in households: A bibliometric analysis. *Environmental Economics*, **14**(2): 13–27. [http://doi.org/10.21511/ee.14\(2\).2023.02](http://doi.org/10.21511/ee.14(2).2023.02)
- Xia, W., Apergis, N., Bashir, M., Ghosh, S., Doğan, B. and Shahzad, U. 2022. Investigating the role of globalisation, and energy consumption for environmental externalities: Empirical evidence from developed and developing economies. *Renewable Energy*, **183**: 219–228. <https://doi.org/10.1016/j.renene.2021.10.084>. Last Accessed on 8th January, 2024.
- Yang, H., He, J. and Chen, S. 2015. The fragility of the environmental Kuznets curve: revisiting the hypothesis with Chinese data via an “extreme bound analysis”. *Ecological Economics*, **109**: 41–58. <https://doi.org/10.1016/j.ecolecon.2014.10.023>
- Zappa, W., Junginger, M. and van den Broek, M. 2019. Is a 100% renewable European power system feasible by 2050? *Applied Energy*, 233–234, 1027–1050. <https://doi.org/10.1016/j.apenergy.2018.08.109>. Last Accessed on 8th January, 2024.
- Ziegler, M.S., Mueller, J.M., Pereira, G.D., Song, J., Ferrara, M., Chiang, Y.-M. and Trancik, J.E. 2019. Storage Requirements and Costs of Shaping Renewable Energy Toward Grid Decarbonization. *Joule*, **3**(9): 2134–2153. <https://doi.org/10.1016/j.joule.2019.06.012>. Last Accessed on 8th January, 2024.

