ESTIMATION OF TENDENCIES OF TRANSFORMING THE ENERGY SECTORS OF WORLD, EUROPEAN UNION AND UKRAINE IN THE PERSPECTIVE TO 2050 WITH USING THE RENEWABLE ENERGY SOURCES IN THE CONCEPT OF SUSTAINABLE DEVELOPMENT

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ABSTRACT
The study presents an approach aimed at assessing trends in the reform of the energy sector of the world, the European Union and Ukraine in the future until 2050, using renewable energy sources in the concept of Sustainable Development. Our research is aimed at: analysing the energy sector of the world, the European Union and Ukraine and identifying the benefits of using renewable energy sources in the concept of Sustainable Development, assessment of prospects for the application of innovative technologies based on renewable energy sources in the concept of Sustainable Development. A number of criteria for energy, economic and environmental efficiency of innovative technologies for the use of renewable energy sources are analysed in order to conduct a comprehensive assessment of the effectiveness of energy and resource-saving, environmentally friendly and cost-effective innovative technologies in the concept of Sustainable Development. This approach allows providing a reasonable definition of prospects for the use of energy and resource-saving, environmentally friendly and cost-effective innovative technologies for the use of renewable energy sources in the concept of sustainable development to increase energy, economic efficiency and environmental security of Ukraine's energy sector.

INTRODUCTION

The processes of globalization of world economic relations are characterized by positive effects, as well as significant risks due to the emergence of various conflicts in various spheres of human activity: economic, political, financial and social. Contradictions and conflicts that arise between states and economic actors increase the vulnerability of their security systems, reduce competitiveness and affect the level of economic prosperity. The role of the fuel and energy complex in ensuring the economic security of the country is determined by the priority of this industry in the economic system.

Energy security plays a key role in the state's national security system. Natural resource factors (mainly the availability and efficiency of energy resources) play a key role in the formation of a comprehensive security system for industrial and post-industrial economies. This problem is also relevant for the Ukrainian economy, which remains one of the most energy-intensive. Issues of national security have become particularly acute in recent years, when Ukraine has faced serious geopolitical challenges and serious socio-economic shocks.

The degree of stability of the energy complex is characterized by the term "energy security", which defines the state of protection of the interests of economic entities associated with ensuring the required level of consumption of various types of energy. Energy plays an important role in the economic and social stability of the country, significantly affects living standards and economic security. Therefore, the stability of the country's economic system in many cases is determined by the level of stability of energy companies.

Integration of the United Energy System (UES) of Ukraine into the European Network of Transmission System Operators for Electricity (ENTSO-E) is one of the strategic goals of national energy company «Ukrenergo», as it will increase the reliability of the energy systems, ensure efficient use of energy resources and increase exchange capacity. This is an important component of Ukraine's energy security. After all, the synchronous operation of Ukraine's energy system with the ENTSO-E energy association will increase the reliability and sustainability of Ukraine's UES, expand electricity exchange opportunities between neighboring countries, increase competition in the domestic market and create opportunities for the European energy market. The integration of the United Energy System of Ukraine into the pan-European energy system ENTSO-E is provided for in the Association Agreement between Ukraine and the European Union (EU).

The concept of Sustainable Development involves a combination of economic, social and environmental trends in the modern world. The concept of Sustainable Development provides for the reduction of consumption of scarce natural non-renewable resources while increasing the use of non-traditional renewable energy resources through the widespread use of environmentally friendly energy- and resource-saving production technologies at all stages of the life cycle.

The concept of sustainable development, according to (Arkhypova, et al, 2021; Brych and Fedirko, 2018; Emas, 2015; Koval, et al, 2019; Mandryk, et al, 2017; Ostapenko, 2020), aims to maintain economic advancement and progress while protecting the long-term value of the environment. The concept of sustainable development implies the optimal use of limited resources and the use of environmentally friendly nature-, energy- and material-saving technologies at all stages of the life cycle with the production of environmentally acceptable products (Koval, et al, 2017, 2018, 2019).

As it is noted in (Ostapenko, Savina, et al, 2020), the concept of Sustainable Development is determinates the 17 Sustainable Development Goals (SDGs), that defined the tendencies of development of sustainable energy and fuel and energy complex of Ukraine in the direction of European integration, ensuring reduction of greenhouse gas emissions and increasing the use of non-traditional and renewable energy sources with the application of energy- and resource-saving, environmentally safe and cost-effective innovative technologies.

1 ANALYSIS OF ENERGY SECTORS OF WORLD AND EUROPEAN UNION AND DETERMINATION OF ADVANTAGES OF APPLICATION OF RENEWABLE ENERGY SOURCES FOR UKRAINE IN THE CONCEPT OF SUSTAINABLE DEVELOPMENT

The International Energy Agency (IEA) has prepared an analytical work "For ecast of world energy development for the period up to 2035", which states that in the period 2010 - 2035 there will be an increase in world energy consumption by 35%: the smallest increase in consumption will be use of coal (13%), the largest - for the use of renewable energy sources (RES) (87%). It is noted that fossil energy resources will play a key role in the further development of world energy, however, their share in primary energy consumption in 2035 will be reduced to 75% (today – 81%) ("Foreign experience in improving energy efficiency and introducing new technologies for electricity generation", 2021). It should be noted that the long-term forecast of the IEA and other international organizations provides for an annual reduction in energy intensity of gross domestic product (GDP), which is planned to increase energy efficiency in all sectors of the economy, especially the most energy-intensive - industry and energy.

At the same time, in Ukraine the level of fuel and energy expenditures on GDP production, especially in industry and energy, is declining at a relatively slow pace and as of the end of 2020 significantly exceeded the average level both in the EU and in the world as a whole. This indicates a relatively low level of implementation of energy efficient technologies in the sectors of economy and energy in Ukraine. Electricity is the fastest growing sector of energy consumption (56% growth by 2035). In developed countries, almost all the increase is due to the generation and consumption of electricity and heat. In developing countries, the main increase in demand – in electricity and industry. In the transport sector, in addition to oil, the use of other fuels is increasing, but their share will not exceed 12,5 % by the end of the forecast period.

According to the IEA, world consumption of renewable energy sources (RES) by 2040 will reach almost 3 billion tons of oil equivalent, of which 2,7 billion tons of oil equivalent, including 0,5 billion tons, can be directed to electricity and heat production oil equivalent of hydropower.

Based on the publication ("Main indicators of the fuel and energy complex of Ukraine for 2020", 2021), the structure of electricity generation in the United Energy System of Ukraine in 2020 from power plants of different sources of energy is determined; the results are shown in Tables 1 – 3.

Table 1. Structure of electricity production in the United Energy System of Ukraine in 2020 from power plants of different sources of energy

Source of primary energy for electricity production in the United Energy System of Ukraine	Share of electricity production in the United Energy System of Ukraine,%
Nuclear fuel	29,31
Coal	19,27
Natural gas	15,04
Energy of waves and tides	9,52
Sale of balances	7,40
Solar energy	6,64
Wind energy	4,51
Sales on the market "day ahead" / intraday market	3,13
Imports	2,71
Other fuels / energy	1,08
Biogas	0,54
Biomass	0,39
Information not provided by participants	0,35
Oil fuel	0,06
Industrial gas	0,05
Geothermal energy	0,00

Source: "Main indicators of the fuel and energy complex of Ukraine for 2020", 2021).

In Table 3 are indicated: HPP – hydro power plants, small HPP – small hydro power plants, mini HPP – mini hydro power plants, micro HPP – micro hydro power plants.

Table 2. Structure of electricity generation in the United Energy System of Ukraine in 2020 from different sources of energy

Source of primary energy for electricity production in the United Energy System of Ukraine	Share of costs per 1 kWh,%
Coal	19,27
Natural gas	15,04
Nuclear fuel	29,31
Natural gas	15,04
Hydropower (large energy facilities)	9,52
Renewable energy sources	13,62
Other sources of energy	13,24

Source: "Main indicators of the fuel and energy complex of Ukraine for 2020", 2021).

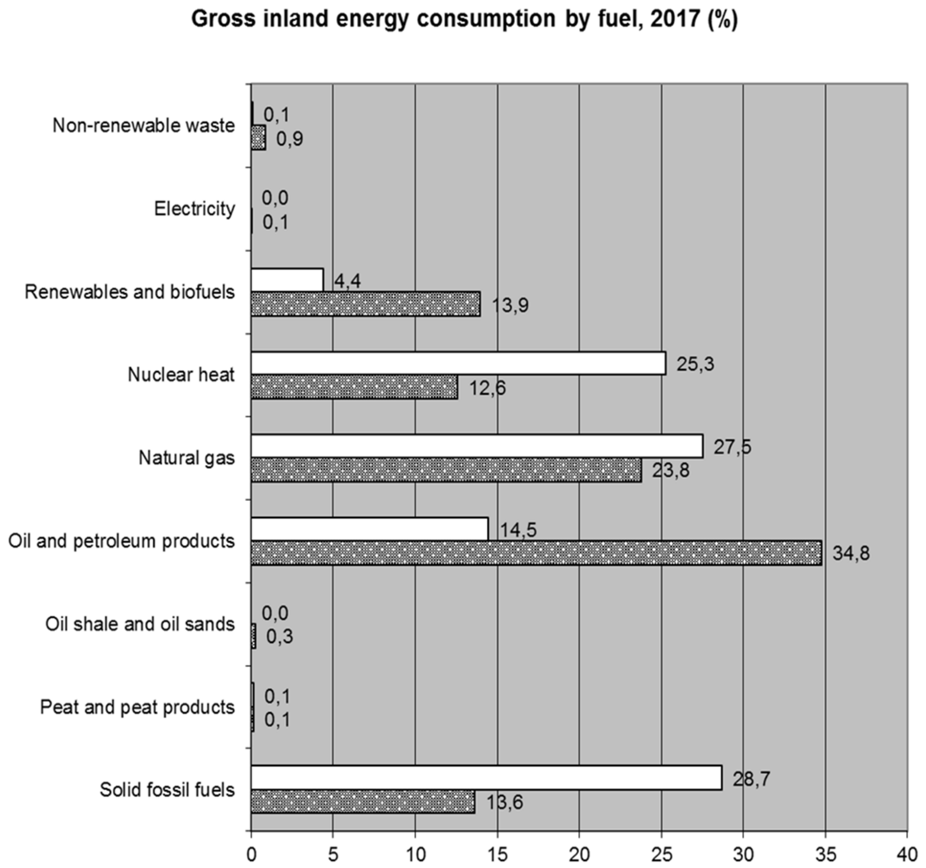
Table 3. Structure of electricity generation in the United Energy System of Ukraine in 2020 from HPP with using hydroenergy, tnergy of waves and tides

Type of power plant for electricity production in the United Energy System of Ukraine	Share of electricity production in the United Energy System of Ukraine,%
HPP with a capacity of more than 10 MW	9,25
Small HPP	0,11
Mini HPP	0,14
Micro HPP	0,02

Source: "Main indicators of the fuel and energy complex of Ukraine for 2020", 2021).

It should be noted, that the long-term forecast of the IEA and other international organizations takes into account the annual decline in energy intensity of gross domestic product by increasing energy efficiency in all sectors of the economy, especially more energy-intensive – in industry and energetics ("Foreign experience in improving energy efficiency and introducing new technologies for electricity generation", 2021).

In Fig. 1 (from the investigation (Ostapenko, Savina, et al, 2020)) shows a comparison of gross inland energy consumption by fuel (in%) for 28 EU countries and Ukraine.



	Solid fossil fuels	Peat and peat products	Oil shale and oil sands	Oil and petroleum products	Natural gas	Nuclear heat	Renewables and biofuels	Electricity	Non-renewable waste
Ukraine	28,7	0,1	0,0	14,5	27,5	25,3	4,4	0,0	0,1
EU-28	13,6	0,1	0,3	34,8	23,8	12,6	13,9	0,1	0,9

Ukraine EU-28

Fig. 1. Comparison of gross inland energy consumption by fuel (in%) for 28 EU countries (EU-28) and Ukraine

Source: author's research results from (Ostapenko, Savina, et al, 2020)

From fig. 1 (Ostapenko, Savina, et al, 2020) shows that in Ukraine, the percentage of usage of renewable energy and biofuels is 3…4 times lower than in the EU. This indicates the need to increase the share of non-traditional and renewable energy sources in the fuel and energy sector and in the energy sector of Ukraine.

As it is noted in (Ostapenko, 2020) sustainable development of society is possible only in the conditions of energy saving, that is, the development of systems that use energy more efficiently, provide the same or even higher level of transport services, lighting, heating, etc. with less energy consumption. The use of fossil fuels and nuclear energy is contrary to the principle of sustainable development, since these resources are non-renewable, and their use pollutes the environment. Moving towards a sustainable society requires a slow elimination of dependence on fossil fuels. Therefore, the way to overcome the current energy crisis is to switch to the use of alternative (non-traditional) energy sources, in particular, the introduction of heat pump installations. Advantages of application of heat pump installations for the conditions of Ukraine are determined and substantiated on the basis of the results of research, published in a number of national and foreign publications (Ostapenko, 2015, 2016, 2017, 2018, 2019, 2020; Ostapenko, Savina, et al, 2020; Ostapenko, Bakum and Yuschishina, 2013; Ostapenko, Leshchenko and Tikhonenko, 2015; Ostapenko and Portnov, 2018; Ostapenko and Shevchenko, 2011; Ostapenko, Valigura and Kovalenko, 2013), as it is noted in (Ostapenko, 2020).

A number of investigations in recent years were devoted to the studying of efficiency of application of innovative resource-saving technologies in the world and Ukraine (Arkhypova, et al, 2021; Koval, et al, 2019; Ostapenko, 2019, 2020; Ostapenko, Savina, et al, 2020).

Our research (Ostapenko, Savina, et al, 2020) is based on the "Tracking SDG7" – resource, which uses the databases of the International Renewable Energy Agency (IRENA), the International Energy Agency (IEA), the World Bank, the United Nations Statistics Division (UNSD) and others ("Tracking SDG7", "Rise", "Esmap"). We also used statistics from Eurostat and World Bank resources ("Eurostat", "DataBank. WorldBank").

The paper (Ostapenko, Savina, et al, 2020) considers the prospects for the application of innovative resource-saving technologies in the concepts of green logistics and sustainable development. Assessment of the perspectives of application of innovative resource-saving technologies in Ukraine was carried out with taking into consideration the main goals of sustainable development, tendencies of development of sustainable energy and fuel and energy complex of Ukraine in the direction of European integration, ensuring reduction of greenhouse gas emissions and increasing the use of non-traditional and renewable energy sources. The study illustrates the application of principles and objectives of the concept of green logistics in order to increase the level of energy-economic efficiency of the energy sector of Ukraine with the application of energy- and resource-saving, environmentally safe and cost-effective innovative technologies.

Presented research is also based on the "Tracking SDG7" – resource, which uses the databases of the International Renewable Energy Agency (IRENA), the International Energy Agency (IEA), the World Bank, the United Nations Statistics Division (UNSD) and others ("Tracking SDG7", "Rise", "Esmap"). We also used statistics from Eurostat and World Bank resources ("Eurostat", "DataBank. WorldBank").

The scientific results, presented in our study, are based on data from the International Renewable Energy Agency (IRENA) database ("IRENA", 2021).

The International Renewable Energy Agency (IRENA) is an intergovernmental organization that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a center of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. The «REmap 2030», developed by IRENA, is a roadmap to double renewable energy use worldwide by 2030 ("IRENA", 2021).

In Fig. 2 shows a structure of supply of electricity in European Union (EU), January 2019 to January 2020 (in GWh).

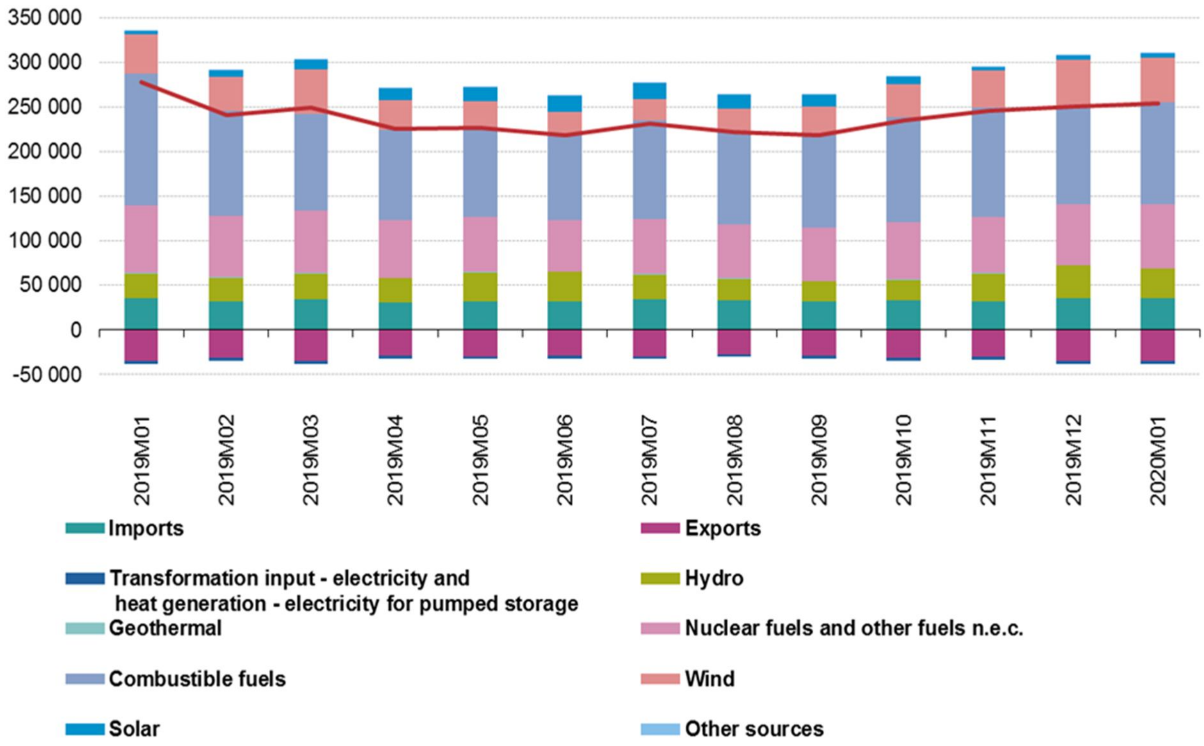


Fig. 2. Structure of supply of electricity in European Union (EU), January 2019 to January 2020 (in GWh)
(Source: Eurostat)

The «Global Renewable Energy Outlook: Transforming Energy by 2050 (April 2020)», developed by the International Renewable Energy Agency (IRENA), shows the path to create a sustainable future energy system. This flagship report highlights climate-safe investment options until 2050, the policy framework needed for the transition and the challenges faced by different regions.

The «Global Renewable Energy Outlook: Transforming Energy by 2050 (April 2020)», shows the outlines the investments and technologies needed to decarbonize the energy system under the Paris Agreement. It is also exploring deeper decarburization options for the heaviest sectors, with the aim of eventually reducing carbon dioxide (CO_2) emissions to zero ("IRENA", 2021).

In Fig. 3 shows a structute of generation (net) of electricity by type of fuel in EU, January 2019 to January 2020 (in % based on GWh).

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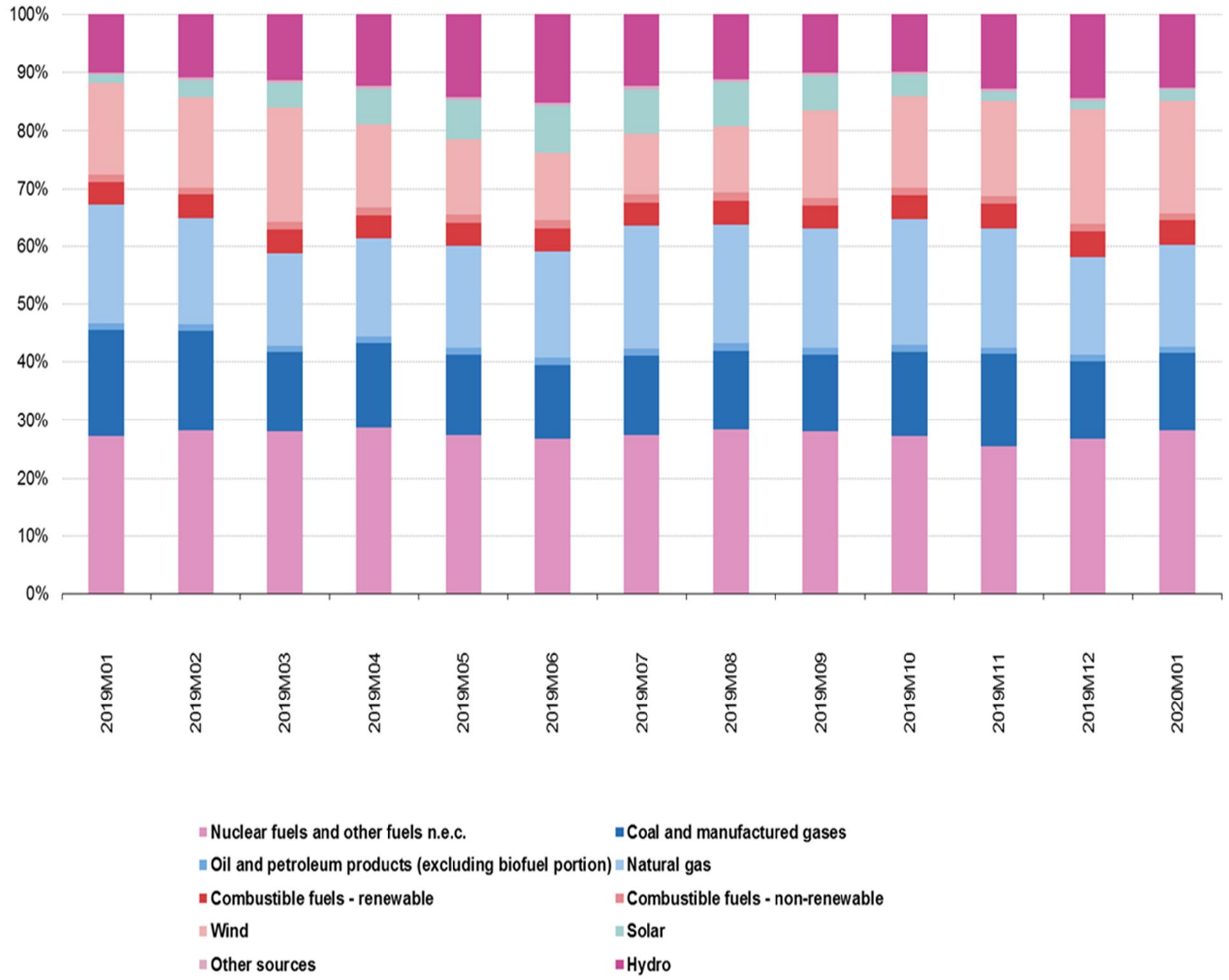

Fig. 3. Structure of generation (net) of electricity by type of fuel in EU, January 2019 to January 2020 (in % based on GWh)
(Source: Eurostat)

With a mandate from countries around the world, IRENA encourages governments to adopt enabling policies for renewable energy investments, provides practical tools and policy advice to accelerate renewable energy deployment, and facilitates knowledge sharing and technology transfer to provide clean, sustainable energy for the world's growing population ("IRENA", 2021).

In Figs. 4 – 23 shows the criteria for energy, economic and environmental efficiency of innovative technologies for the use of renewable energy sources, which analysed in order to conduct a comprehensive assessment of the effectiveness of energy and resource-saving, environmentally friendly and cost-effective innovative technologies in the concept of Sustainable Development. The results of research, shown in Figs. 4 – 23, were obtained by the author with using a database IRENA.

Fig. 4 displays the cumulative renewable energy investment needs in the world from 2016 to 2050 that will result from the full deployment of REmap options by region and category.

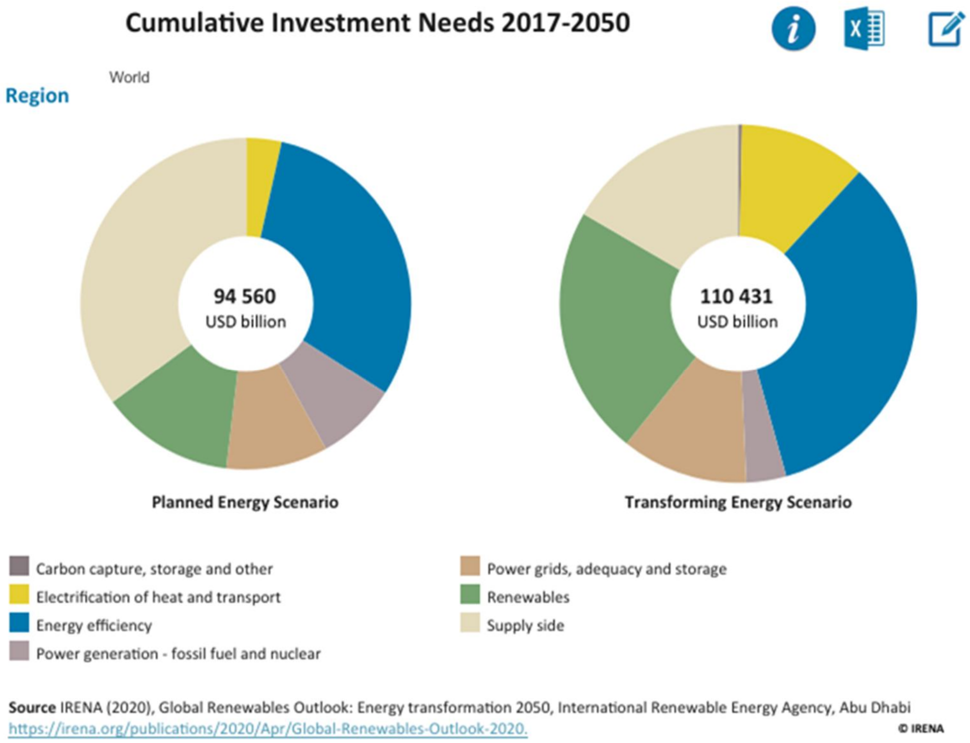

Fig. 4. Cumulative renewable energy investment needs from 2016 to 2050 (Source: author's research results with using database IRENA)

Fig. 5 displays the cumulative renewable energy investment needs in EU-28 from 2016 to 2050 that will result from the full deployment of REmap options by region and category.

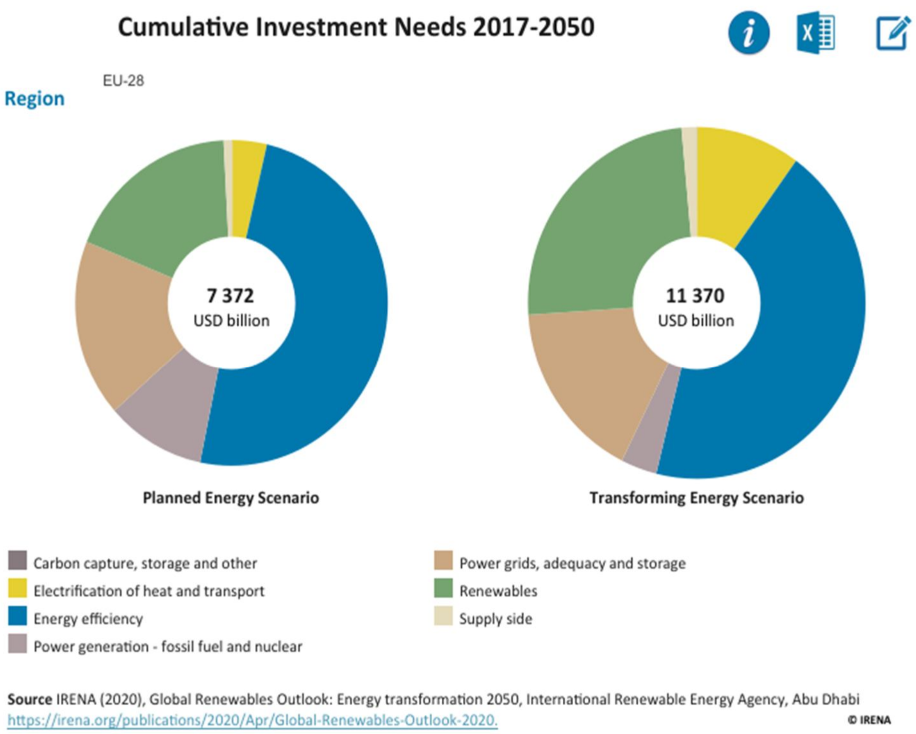

Fig. 5. Cumulative renewable energy investment needs in EU-28 from 2016 to 2050 (Source: author's research results with using database IRENA)

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Fig. 6 provides data by electrical capacity for planned and transforming energy scenario to 2050 for different renewable sources of energy in the world.

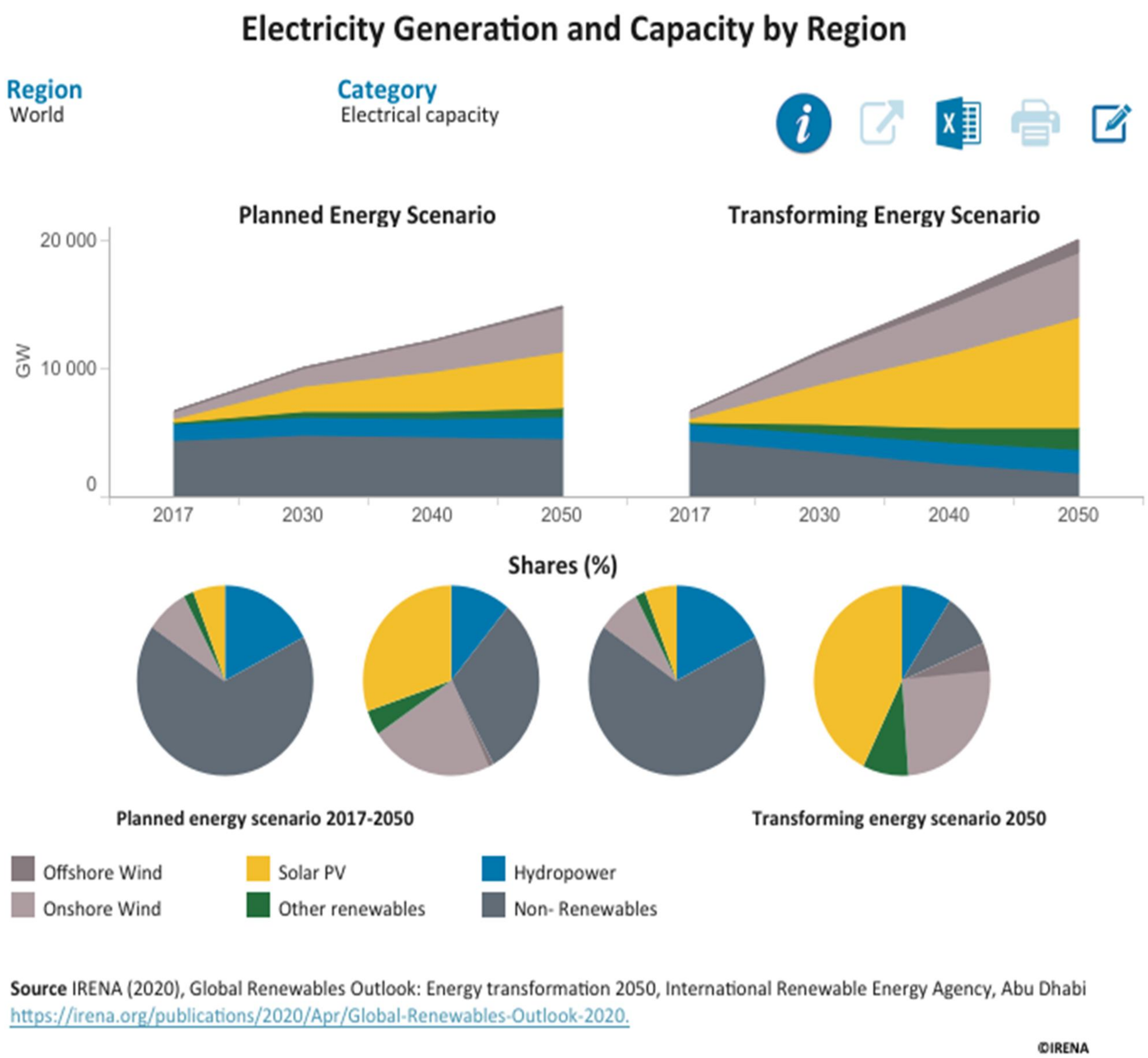

Fig. 6. Data by electricity generation and power capacity for planned and transforming energy scenario to 2050 for different renewable sources of energy in the world. (Source: author's research results with using database IRENA)

Fig. 7 provides data by electricity generation for planned and transforming energy scenario to 2050 for different renewable sources of energy in the world.

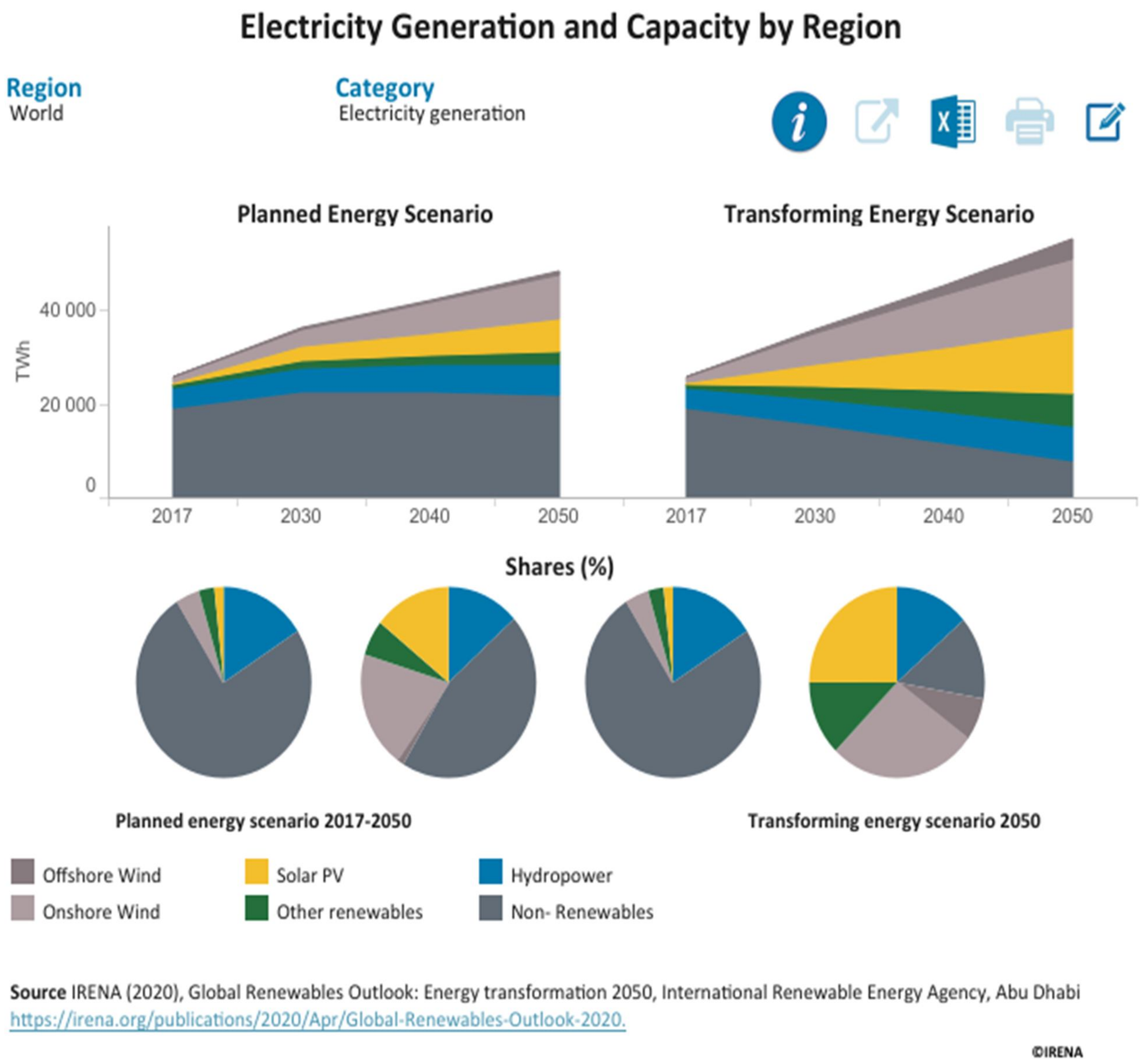

Fig. 7. Data by electricity generation for planned and transforming energy scenario to 2050 for different renewable sources of energy in the world

Source: author's research results with using database IRENA

Fig. 8 provides data by electrical capacity for planned and transforming energy scenario to 2050 for different renewable sources of energy in EU-28.

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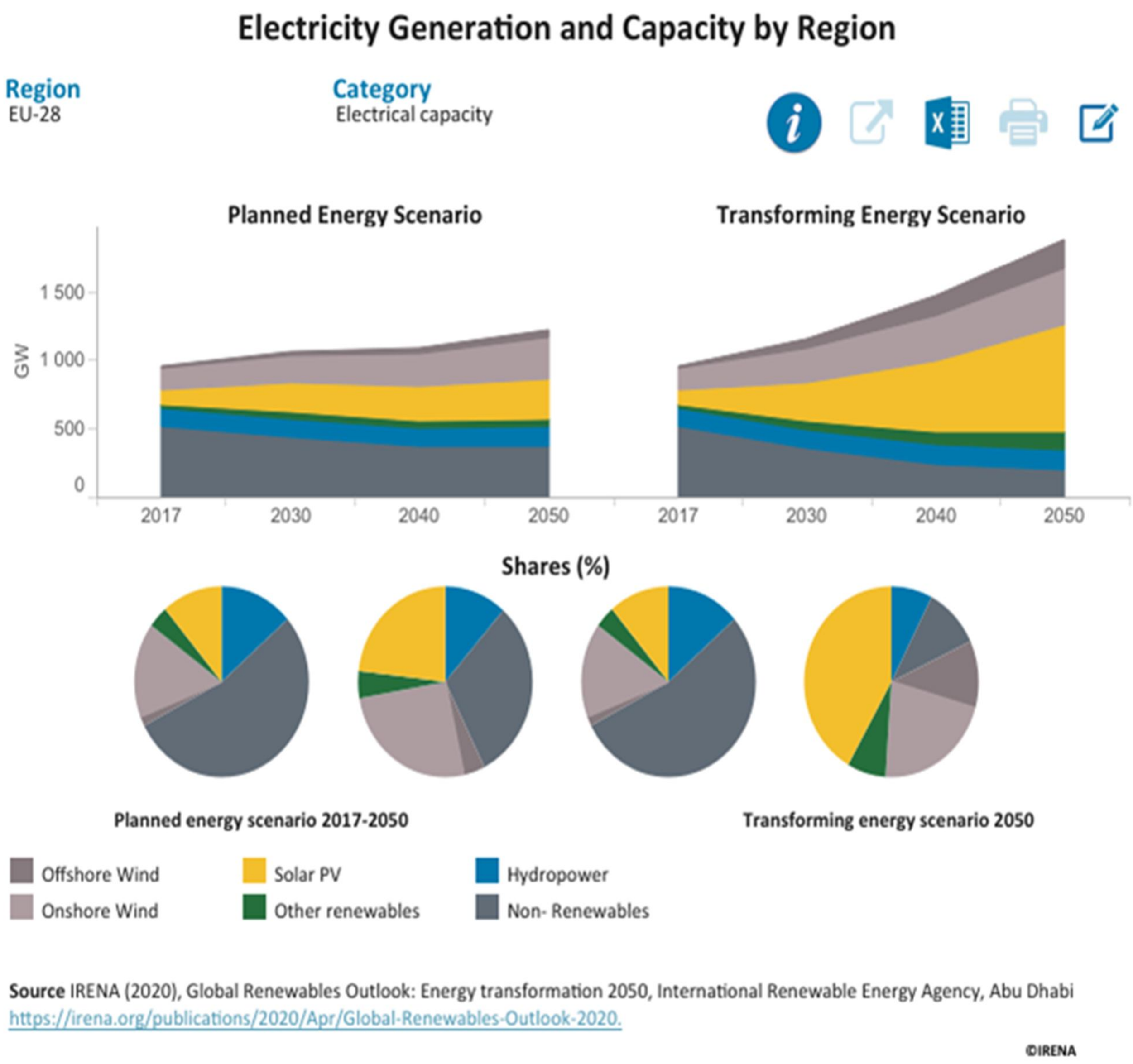

Fig. 8. Data by electrical capacity for planned and transforming energy scenario to 2050 for different renewable sources of energy in EU-28
(Source: author's research results with using database IRENA)

Fig. 9 provides data by electricity generation for planned and transforming energy scenario to 2050 for different renewable sources of energy in EU-28.

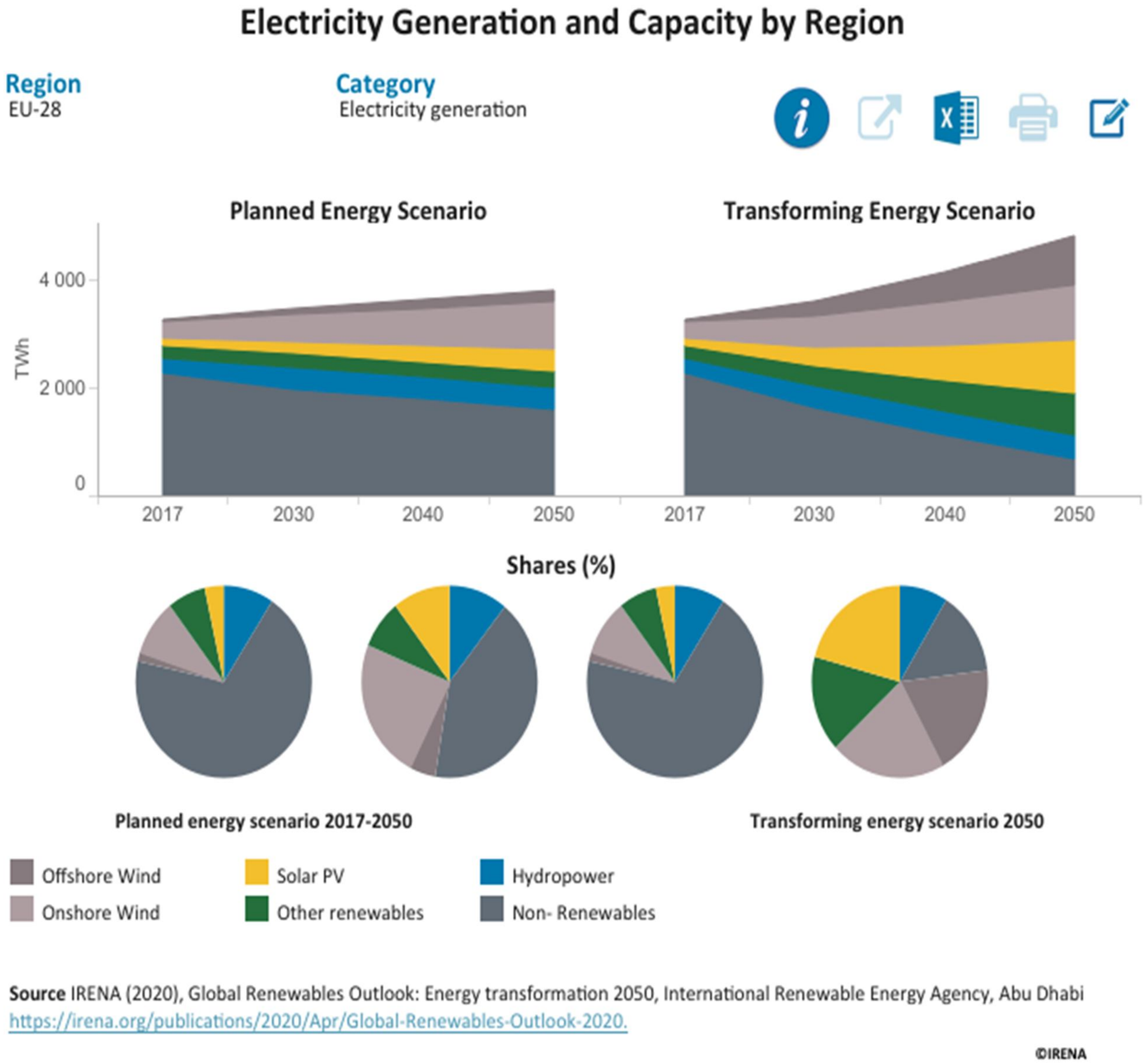

Fig. 9. Data by electricity generation for planned and transforming energy scenario to 2050 for different renewable sources of energy in EU-28
(Source: author's research results with using database IRENA)

Fig. 10 provides an overview of the total primary energy supply (TPES) for planned and transforming energy scenario to 2050 for different sources of energy in the world.

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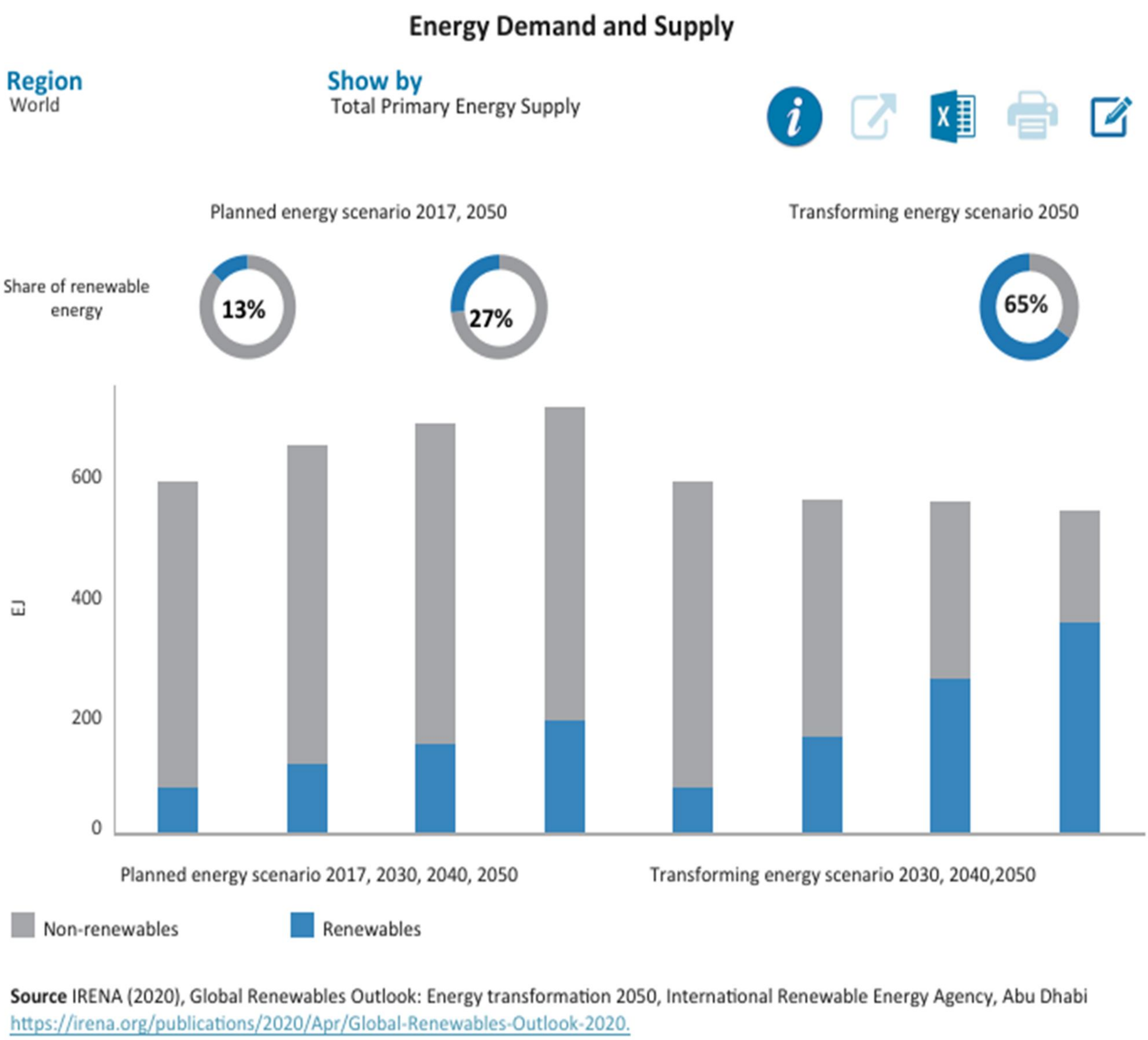

Fig. 10. The total primary energy supply (TPES) for planned and transforming energy scenario to 2050 for different sources of energy in the world
(Source: author's research results with using database IRENA)

Fig. 11 provides an overview of the total primary energy supply (TPES) for planned and transforming energy scenario to 2050 for different sources of energy in EU-28

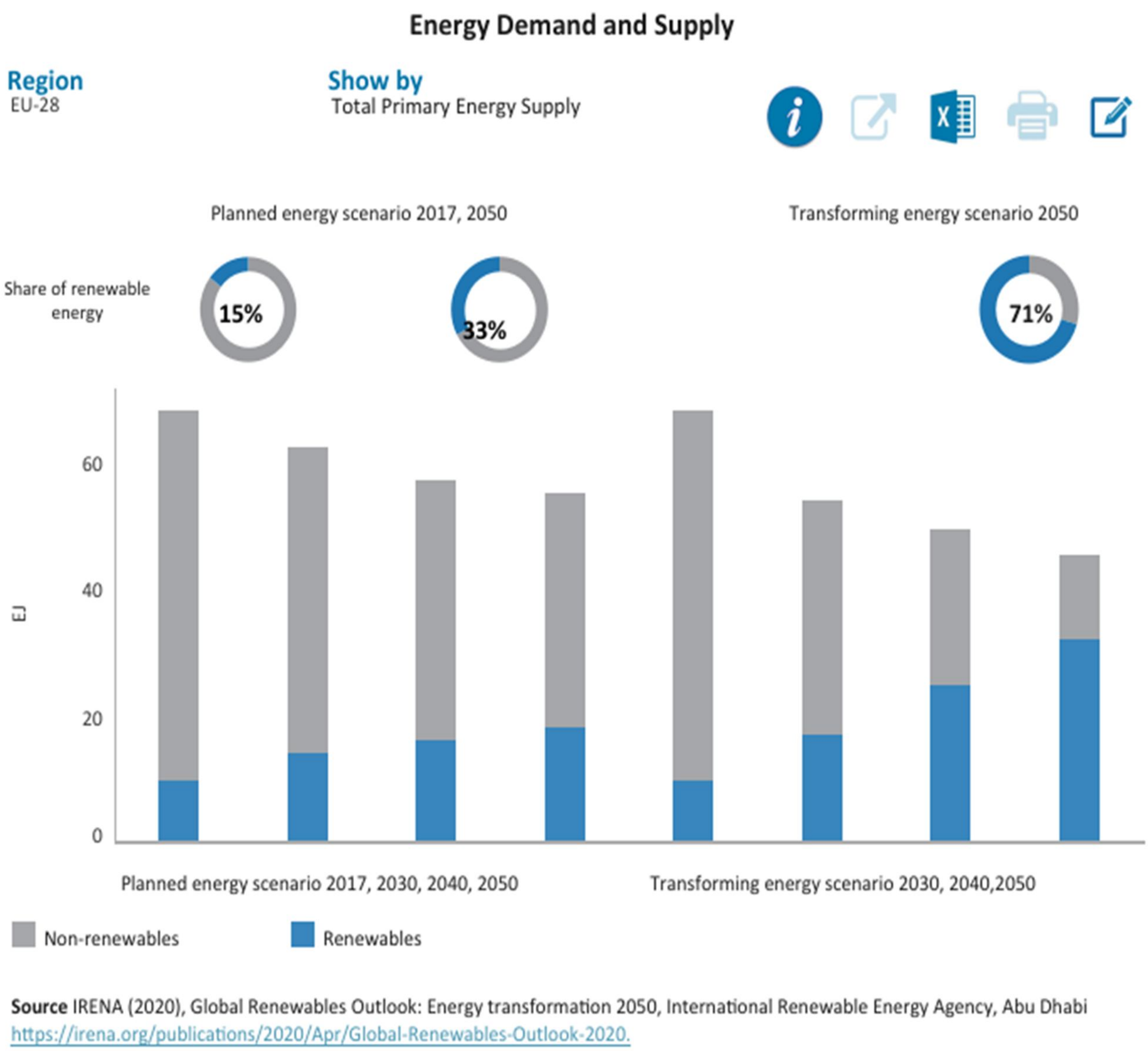

Fig. 11. The total primary energy supply (TPES) for planned and transforming energy scenario to 2050 for different sources of energy in EU-28
(Source: author's research results with using database IRENA)

Fig. 12 provides an overview of the total final energy consumption by sector (TFEC) for planned and transforming energy scenario to 2050 in the world

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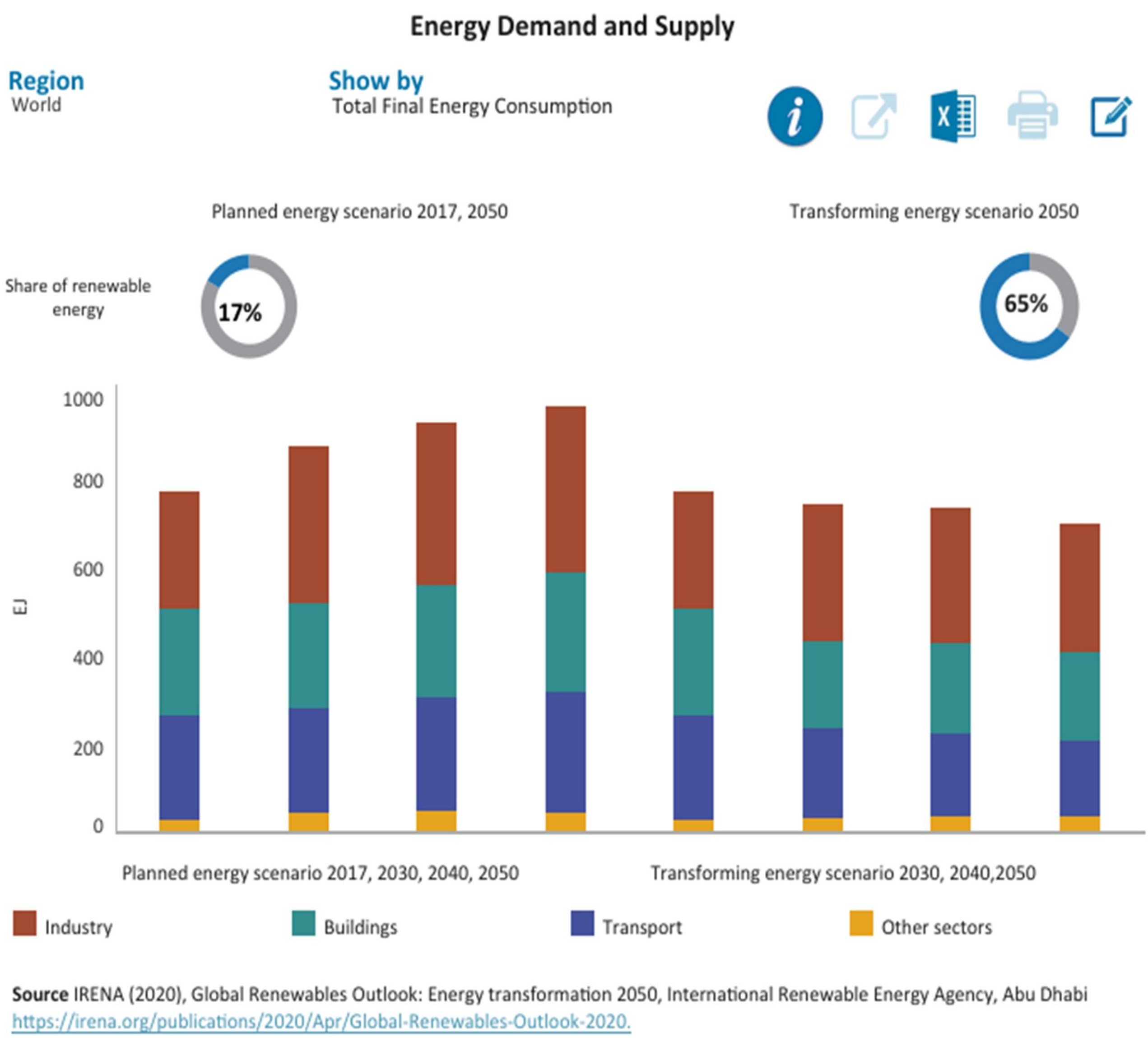

Fig. 12. The total final energy consumption by sector (TFEC) for planned and transforming energy scenario to 2050 in the world

(Source: author's research results with using database IRENA)

Fig. 13 provides an overview of the total final energy consumption by sector (TFEC) for planned and transforming energy scenario to 2050 in EU-28

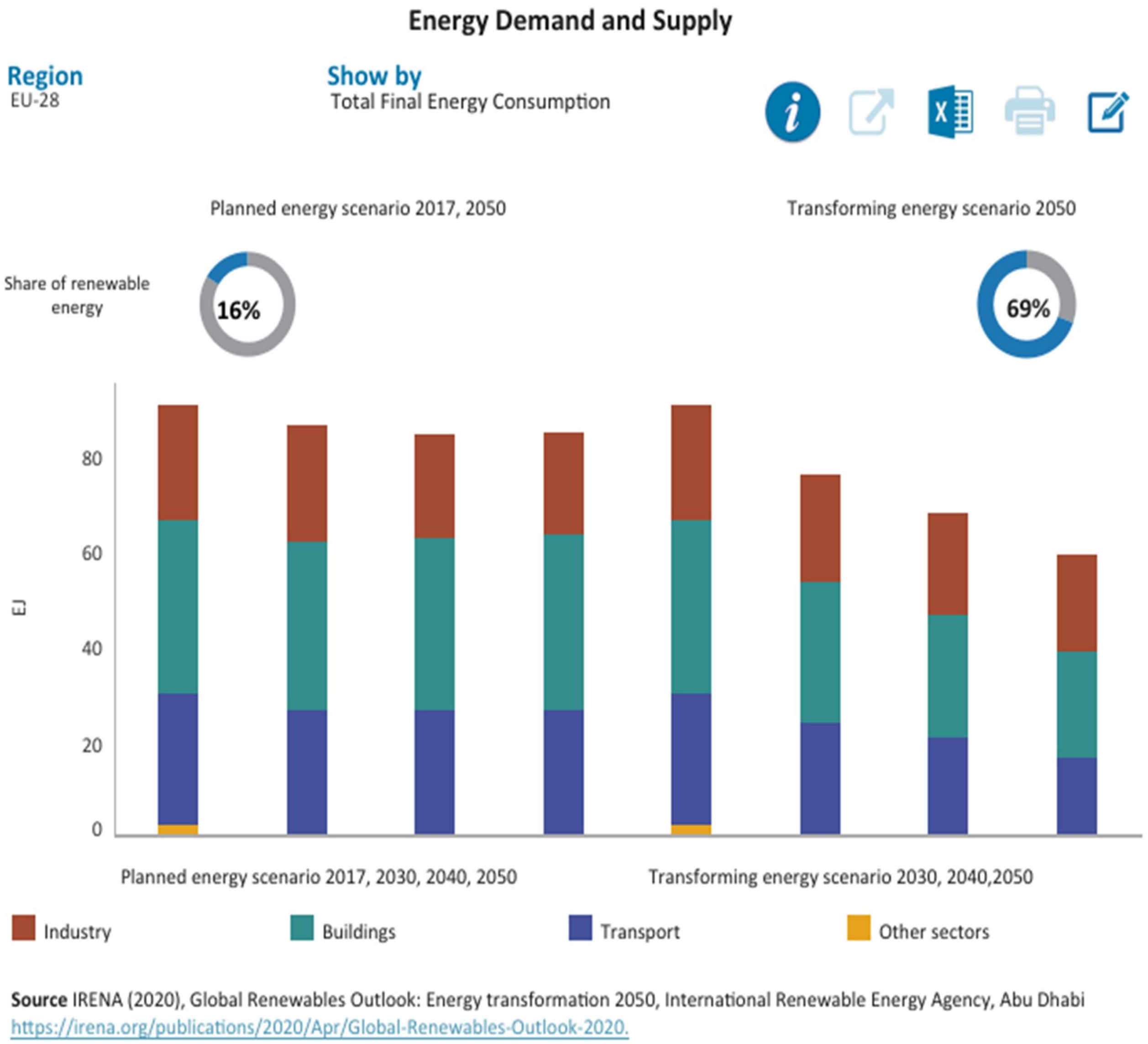

Fig. 13. The total final energy consumption by sector (TFEC) for planned and transforming energy scenario to 2050 in EU-28
(Source: author's research results with using database IRENA)

Fig. 14 shows the key highlights from the latest Renewable Energy Auctions report that provides key updates on this crucial mechanism for price discovery and market development.

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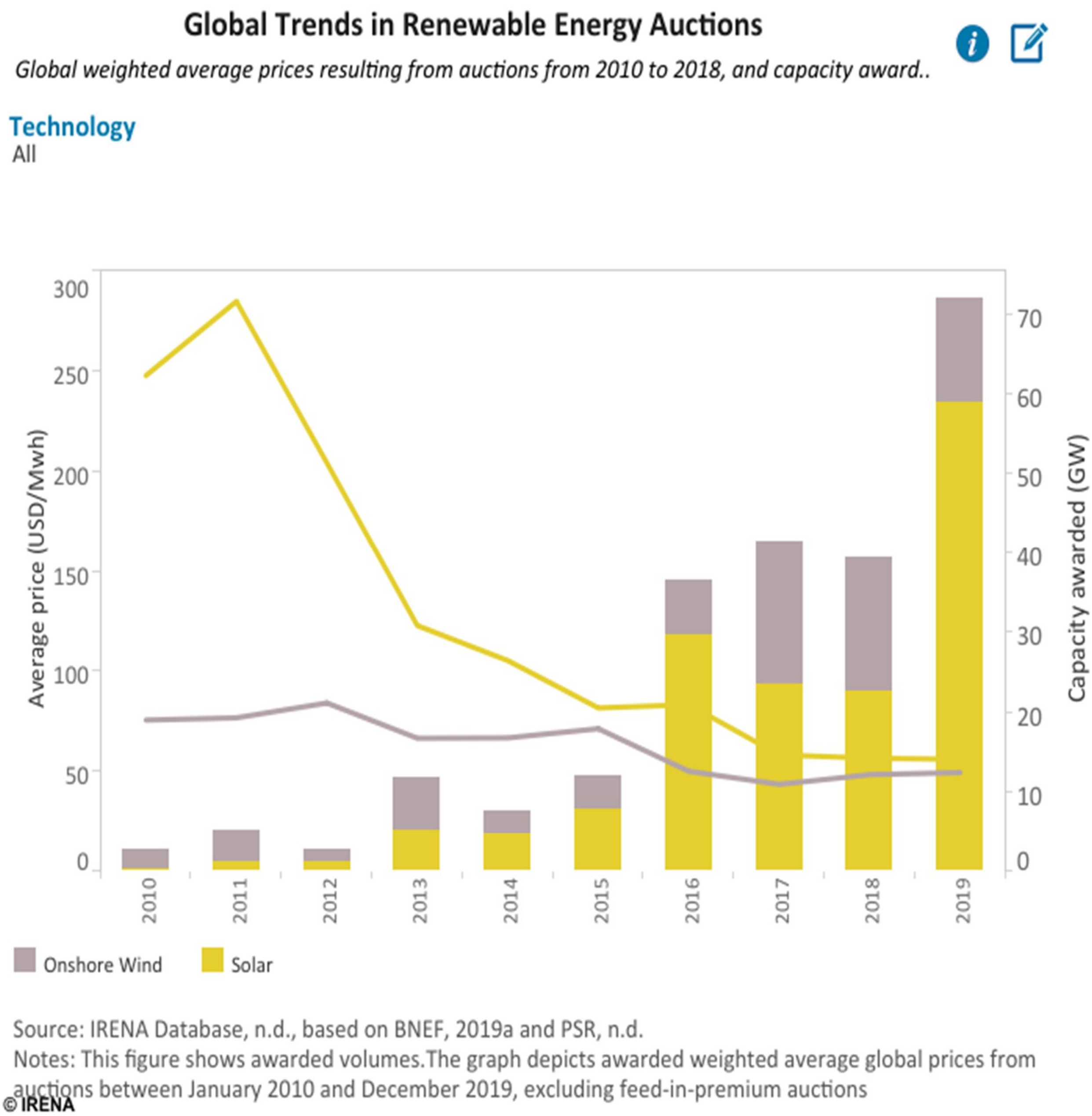

Fig. 14. The key highlights from the latest Renewable Energy Auctions (solar and wind technology)
(Source: author's research results with using database IRENA)

Fig. 15 provides an overview on the latest wind costs for wind projects.

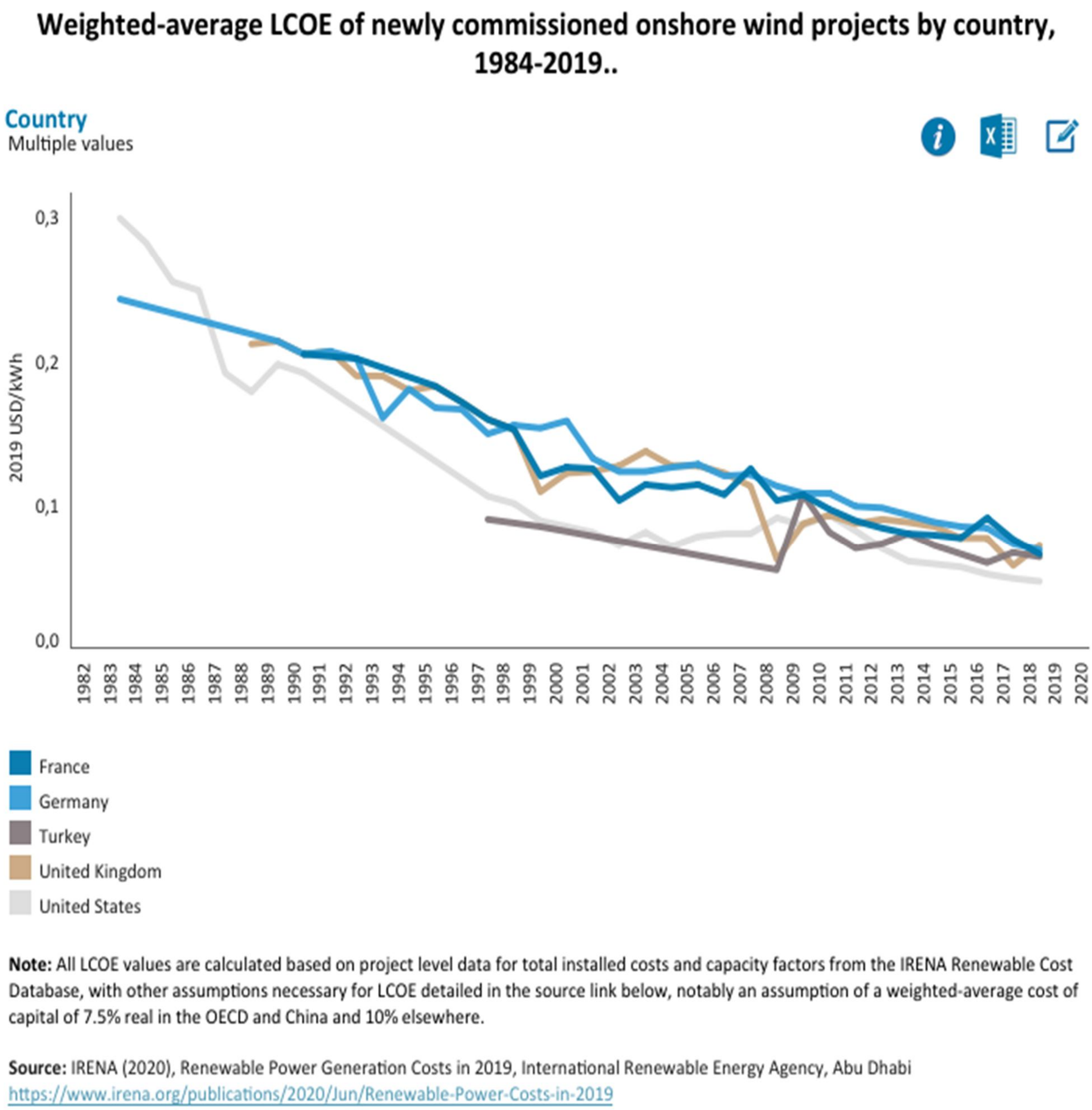

Fig. 15. Overview on the latest wind costs
(Source: author's research results with using database IRENA)

Fig. 16 provides an overview on the latest Solar PV costs.

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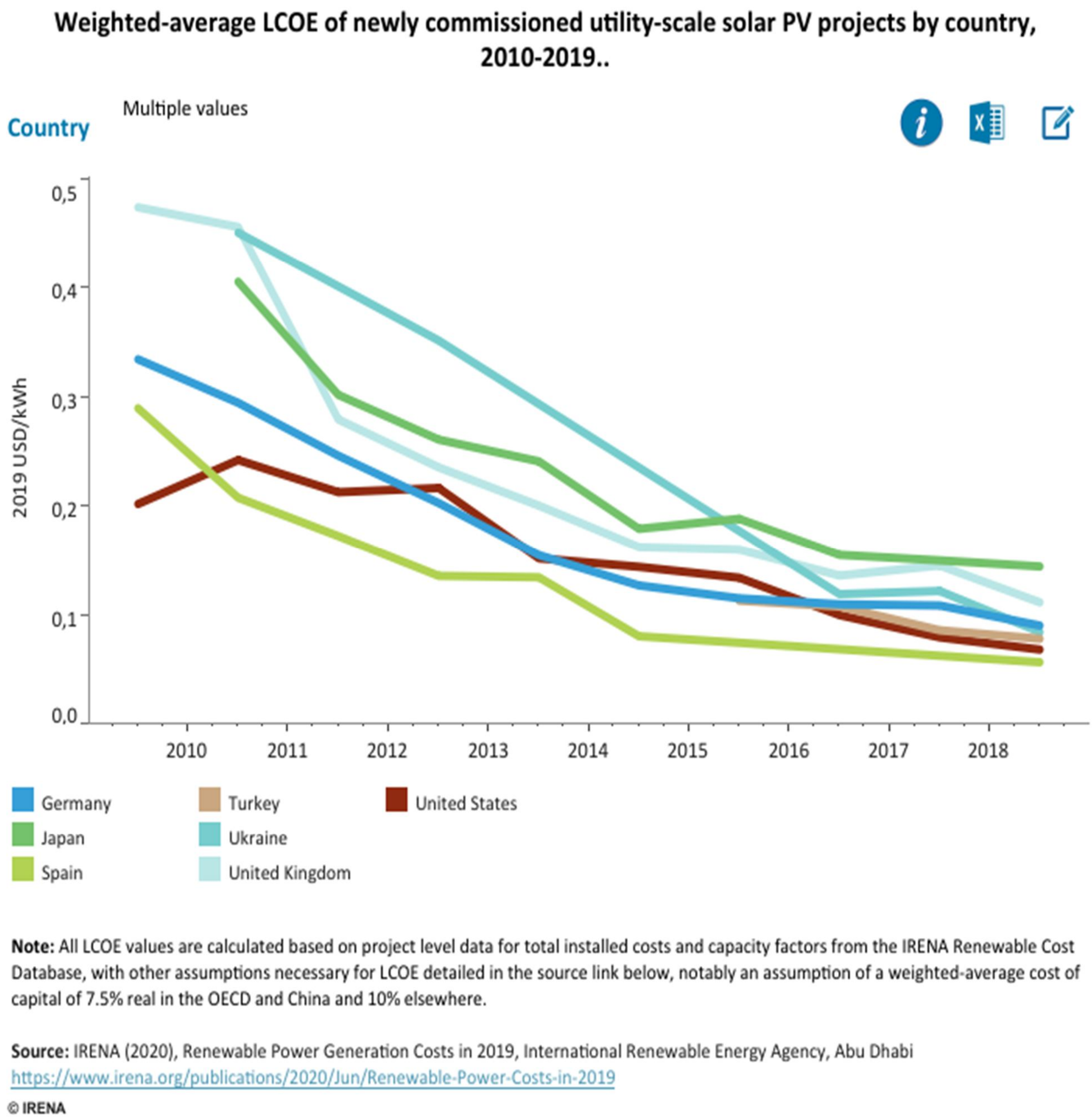
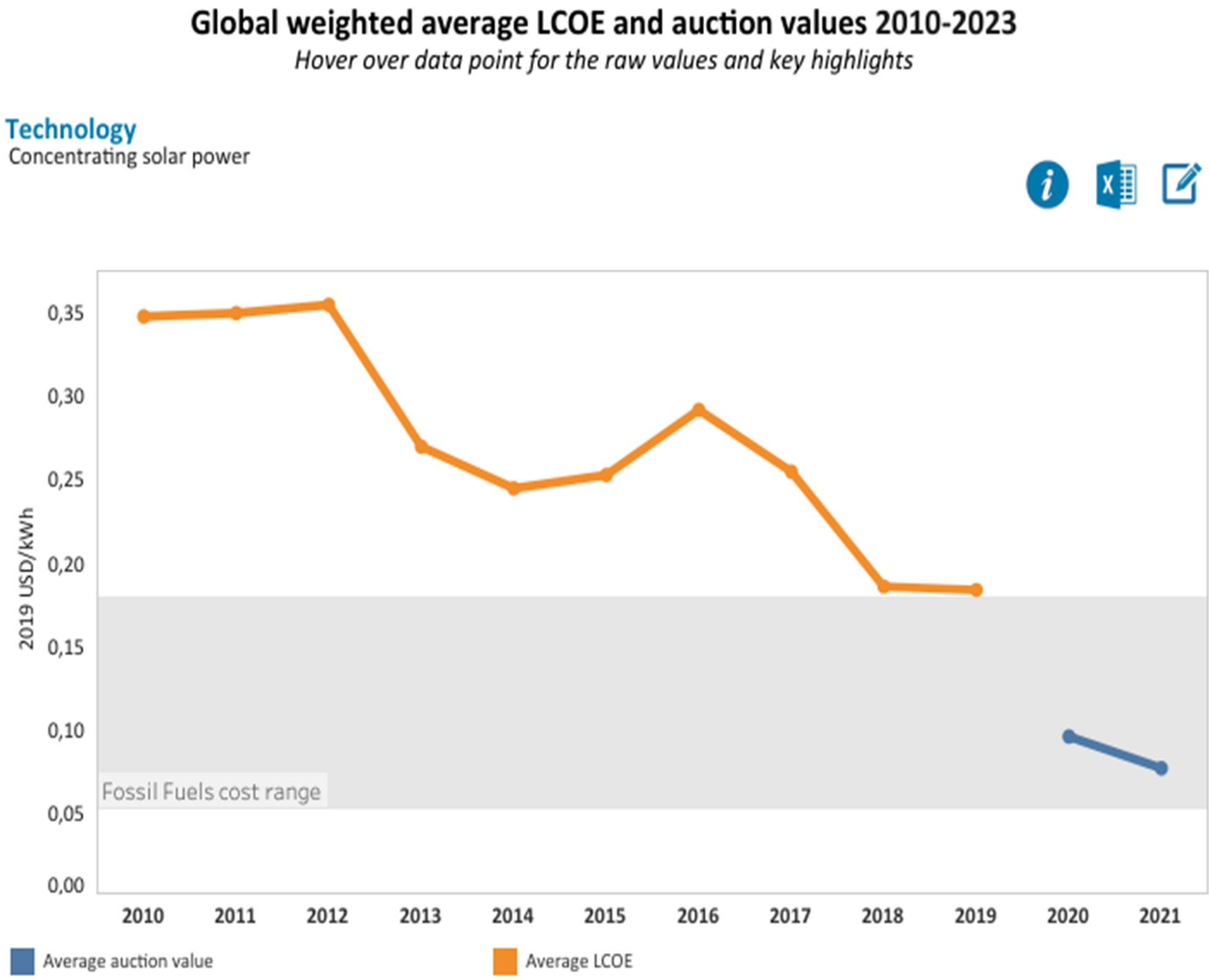


Fig. 16. Overview on the latest Solar PV costs
(Source: author's research results with using database IRENA)

Fig. 17 provides an overview on trends in global weighted average Levelised Cost of Energy (LCOE) and auction values.



Note: All LCOE values are calculated based on project level data for total installed costs and capacity factors from the IRENA Renewable Cost Database, with other assumptions necessary for LCOE detailed in the source link below, notably an assumption of a weighted-average cost of capital of 7.5% real in the OECD and China and 10% elsewhere. Auction price data is corrected for inflation, but care must be taken in interpreting the results as not all PPA/Auction prices are directly comparable to LCOE values."

Source: IRENA (2020), Renewable Power Generation Costs in 2019, International Renewable Energy Agency, Abu Dhabi https://www.irena.org/publications/2020/Jun/Renewable-Power-Costs-in-2019

Fig. 17. Overview on trends in global weighted average Levelised Cost of Energy (LCOE) and auction values

(Source: author's research results with using database IRENA)

Fig. 18 provides an overview on latest global trends in renewable energy costs (on example of geothermal energy). It displays global weighted average total installed costs, capacity factors and LCOE by technology.

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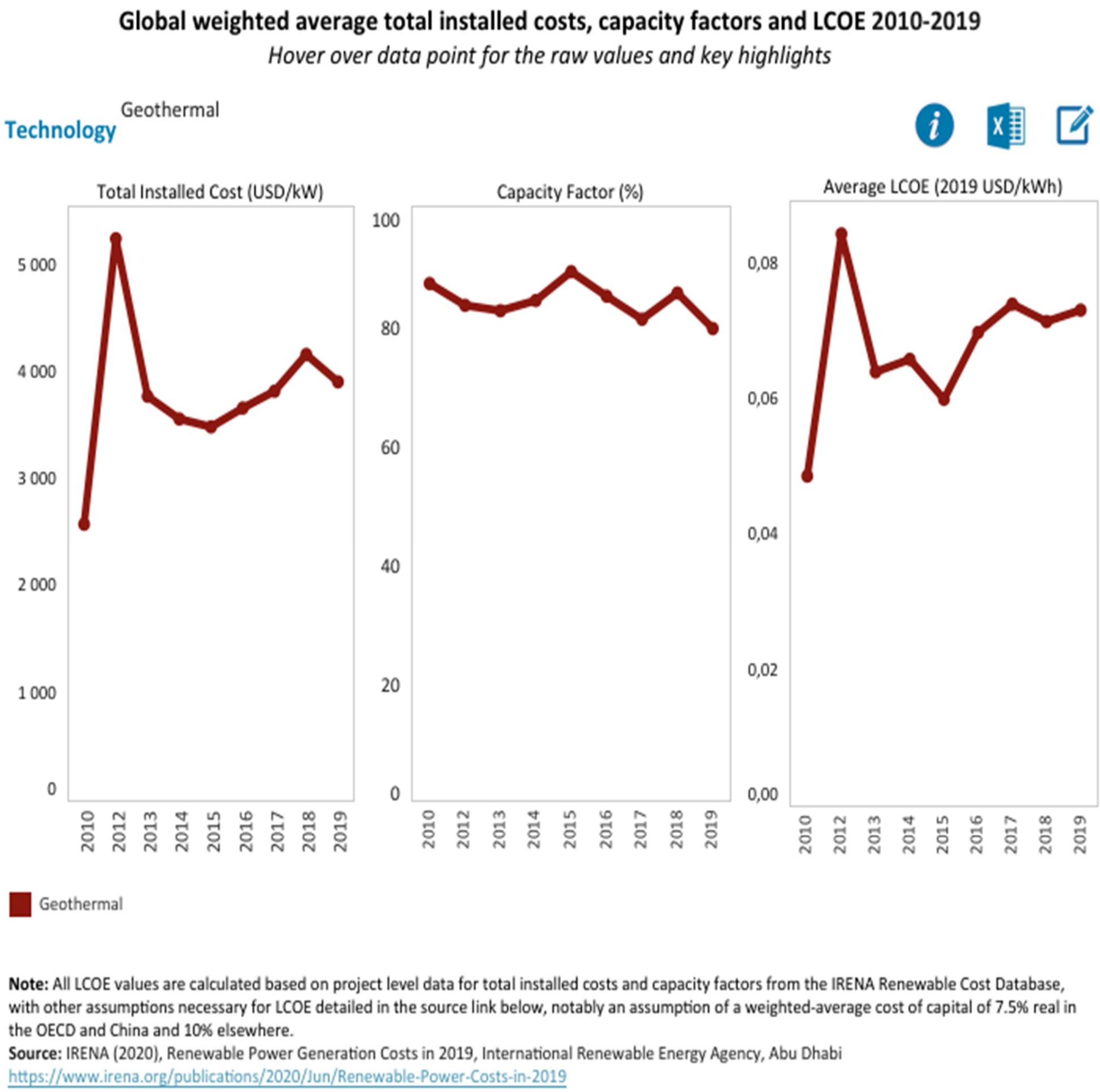

Fig. 18. Overview on latest global trends in renewable energy costs (on example of geothermal energy)

(Source: author's research results with using database IRENA)

Figs. 19, 20 provides an overview of renewable energy finance flows by development financial institutions. It covers investments linked to renewable energy project assets between the years 2009-2017.

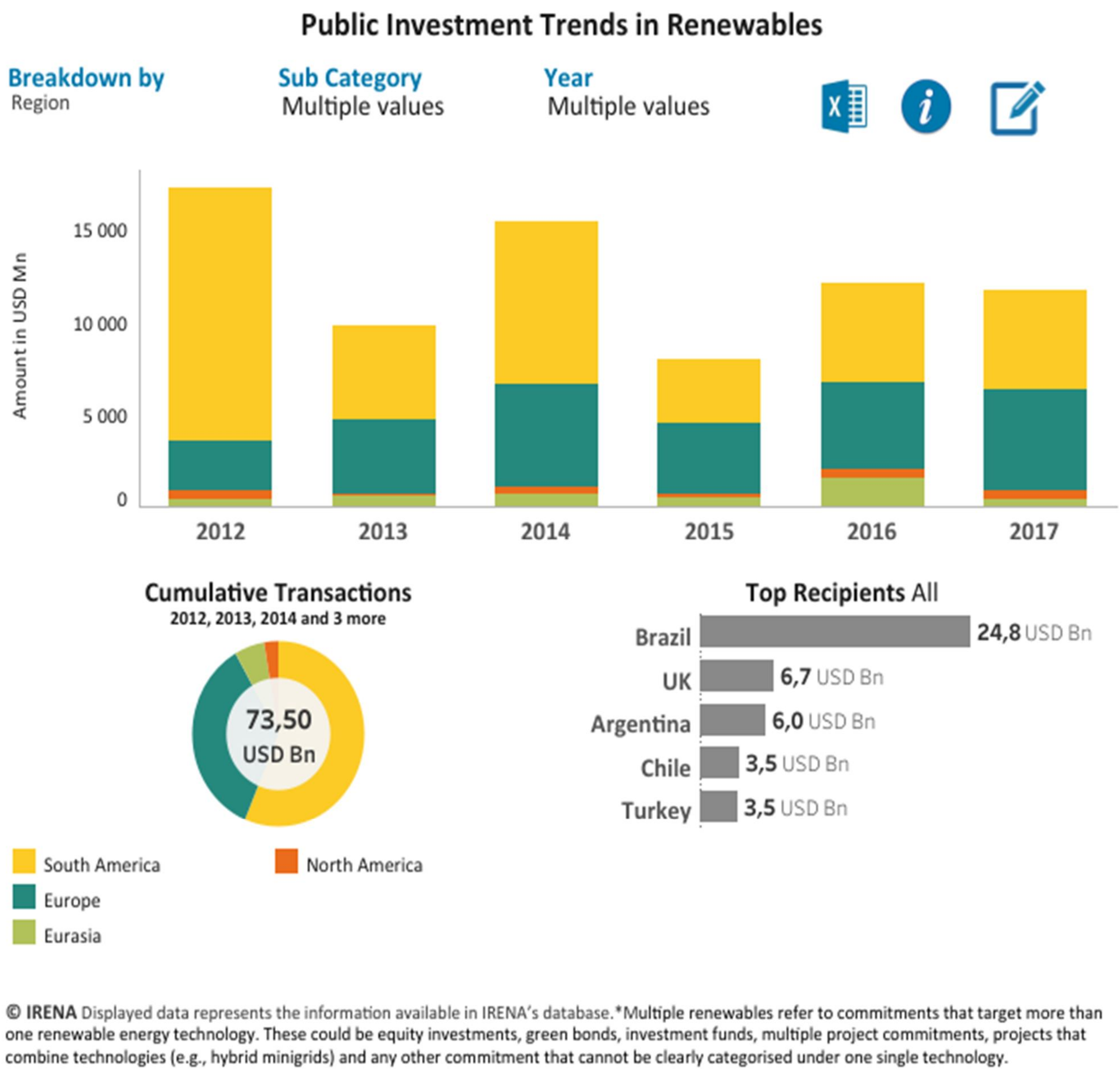

Fig. 19. Overview of renewable energy finance flows by development financial institutions between the years 2009-2017

(Source: author's research results with using database IRENA)

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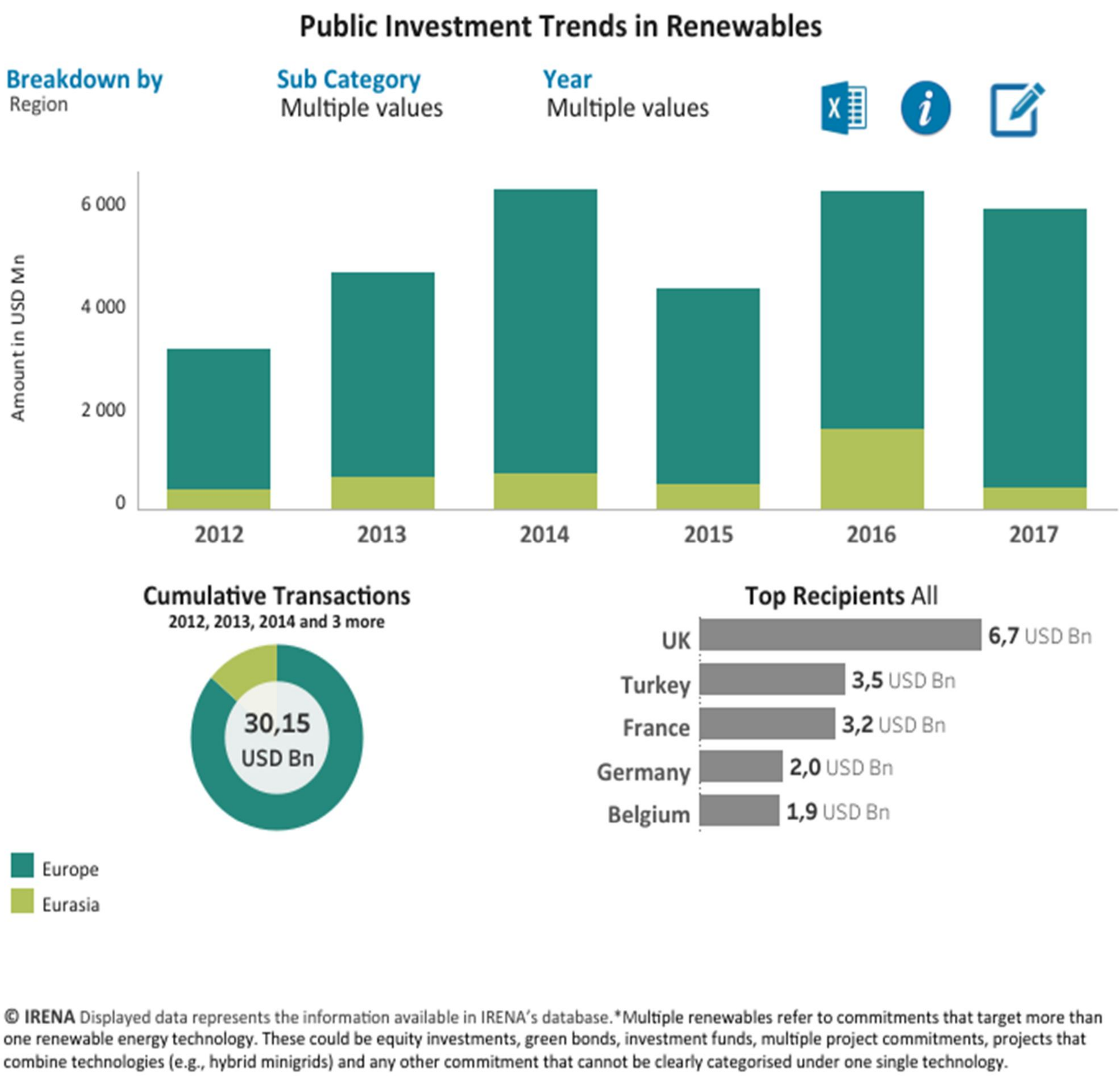
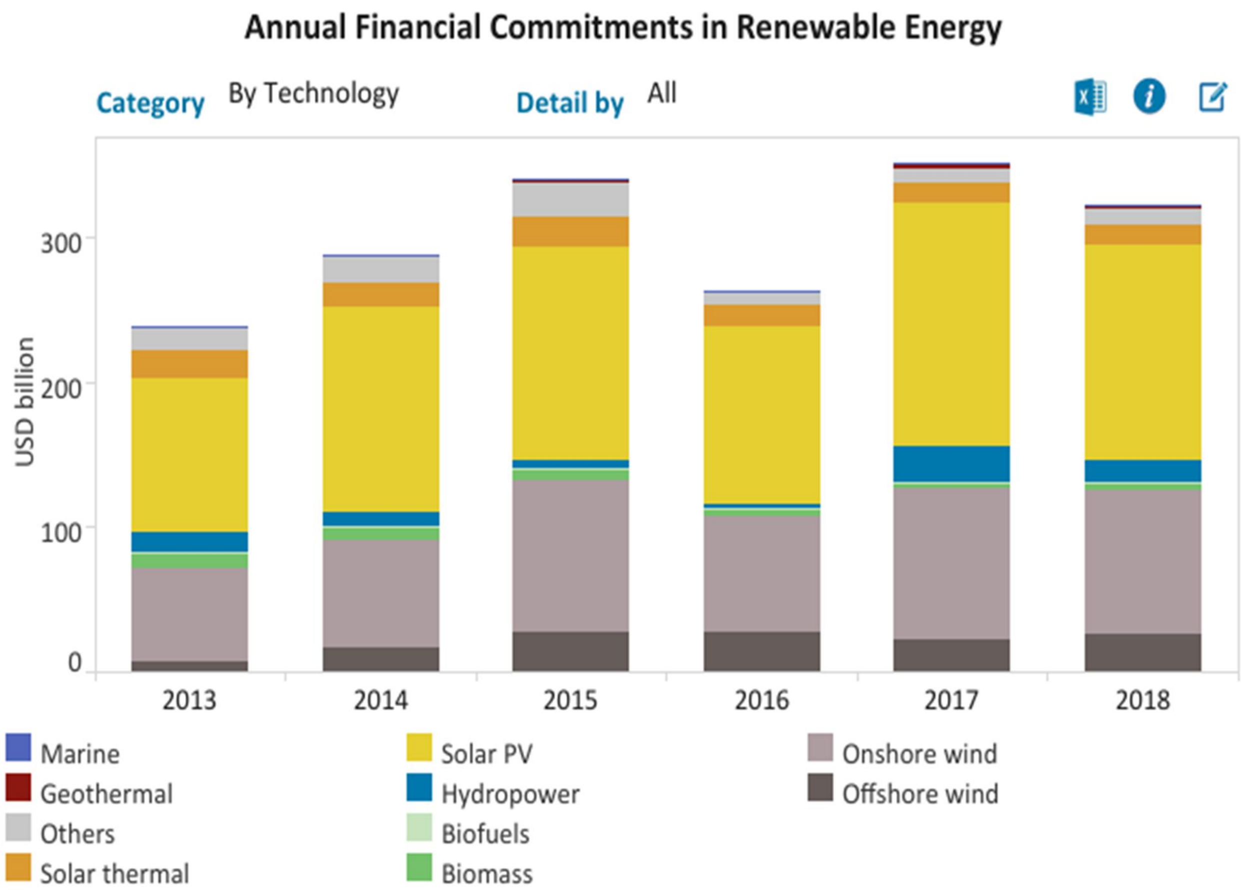


Fig. 20. Overview of renewable energy finance flows by development financial institutions between the years 2009-2017
(Source: author's research results with using database IRENA)

Fig. 21 provides an overview on global renewable energy investment trends between the years 2013-2018



In 2013-2018, solar PV and onshore wind consolidated their dominance, attracting, respectively, 46% and 29% of global renewable energy investments. Investment in offshore wind has picked up, attracting 7% of the total, followed by solar thermal at 6%. Other renewable energy technologies (including hydropower, biomass, biofuels, geothermal and marine energy) altogether contributed only 7% of total investment in 2013-2018, with hydropower making up a relatively significant portion of the total.

Source: IRENA and CPI (2020), Global Landscape of Renewable Energy Finance 2020, 2020, International Renewable Energy Agency, Abu Dhabi. Details of the methodology used to track global renewable energy investment can be found here: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_GLREF_2020_Methodology.pdf

Fig. 21. Overview on global renewable energy investment trends between the years 2013-2018
(Source: author's research results with using database IRENA)

Fig. 22 provides information on the annual energy-related CO_2 emissions by sector for the reference case and REmap case by year for planned and transforming energy scenario to 2050 in the world.

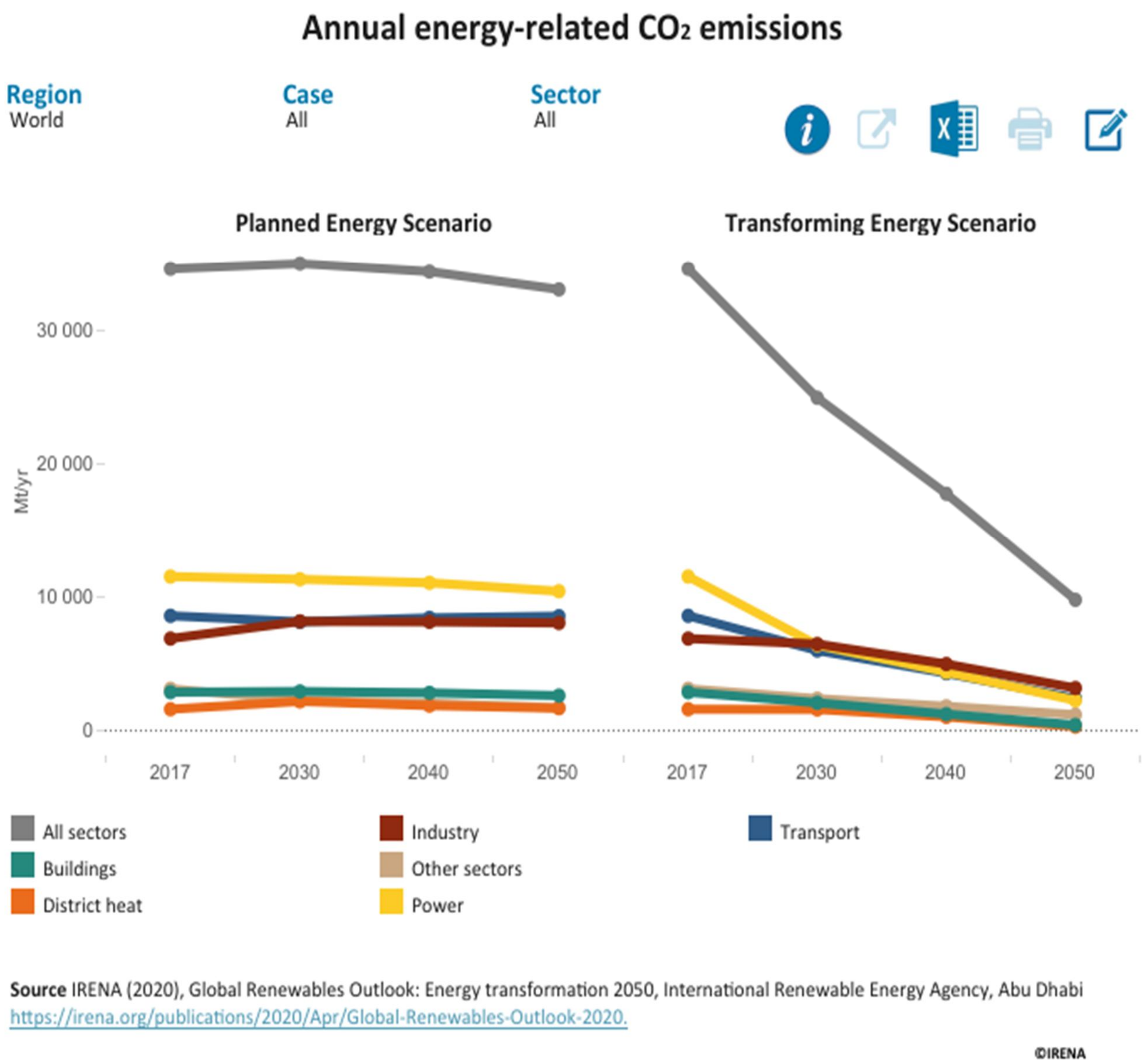


Fig. 22. The annual energy-related CO2 emissions by sector for the reference case and REmap case by year for planned and transforming energy scenario to 2050 in the world

(Source: author's research results with using database IRENA)

Fig. 23 provides information on the annual energy-related CO2 emissions by sector for the reference case and REmap case by year for planned and transforming energy scenario to 2050 in EU-28.

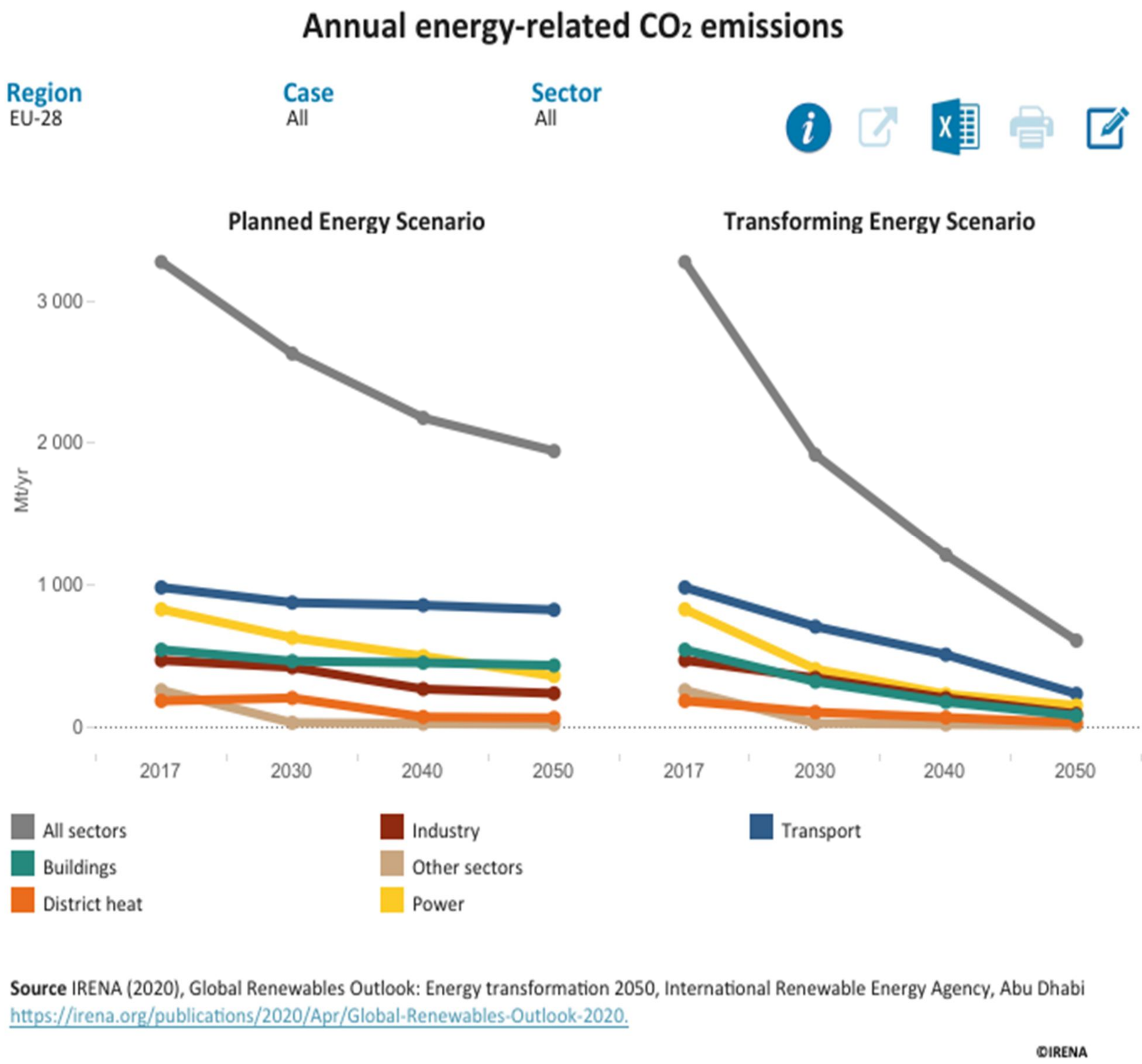


Fig. 23. The annual energy-related CO2 emissions by sector for the reference case and REmap case by year for planned and transforming energy scenario to 2050 in EU-28

(Source: author's research results with using database IRENA)

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2 ANALYSIS OF ENERGY SECTORS OF UKRAINE AND DETERMINATION OF ADVANTAGES OF APPLICATION OF RENEWABLE ENERGY SOURCES FOR UKRAINE IN THE CONCEPT OF SUSTAINABLE DEVELOPMENT

In Figs. 24 – 34 shows the criteria for energy, economic and environmental efficiency of innovative technologies for the use of renewable energy sources in Ukraine, which analysed in order to conduct a comprehensive assessment of the effectiveness of energy and resource-saving, environmentally friendly and cost-effective innovative technologies in the concept of Sustainable Development. The results of research, shown in Figs. 24 – 34, were obtained by the author wuth using a database IRENA.

The scenario of the transformation of the energy system of the World and the European Union, analyzed in Chapter 1, in combination with an additional deeper perspective on reducing carbon dioxide emissions provides a sustainable, environmentally friendly and climate-friendly basis for stable long-term economic development. According to research ("IRENA", 2021), this offers the prospect of higher economic growth, cleaner living conditions and significant improving the level of well-being. This perspective will reduce global emissions carbon dioxide (CO_2) associated with energy production by 70% by 2050. More than 90% of this reduction will be achieved through renewable energy sources and measures to increase energy efficiency. The transition to alternative energy sources can stimulate wider social economic development accompanied by integrated policies that promote transformational processes aimed at reducing carbon dioxide emissions in different countries. Such a holistic approach would lead to a reduction in carbon dioxide emissions gas related to energy production, in line with economic, environmental and
social goals. According to research ("IRENA", 2021), the ultimate global climate target will be zero emissions. This perspective also looks at ways to reduce CO_2 emissions from 2050 to zero energy balance and possibly even zero. Hydrogen and synthetic fuels, direct electrification, modern biofuels and carbon reduction measures gas will be critical along with innovative business models, structural changes and behavioral adaptation.

Fig. 24 displays information on the distribution of renewable energy technologies in Ukraine, of choice in relation to renewable energy power capacity and electricity generation figures.

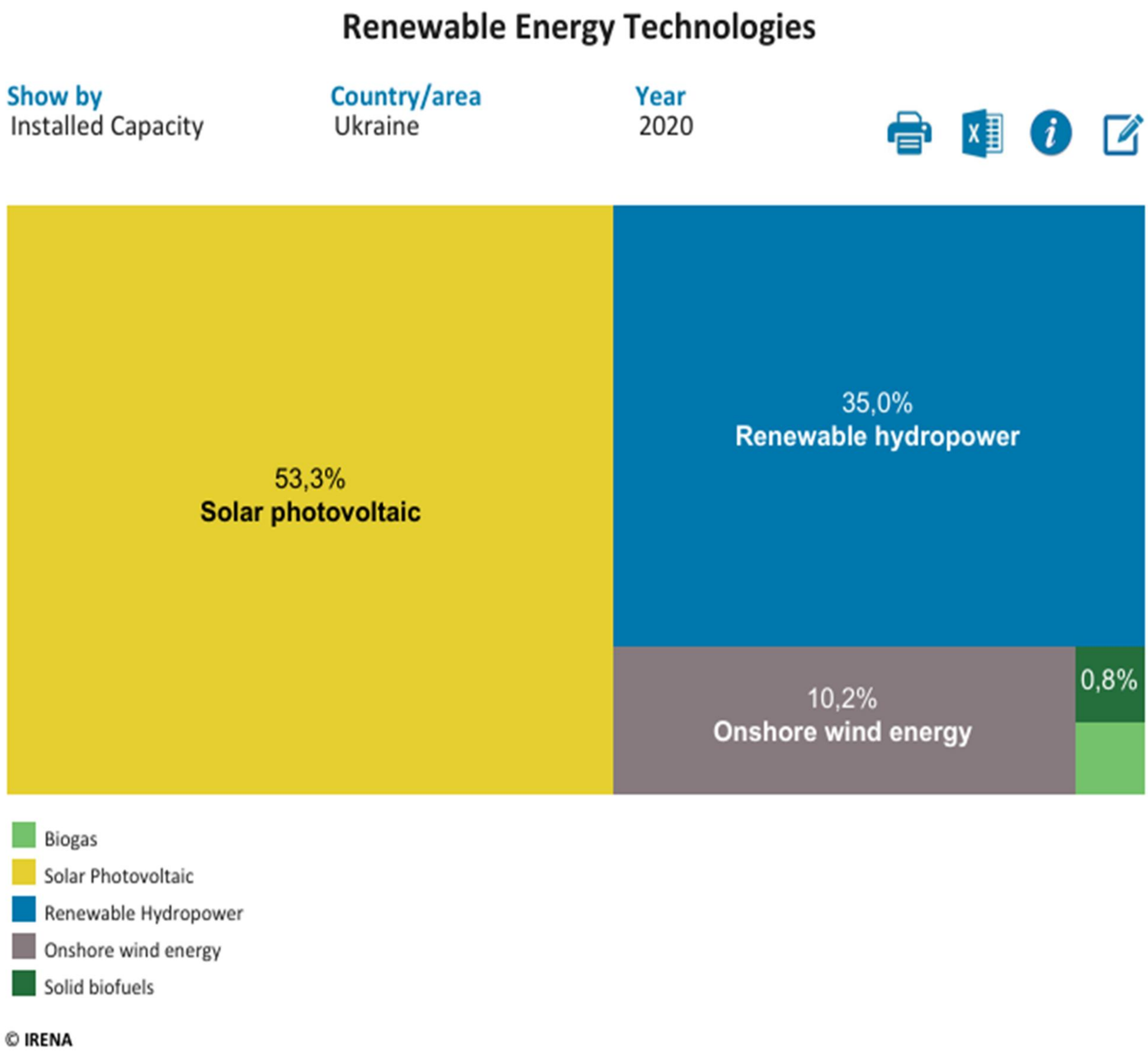

Fig. 24. Distribution of renewable energy technologies in Ukraine
(Source: author's research results with using database IRENA)

Fig. 25 displays information on final renewable energy consumption in Ukraine by sector.

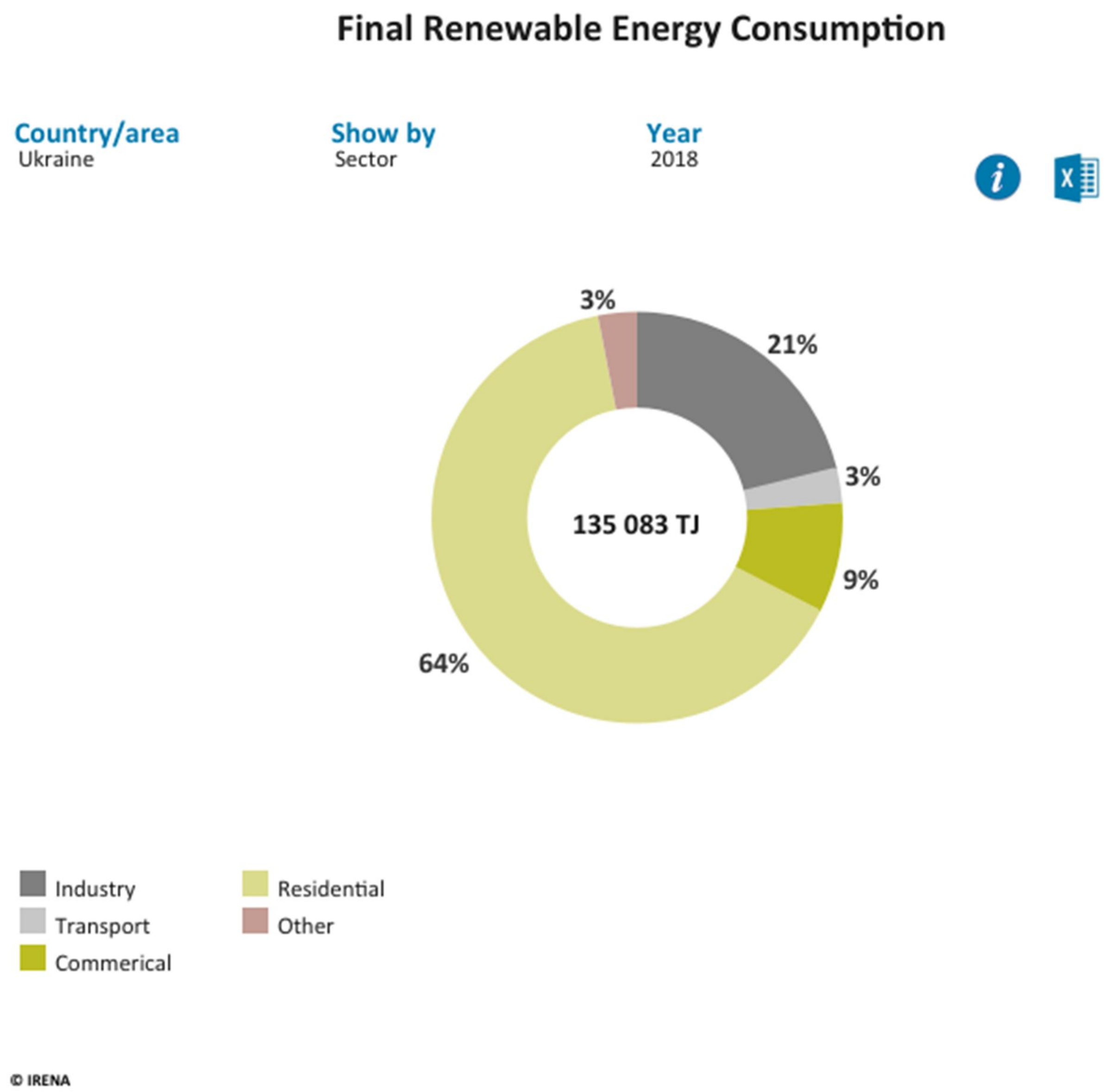

Fig. 25. Information on final renewable energy consumption in Ukraine by sector.
(Source: author's research results with using database IRENA)

Fig. 26 displays information on final renewable energy consumption in Ukraine by technology.

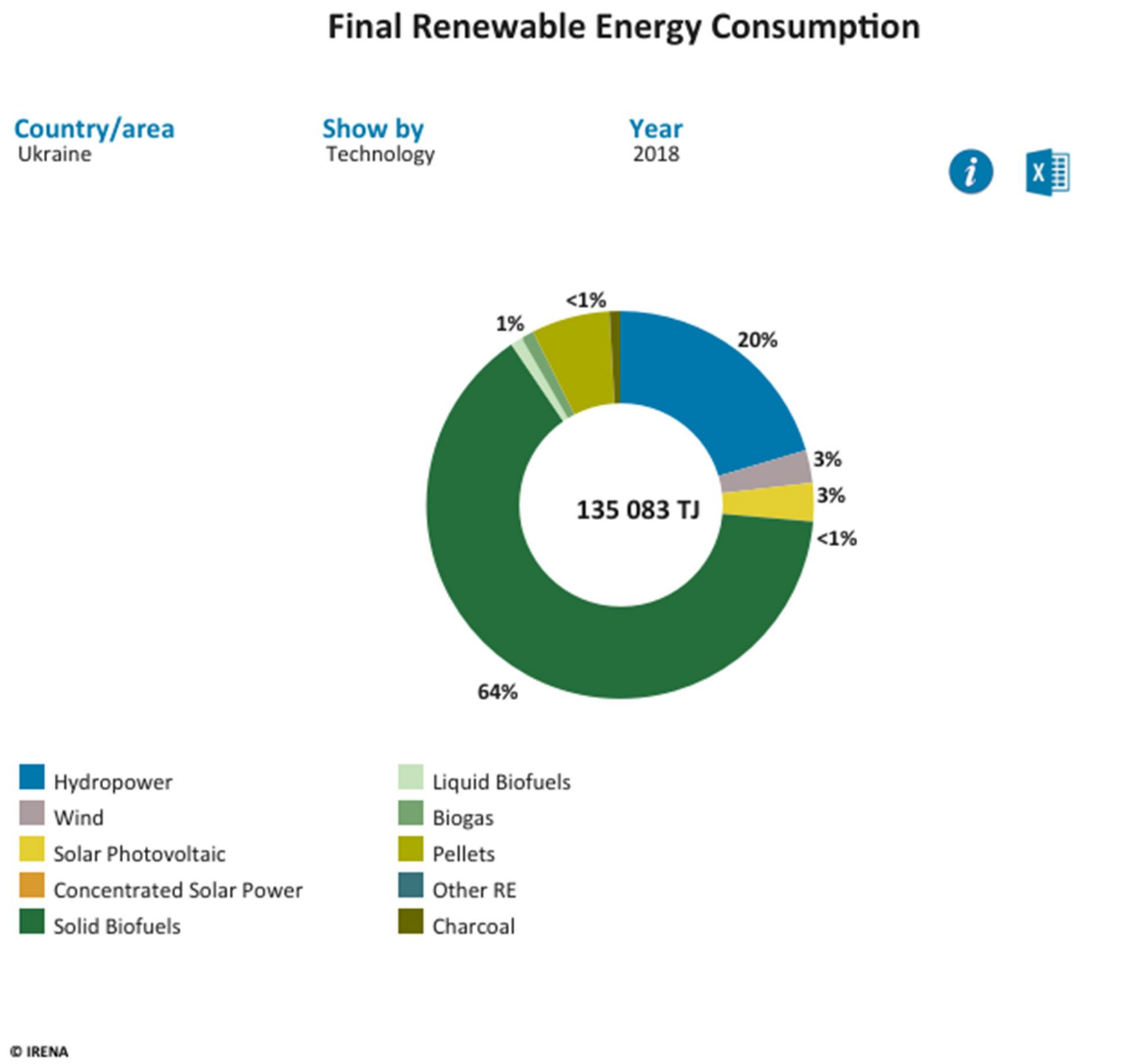

Fig. 26. Information on final renewable energy consumption in Ukraine by technology
(Source: author's research results with using database IRENA)

Fig. 27 provides an overview of the total final energy consumption by sector (TFEC) by source for the reference case and REmap case by year for planned and transforming energy scenario to 2050 in Ukraine

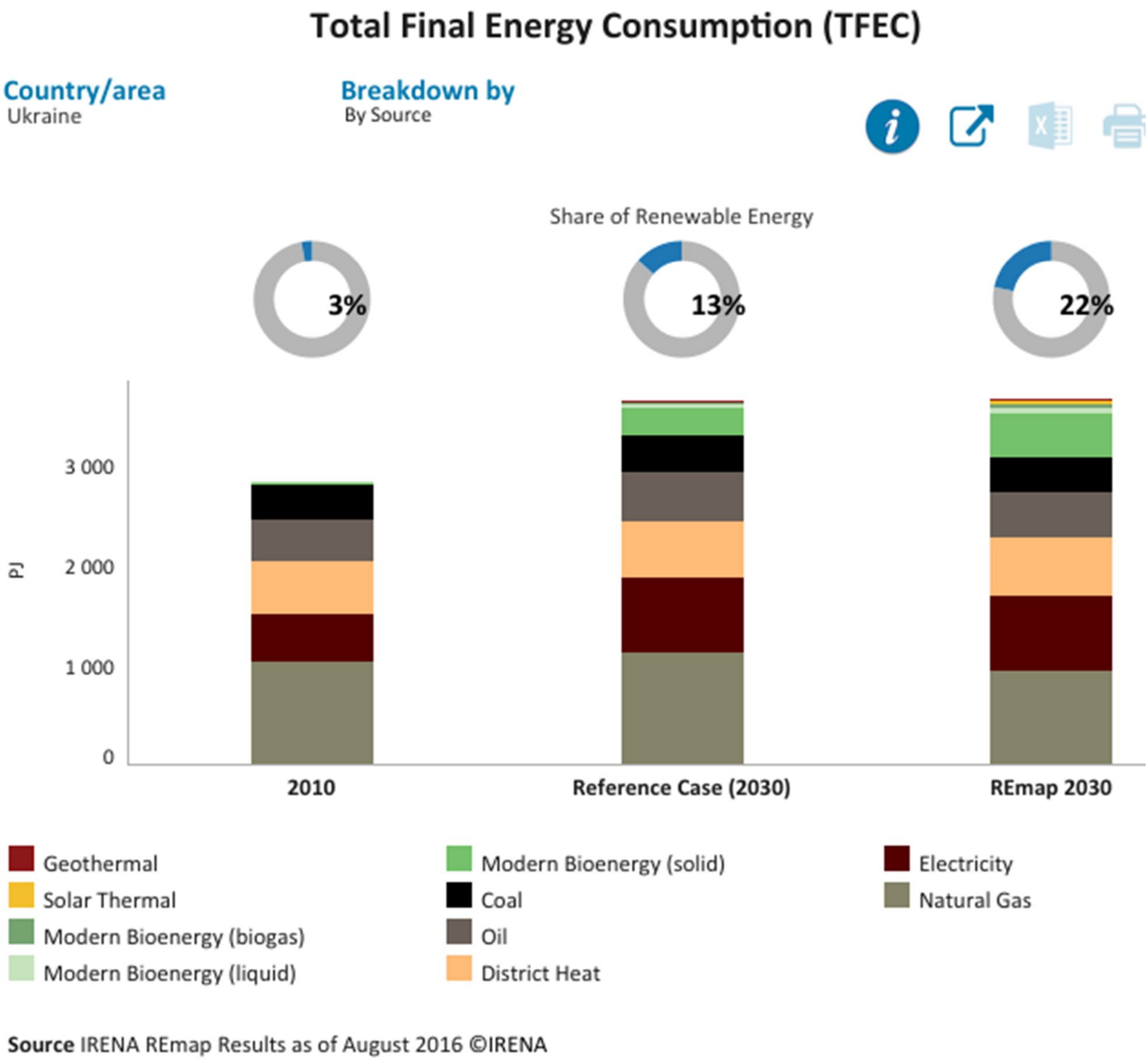

Fig. 27. The total final energy consumption by sector (TFEC) by source for the reference case and REmap case by year for planned and transforming energy scenario to 2050 in Ukraine
(Source: author's research results with using database IRENA)

Fig. 28 provides an overview of the total final energy consumption by sector (TFEC) for the reference case and REmap case by year for planned and transforming energy scenario to 2050 in Ukraine

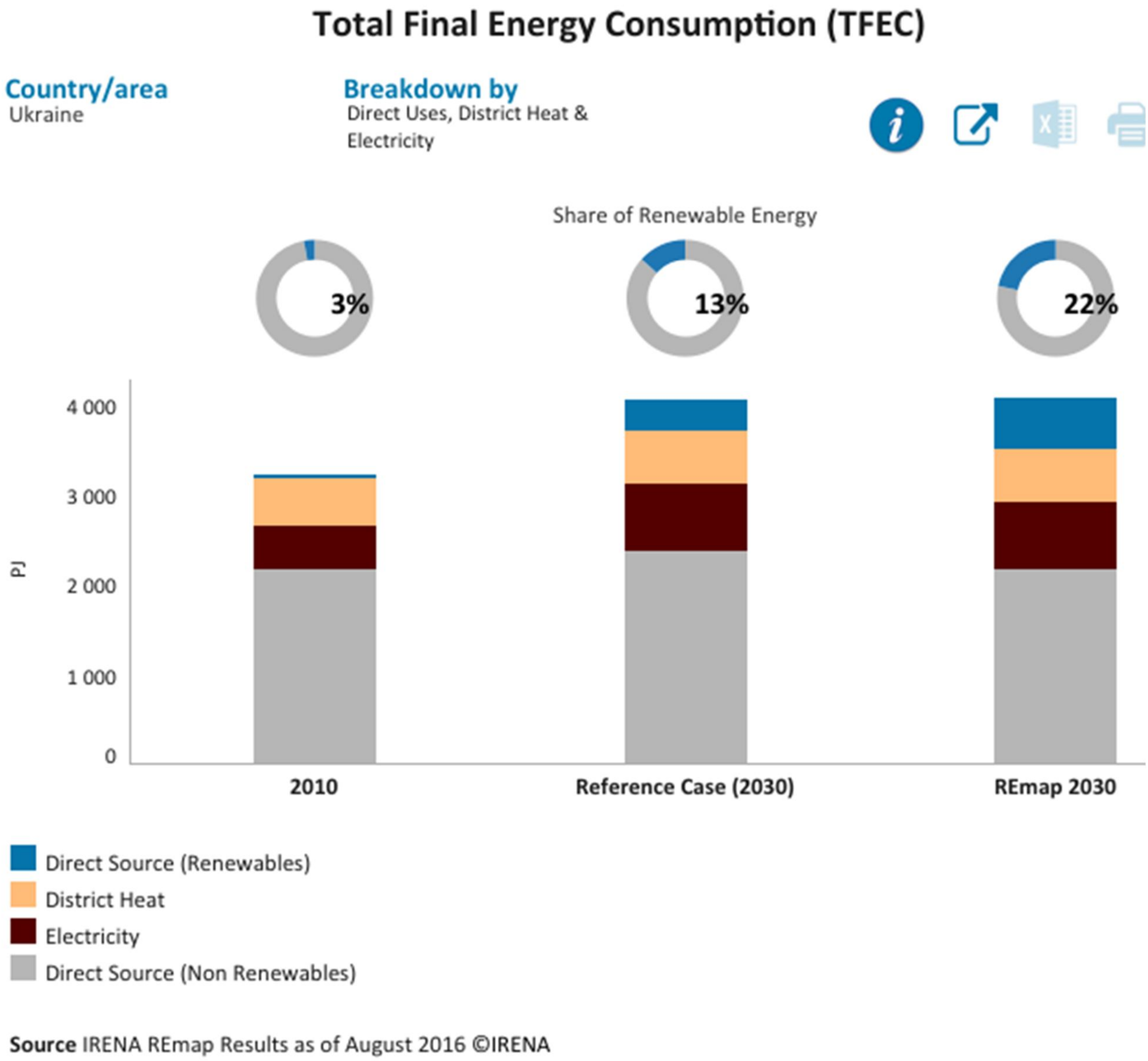

Fig. 28. The total final energy consumption by sector (TFEC) for the reference case and REmap case by year for planned and transforming energy scenario to 2050 in Ukraine
(Source: author's research results with using database IRENA)

Fig. 29 provides an overview on the renewable energy balance for Ukraine

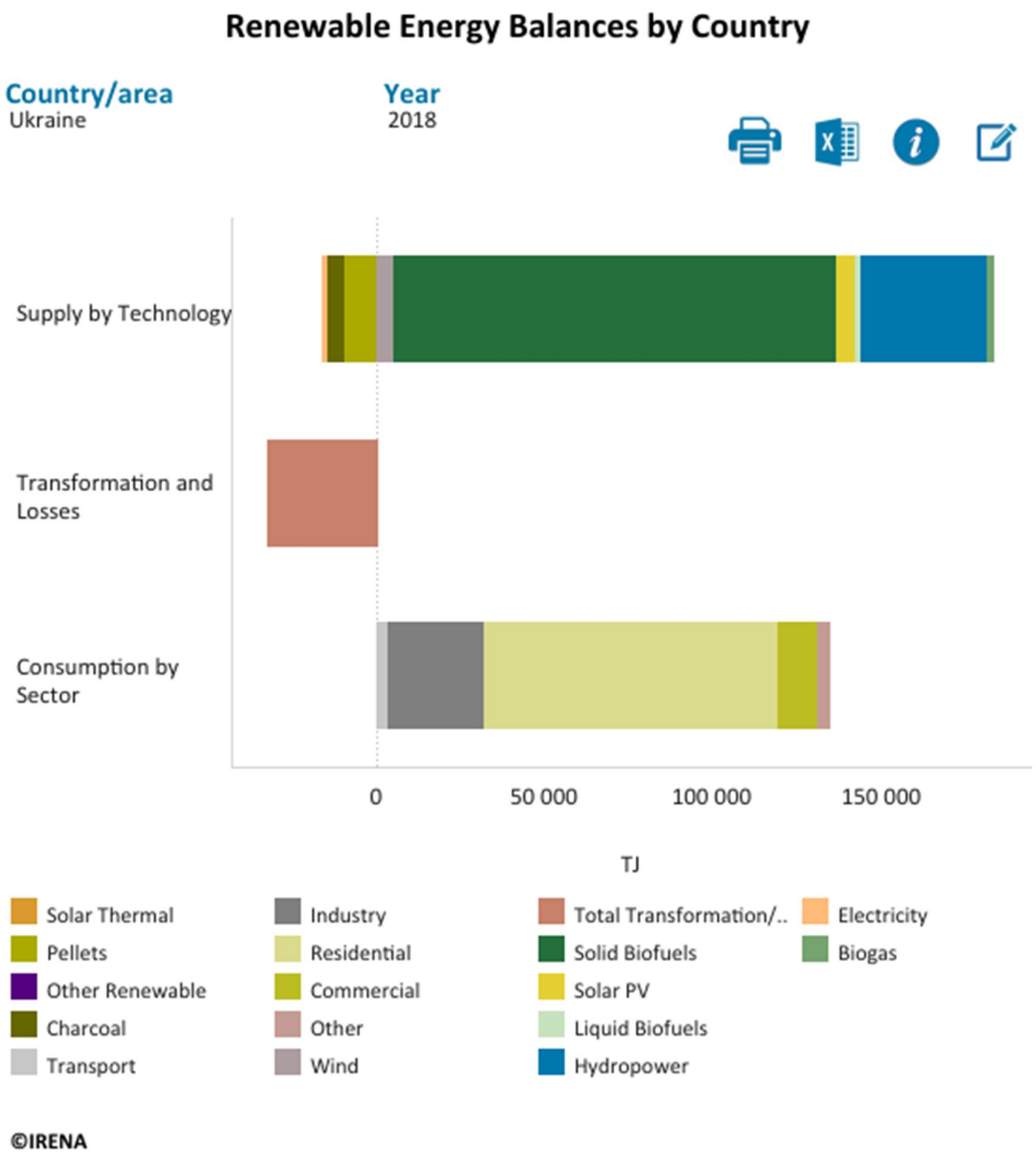

Fig. 29. The renewable energy balance for Ukraine
(Source: author's research results with using database IRENA)

Figs. 30 – 34 estimates the greenhouse gas emissions avoided in Ukraine due to a renewable electricity generation in a given year compared to various fossil fuel generation scenarios

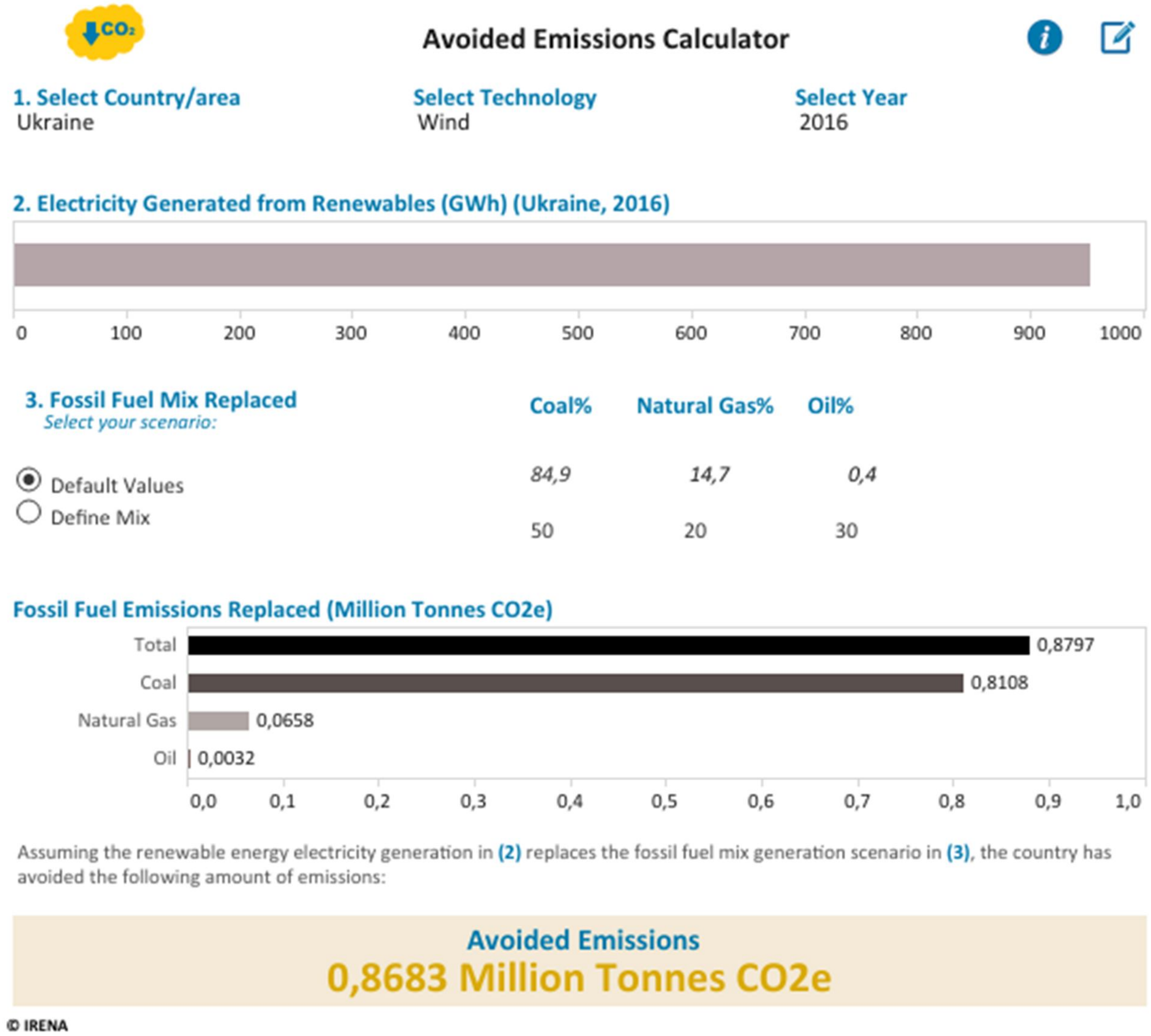

Fig. 30. Greenhouse gas emissions avoided in Ukraine due to a renewable (wind) electricity generation in 2018 compared to various fossil fuel generation scenarios

(Source: author's research results with using database IRENA)

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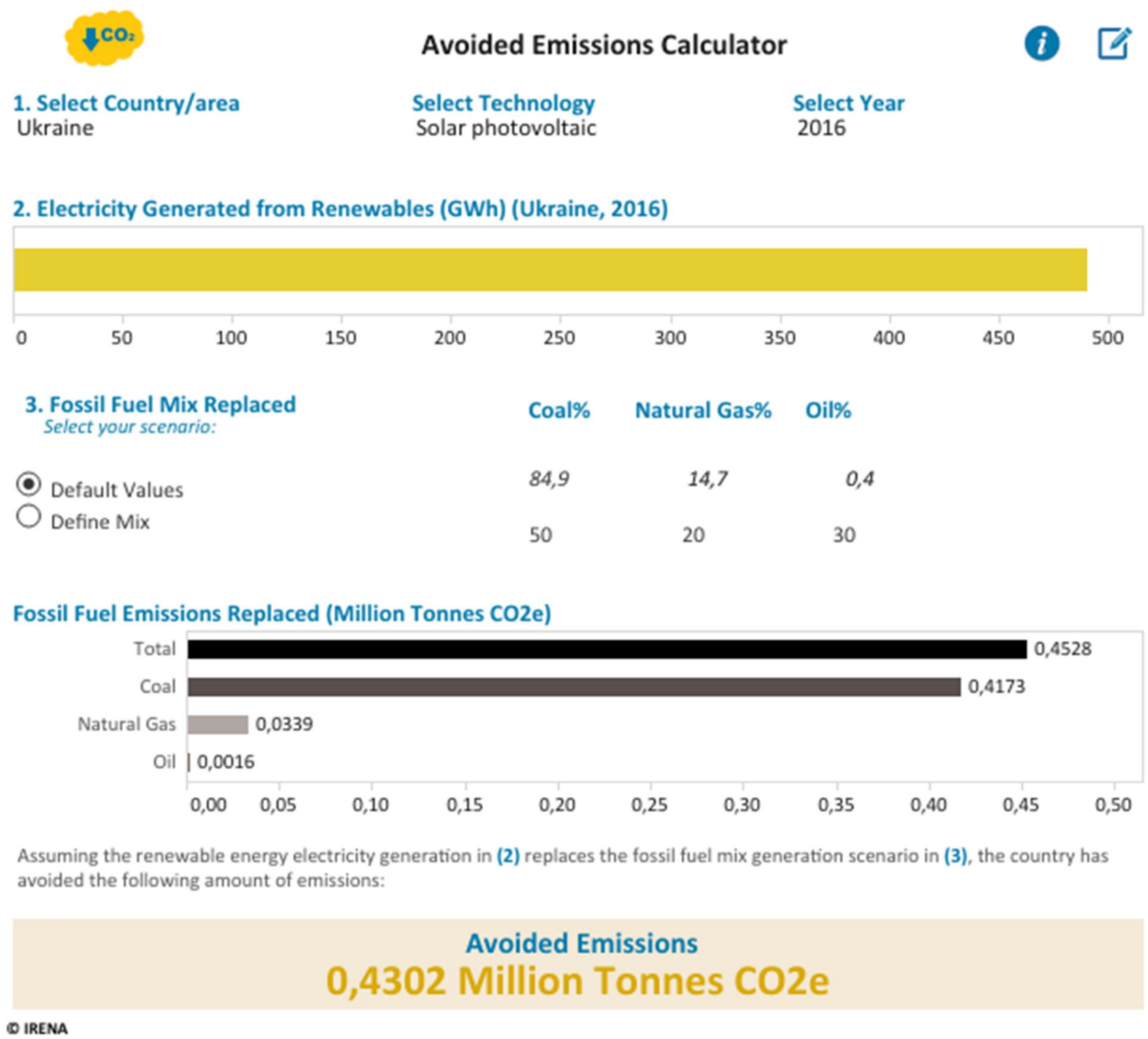

Fig. 31 Greenhouse gas emissions avoided in Ukraine due to a renewable (solar photovoltaic) electricity generation in 2018 compared to various fossil fuel generation scenarios
(Source: author's research results with using database IRENA)

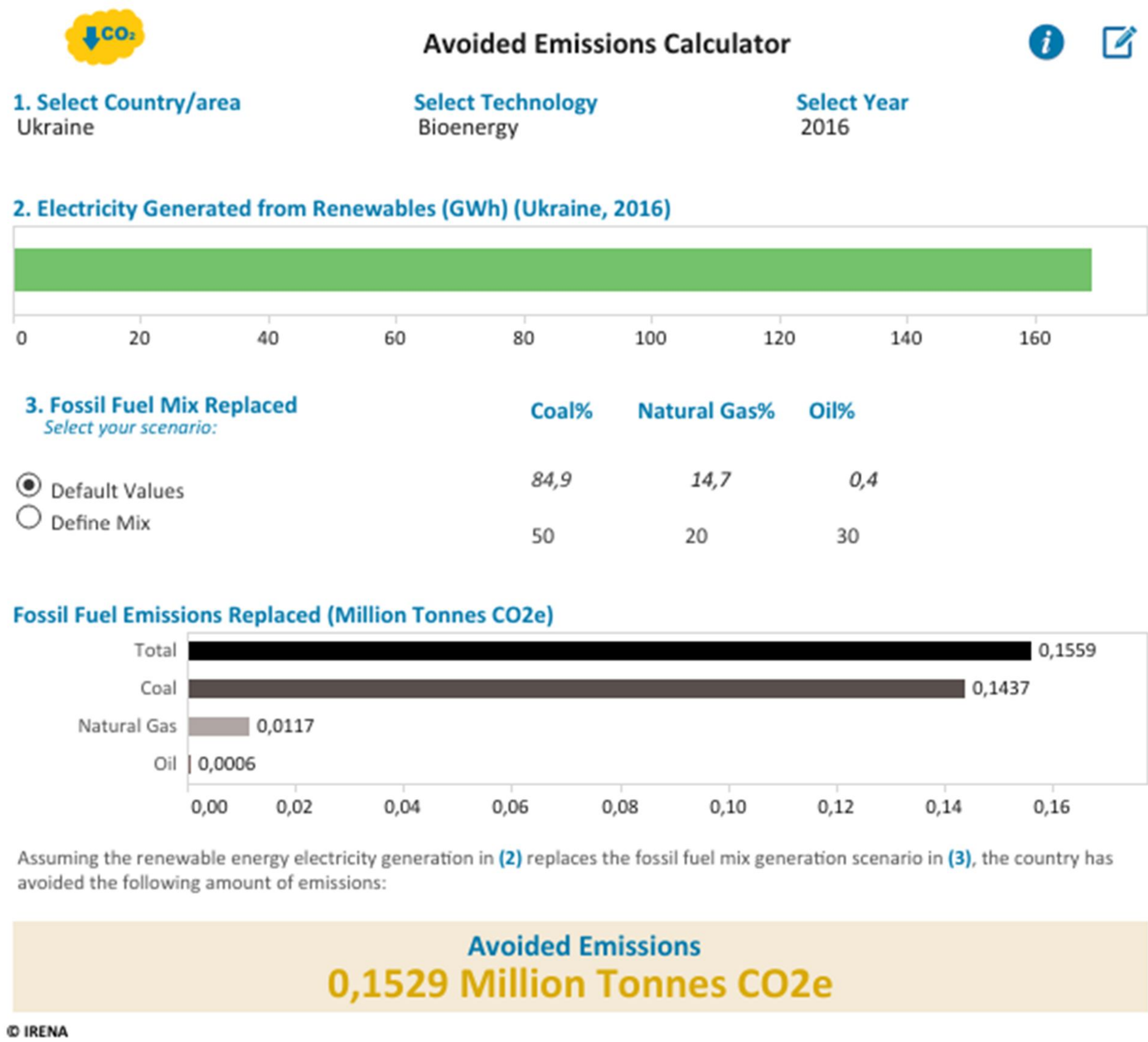

Fig. 32 Greenhouse gas emissions avoided in Ukraine due to a renewable (bioenergy) electricity generation in 2018 compared to various fossil fuel generation scenarios

(Source: author's research results with using database IRENA)

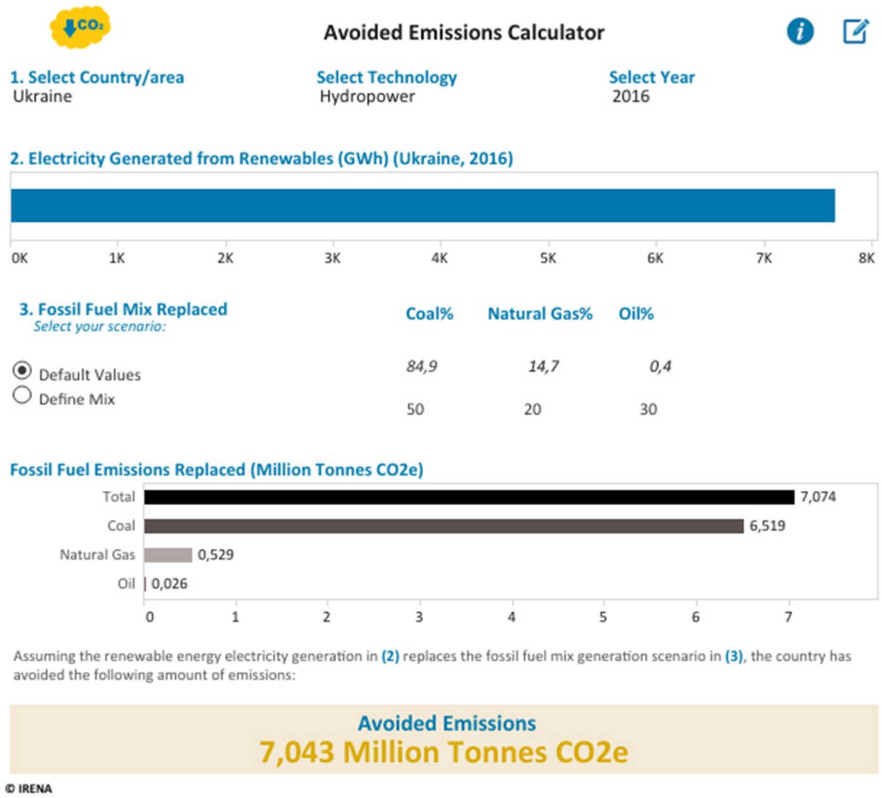

Fig. 33 Greenhouse gas emissions avoided in Ukraine due to a renewable (hydropower) electricity generation in 2018 compared to various fossil fuel generation scenarios

Source: author's research results with using database IRENA

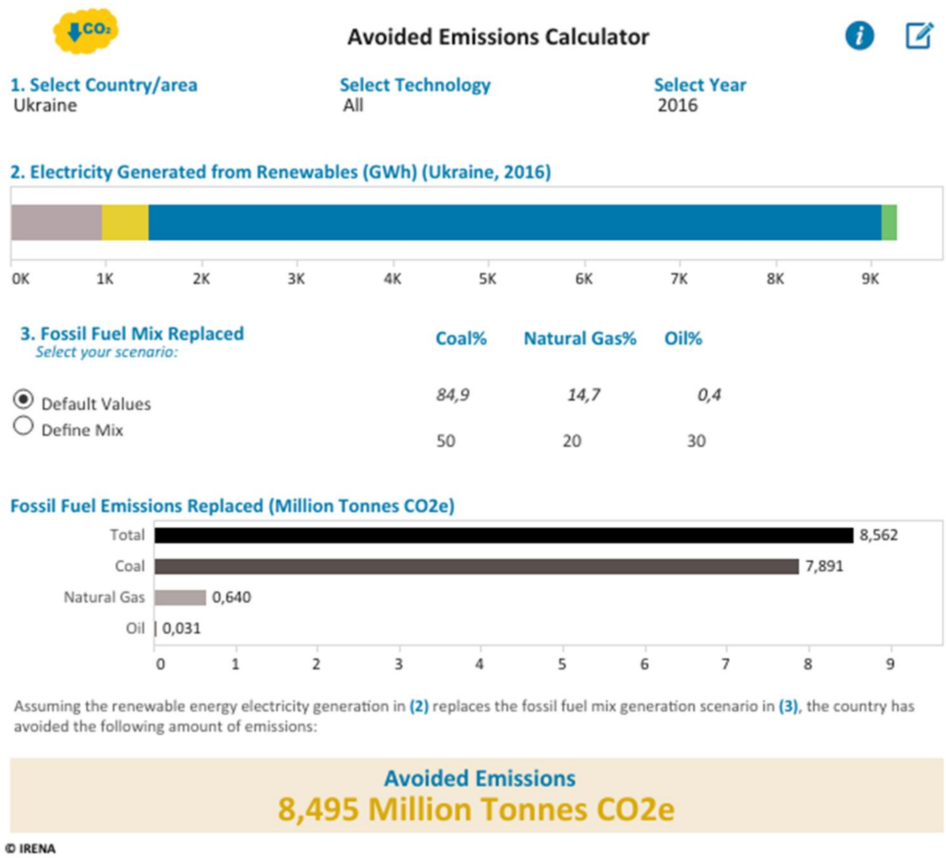

Fig. 34 Greenhouse gas emissions avoided in Ukraine due to a renewable (wind, solar photovoltaic, bioenergy and hydropower) electricity generation in 2018 compared to various fossil fuel generation scenarios

CONCLUSIONS.

The investigation presents an approach aimed at assessing trends in the reform of the energy sector of the world, the European Union and Ukraine in the future until 2050, using renewable energy sources in the concept of Sustainable Development.

Our research is aimed at: analysing the energy sector of the world, the European Union and Ukraine and identifying the benefits of using renewable energy sources in the concept of Sustainable Development, assessment of prospects for the application of innovative technologies based on renewable energy sources in the concept of Sustainable Development. A number of criteria for energy, economic and environmental efficiency of innovative technologies for the use of renewable energy sources are analysed in order to conduct a comprehensive assessment of the effectiveness of energy and resource-saving, environmentally friendly and cost-effective innovative technologies in the concept of Sustainable Development.

This approach allows providing a reasonable definition of prospects for the use of energy and resource-saving, environmentally friendly and cost-effective innovative technologies for the use of renewable energy sources in the concept of sustainable development to increase energy, economic efficiency and environmental security of Ukraine's energy sector.

The scenario of the transformation of the energy system of the World and the European Union, analyzed in Chapter 1, in combination with an additional deeper perspective on reducing carbon dioxide emissions provides a sustainable, environmentally friendly and climate-friendly basis for stable long-term economic development. According to research ("IRENA", 2021), this offers the prospect of higher economic growth, cleaner living conditions and significant improving the level of well-being. This perspective will reduce global emissions carbon dioxide (CO2) associated with energy production by 70% by 2050. More than 90% of this reduction will be achieved through renewable energy sources and measures to increase energy efficiency. The transition to alternative energy sources can stimulate wider social economic development accompanied by integrated policies that promote transformational processes aimed at reducing carbon dioxide emissions in different countries. Such a holistic approach would lead to a reduction in carbon dioxide emissions gas related to energy production, in line with economic, environmental and

social goals. According to research ("IRENA", 2021), the ultimate global climate target will be zero emissions. This perspective also looks at ways to reduce CO2 emissions from 2050 to zero energy balance and possibly even zero. Hydrogen and synthetic fuels, direct electrification, modern biofuels and carbon reduction measures gas will be critical along with innovative business models, structural changes and behavioral adaptation.

The application of the methods of sustainable development and sustainable energy in order to increase the level of energy-economic efficiency of the energy sector of Ukraine with using of renewable energy sources is presented in given paper.

The justification of the application of the methods of green logistics and sustainable development for the analysis of perspectives of application of innovative technologies is presented in the research (Ostapenko, Savina, et al, 2020).

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