# Green Horizons: Global Trends in Renewable Energy

**August 2024**

Photo by Thomas Richter on Unsplash

PARIS ADVANCED RESEARCH CENTER

*Green Horizons: Global Trends in Renewable Energy*

# Introduction

As nations seek to address the pressing challenges of climate change, energy security and economic stability, the global energy landscape is undergoing profound change.Indeed, determining geopolitical events such as the Russian-Ukrainian war, the Israeli conflict and related humanitarian crises have made it more urgent than ever for governments to move away from fossil fuels and more generally to develop a more sustainable energy system. In particular, in this necessary transition, renewable energies are leading the way, offering a sustainable alternative to fossil fuels and playing a crucial role in mitigating environmental impacts. Specifically, according to the International Energy Agency (IEA), the use of renewable energy in the electricity, heat and transport sectors is one of the key factors in achieving the goal of limiting the global temperature increase to 1.5 degrees. In concrete terms, according to the 'Net Zero Emissions' scenario by 2050, renewable energies allow electricity production to be almost completely decarbonised, while renewable transport fuels and renewable heat contribute to significant emission reductions in the respective sectors. Consequently, by examining the policies, interventions and market dynamics driving the promotion of renewable energy, this report provides a comprehensive overview of the evolution of the global energy sector, as IEA forecasts state that for the first time, global demand for the main fossil fuels - coal, oil and gas - will peak by 2030 due to active policies, indicating a clear paradigm shift in the energy sector. Consequently, this study focuses on global renewable energy trends driven by international initiatives over the years, with particular emphasis on European Union renewable energy policies and the corresponding EU energy/electricity mix. The report begins with an examination of the definition and different types of renewable energy sources. It then looks at the evolution of global cooperation on renewable energy policies, from the Kyoto Protocol to the recent COP28 resolution, to to better understand the impact of these policies in shaping the role of renewables in the global energy mix. Furthermore, the paper focuses on the study of the European Union's renewable energy policy, tracing its evolution over the years, from the 2009 Renewable Energy Directive to the revision of RED II in 2023. This historical overview provides a critical understanding of the current policy landscape and its impact on the EU's energy and electricity mix. Finally, the report highlights the opportunities and challenges in this evolving landscape, and emphasizes the need for industry to adapt rapidly to the changing energy dynamics. Particular attention is given to innovation to help decarbonise hard-to-decarbonise sectors, such as heavy industry. To meet global climate goals and ensure energy security for all, the global community needs new investment in energy efficiency, renewables, electricity grids and above all in innovative technologies such as floating offshore wind farms,and low-carbon hydrogen, as these are increasingly seen as fundamental. Ultimately, this report aims to highlight the opportunities and challenges of the changing energy landscape, highlighting the imperative for administrations to swiftly respond to the new energy dynamics required.

# I. Renewable Energy and its Sources

## A. Understanding Renewable Energy: Definition and Varieties

Although there is wide consensus among international actors as to what qualifies as renewable energy, no universally accepted formal definition exists. On the contrary, numerous definitions are used, each emphasizing different aspects of renewable energy. Of these, the two most prominent are those developed by the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA).[1] The former offered a generic interpretation back in 2002, outlining renewable energy resources as those "derived from natural processes and replenished at a faster rate than they are consumed". Accordingly, the IEA definition includes “solar, wind, ocean, hydro, biomass, geothermal resources, biofuels and hydrogen derived from renewable resources”.[2] However, the younger IRENA institute subsequently established a statutory definition in January 2009. This stipulates that “renewable energy includes all forms of energy produced from renewable sources in a sustainable manner, including bioenergy, geothermal energy, hydropower, ocean energy, solar energy, and wind energy”.[3]

Both of these definitions do not differ significantly in terms of the types of renewable energy sources included. Namely, six distinct types can be identified in both cases: solar, wind, ocean, hydro, biomass and geothermal. The only subtle divergence concerns the specification of biofuels and hydrogen by the IEA, whereas IRENA used the broader term bioenergy.[4] Each of these sources presents its own specificity both in terms of characteristics and mode of use. Solar energy is the most widespread of all energy resources and can be exploited even in overcast conditions; in fact, the speed at which the Earth captures it far exceeds the rate at which mankind consumes energy. Although only some countries can benefit equally from solar energy, for many it can still make a significant contribution to the energy mix through direct solar output. The most widely used solar technology for electricity production is photovoltaic panels and it is the steep drop in their cost of production over the last decade that makes these technologies the cheapest form of electricity.[5] Another fundamental renewable energy is wind energy, which relies on the kinetic energy of moving air by means of large turbines placed either on land, in the case of onshore wind energy, or at sea or in freshwater, in the case of offshore wind turbines. In spite of the long-standing use of wind energy for energy purposes, both technologies mentioned have evolved more recently through taller turbines and larger rotor diameters in order to maximize the electricity produced. Furthermore, notwithstanding the variations in territorial predisposition and, consequently, in average wind speed according to location, the overall technical potential of wind energy is greater

---

[1] Sustainable Energy for All. (2013). Global tracking framework: Chapter 4: Renewable Energy. Sustainable Energy for All. Retrieved from https://www.seforall.org/sites/default/files/l/2013/09/9-gtf_ch4.pdf

[2] International Energy Agency (IEA). (2002). Renewables Information 2002. Paris: OECD Publishing. Retrieved from https://doi.org/10.1787/9789264099531-en

[3] International Renewable Energy Agency (IRENA). (2009). Statute of the International Renewable Energy Agency. IRENA. Retrieved from https://www.irena.org/-/media/Irena/Files/Official-documents/IRENA-Statute/IRENAstatuteenIRENAFCStatutesignedinBonn26012009incldeclarationonfurtherauthenticversions.pdf?rev=d619033053354d20884bde3aef72224f

[4] Sustainable Energy for All. (2013). Global tracking framework: Chapter 4: Renewable Energy. Sustainable Energy for All. Retrieved from https://www.seforall.org/sites/default/files/l/2013/09/9-gtf_ch4.pdf

[5] United Nations. (n.d.). What is renewable energy?. UN Climate Action. Retrieved May 31, 2024 from https://www.un.org/en/climatechange/what-renewable-energy.

than the world's electricity production.[6] Furthermore, another high-impact renewable energy is hydropower, which uses the movement of water from higher to lower altitudes. This type of energy can be generated either from reservoirs or rivers: reservoir hydropower plants rely on stored water, while run-of-river hydropower plants use the available flow of the river. Hydropower is currently the largest source of renewable energy in the electricity sector, as it is mainly based on stable rainfall patterns, yet it is still very sensitive to extreme weather events such as droughts and general changes in ecosystems.[7] The fourth type of renewable energy is geothermal energy, which utilizes thermal energy accessible from the Earth's interior, particularly from underground reservoirs, through the use of wells or other specialized extraction methods. There are two types of reservoirs: the hydrothermal reservoirs, naturally sufficiently hot and permeable, and the enhanced geothermal systems (EGS), sufficiently hot but supported by hydraulic stimulation.[8] Moreover, another renewable energy source is biomass. Biomass energy is produced through the conversion of organic materials, such as agricultural residues, forest by-products, and dedicated energy crops, into usable forms of energy through different processes, including combustion and gasification[9]. This can be described as the most debated source, as its combustion still generates greenhouse gas emissions (GHG), albeit at lower levels than the combustion of fossil fuels. Consequently, it is recommended that bioenergy be used in limited applications.[10] Finally, the last type of renewable energy is ocean energy, the result of technologies that can utilize the kinetic and thermal energy of seawater, particularly in relation to waves or currents. Ocean energy systems, such as wave or tidal energy, are still at an early stage of development and are not yet commercially available, but the theoretical potential of ocean energy easily exceeds current human energy needs.[11]

While both definitions include the same renewable energy sources, a key difference between the two lies in whether sustainability considerations are taken into account, since the IRENA definition, unlike the IEA one, explicitly emphasizes the notion of sustainability, associating renewable energy with sustainable practices. Indeed, all renewable energy sources exhibit remarkable characteristics in terms of eco-sustainability. Nevertheless, despite the high score on sustainability criteria, energy production from these sources inevitably generates both positive and negative environmental, economic, and social impacts. These considerations are most evident in the case of bioenergy and hydropower.[12] For example, bioenergy, while significantly reducing waste, if not managed wisely and prudently, risks causing major environmental disruptions such as soil erosion, loss of biodiversity, and negative impacts on water quality and quantity.[13] Similarly, hydropower represents a stable and reliable source of energy able to ensure energy security, however, large-scale

---

[6] ibid.

[7] ibid.

[8] ibid.

[9] International Energy Agency (IEA). (2023). Bioenergy. IEA. Retrieved from June 1, 2024 https://www.iea.org/energy-system/renewables/bioenergy.

[10] United Nations. (n.d.). What is renewable energy?. UN Climate Action. Retrieved May 31, 2024 from https://www.un.org/en/climatechange/what-renewable-energy.

[11] International Renewable Energy Agency (IRENA). (n.d.). Ocean energy. IRENA. Retrieved June 1, 2024 from https://www.irena.org/Energy-Transition/Technology/Ocean-energy.

[12] Sustainable Energy for All. (2013). Global tracking framework: Chapter 4: Renewable Energy. Sustainable Energy for All. Retrieved from https://www.seforall.org/sites/default/files/l/2013/09/9-gtf_ch4.pdf

[13] World Energy Council. (2013). World Energy Resources: Bioenergy. World Energy Council. Retrieved June 1, 2024 from https://www.worldenergy.org/assets/images/imported/2013/10/WER_2013_7_Bioenergy.pdf

hydropower projects may develop strong environmental impacts, such as disrupting local ecosystems and the displacement of communities, affecting their cultural and social structures.[14] Nevertheless, the inclusion of sustainability criteria in the definition could have a limited impact since there are no internationally accepted sustainability criteria covering the major technologies related to renewable energy, and it is therefore not easy to identify sustainable and less-sustainable deployment. Moreover, this distinction is not particularly taken into account at present as current statistical databases consider all energy production from renewable sources, whether sustainable or not, as "renewable energy".[15]

Having established the complexity and diversity of renewable energy sources and their classification, it is then possible to examine their impact in contemporary society and their role in the global energy and power mix.

## B. Renewable Energy Trends Worldwide

Renewable energy, in all its manifestations, has long been at the forefront of the ecological transition to a low-carbon and sustainable energy system. The promotion of renewable energies in the electricity, heat and transport sectors is among the key factors in keeping the global average temperature increase below 1.5°C. In particular, in the "Net Zero Emissions by 2050" scenario (NZE), renewables enable the almost complete decarbonization of power generation while contributing to significant emission reductions in transport, buildings, and industry. As a result, the last few years have seen strong growth in renewable generation capacity, driven by political support and sharp cost reductions in solar PV and wind power.[16] In this positive wake, the world is poised to further add more renewable capacity over the next five years than has been installed since the first commercial renewable power plant was built more than a century ago. The IEA forecast in the Renewable Report 2023 estimates that nearly 3,700 GW of new renewable capacity will come on stream between 2023-2028, supported by renewable energy policies in more than 130 countries.[17] In fact, this firm commitment to renewable energy was confirmed in the text of the Global Stocktake agreed upon by the 198 governments at COP28, including, among others, the target to triple renewable energy and double the annual rate of energy efficiency improvements by 2030. Threefold the global renewable capacity in the energy sector compared to 2022 levels by 2030 would bring it to over 11,000 GW, which would be in line with the IEA's NZE scenario. On the contrary, with current policies and market conditions, global renewable capacity is expected to reach 7,300 GW in 2028. As such, this path of growth would see global capacity rise to 2.5 times its current level by 2030, just short of the target of tripling.[18] Therefore, governments may close the gap and deliver on the promise made at COP28 to reach more than 11,000 GW by 2030 by fast-tracking the implementation of existing policies and especially by addressing present challenges,

[14] World Energy Council. (2013). World Energy Resources: Hydro.World Energy Council. Retrieved from https://www.worldenergy.org/assets/images/imported/2013/09/Complete_WER_2013_Survey.pdf

[15] Sustainable Energy for All. (2013). Global tracking framework: Chapter 4: Renewable Energy. Sustainable Energy for All. Retrieved from https://www.seforall.org/sites/default/files/l/2013/09/9-gtf_ch4.pdf

[16] International Energy Agency (IEA). (n.d.). Renewables. IEA.Retrieved June 2, 2024 from https://www.iea.org/energy-system/renewables

[17] International Energy Agency (IEA). (2024). Renewables 2023 Analysis and forecast to 2028. IEA. Retrieved from https://iea.blob.core.windows.net/assets/96d66a8b-d502-476b-ba94-54ffda84cf72/Renewables_2023.pdf

[18] ibid.

such as policy ambiguities and delays in policy responses in the changing macroeconomic context; insufficient investment in grid infrastructure preventing a faster expansion of renewables; administrative barriers and social approval problems and even insufficient financing in emerging and developing economies. Simply improving these extensive concerns would lead to almost 21% higher growth in renewables, pushing the world towards meeting the global commitment to triple emissions.[19] Still, 2023 showed that progress is being made in the right direction, as it marked the 22nd consecutive year in which renewable capacity additions set a new record. Specifically, last year, global annual renewable capacity additions increased by almost 50 percent to almost 510 gigawatts (GW), recording the fastest growth rate in 20 years. To be more precise, this increase in renewable capacity was notable in Europe, but it was mainly in the United States and Brazil that the highest rate was reached.[20] Turning the tide, however, was the acceleration of China, which put as many photovoltaics into operation in 2023 as the world as a whole in 2022, while wind additions grew by 66% year-on-year. Globally, solar PV alone accounted for three-quarters of the world's renewable capacity additions.[21]

In addition to these initial figures, to better grasp the role of renewable energies nowadays, it is beneficial to refer to global primary energy consumption, due to its comprehensive insights into energy efficiency and sustainability. Primary energy consumption corresponds to the total amount of energy used by unprocessed sources such as coal, oil or natural gas before being converted into more usable forms. It includes the energy loss of  the conversion process itself, therefore taking into account the inefficiencies associated with the production of electricity, transport fuels and heating for end users.[22] This is crucial for assessing the efficiency of energy production and the effectiveness of policies to minimize energy waste. Furthermore, it is optimal for evaluating the total environmental impact of an energy system. According to the Energy Institute Statistical Review of World Energy 2023, the total global primary energy consumption for the year is approximately 178,899 terawatt-hours (TWh). Compared to total consumption, fossil fuels remain the dominant source with 137,237 Twh, thus reaching 76.71% of total consumption. More specifically, it shows natural gas accounting for 22.03% (39,413 TWh), oil for 29.61% (52,970 TWh) and coal for 25.07% (44,854 TWh). To a very different extent, nuclear energy represents 3.75% of the global primary energy consumption mix, with 6,702 Twh; however small, as a low carbon energy source,  nuclear power contribution plays a central role in improving the reliability and coherence of the energy system. Finally, the mix is concluded by renewable energy sources representing 19.57% (35,010 TWh) of the global primary energy consumption, of which 6.21% (11,111 TWh) from traditional biomass, 6.32% (11,300 TWh) from hydroelectric energy, 3.07% (5,488 TWh) from wind energy, 1.95% (3,488 TWh) from solar energy, 1.35% (2,424 TWh) from other renewable sources such as geothermal and other types of biomass and 0.67% (1,199 TWh) from biofuels.[23]

---

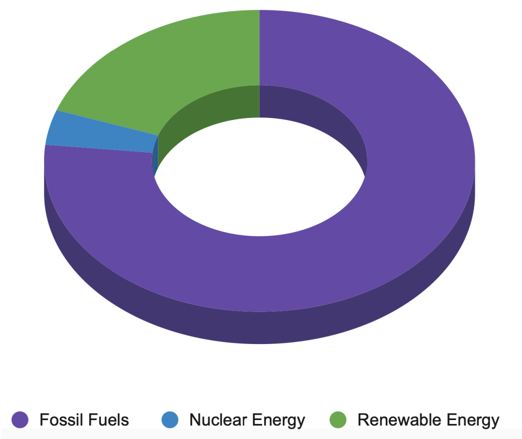
[19] ibid.

[20] ibid.

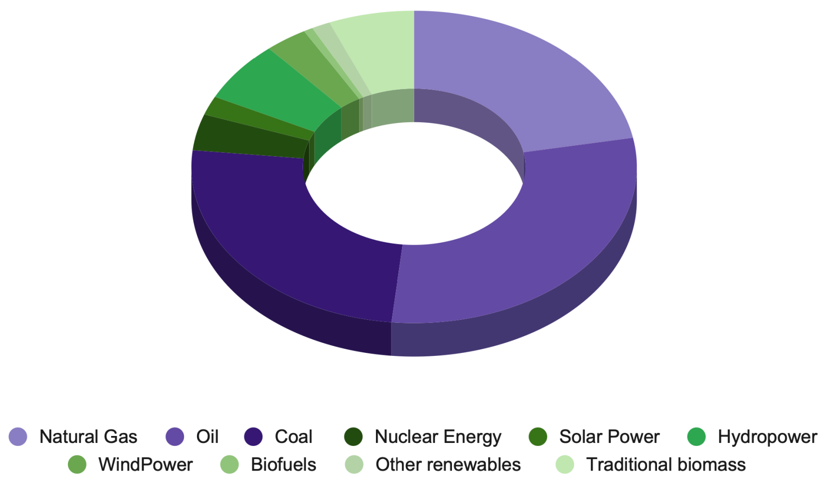
[21] ibid.

[22] Ritchie, H., & Rosado, P. (2024). Energy Mix.Explore global data on where our energy comes from, and how this is changing. Our World in Data. Retrieved June, 2 2024 from https://ourworldindata.org/energy-mix

[23] Energy Institute. (2023). Statistical Review of World Energy. Energy Institute. Retrieved from https://www.energyinst.org/statistical-review




**Global Primary Energy consumption 2023**




**Global Primary Energy consumption 2023**

The role of renewables becomes even more evident when considering the electricity sector. In fact, the electricity sector remains the most promising on the renewables front, thanks to the strong growth of solar photovoltaics and wind power, in addition to the significant contribution of hydropower, now stable for years.[24] Confirming this high level of confidence in renewables, renewable electricity capacity additions are projected to reach an estimated 507 GW in 2023, roughly a 50 percent increase in value compared to 2022. Furthermore, the ongoing political support in more than 130 countries has stimulated a significant shift in the global growth trend.[25] Indeed, had it not been for the drought causing a five-year decline in hydropower, leading to a shortage largely filled by coal, the expansion of clean capacity would have been sufficient to decrease the global power sector's emissions in 2023, given that it currently accounts for one-third of energy-related carbon dioxide emissions. However, there is certainty that this minor setback will have no further impact in the future, but on the contrary, predictions are that a renewed phase in the decline of fossil generation will begin in 2024, marking 2023 as the likely peak of energy sector emissions.[26]

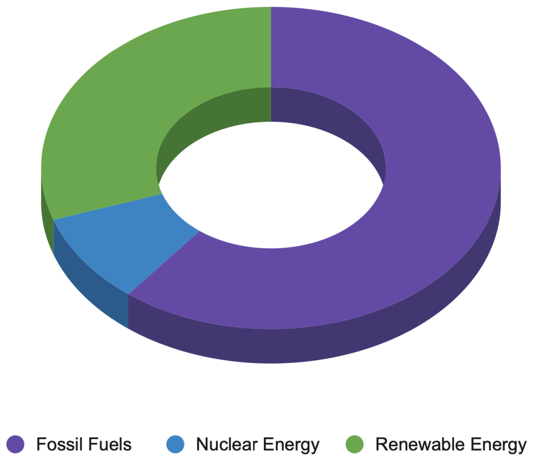
---

[24] International Energy Agency (IEA). (n.d.). Renewables. IEA. Retrieved from https://www.iea.org/energy-system/renewables

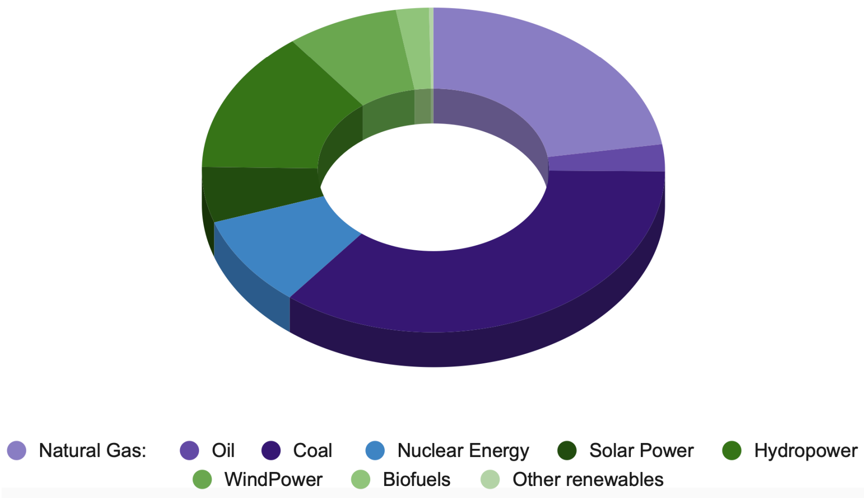
[25] International Energy Agency (IEA). (2024). Renewables 2023 Analysis and forecast to 2028. IEA. Retrieved from https://iea.blob.core.windows.net/assets/96d66a8b-d502-476b-ba94-54ffda84cf72/Renewables_2023.pdf

[26] Ember. (2024). Global Electricity Review 2024. Retrieved from https://ember-climate.org/app/uploads/2024/05/Report-Global-Electricity-Review-2024.pdf

Currently, in the global electricity mix in 2023, renewable sources were able to account for 8,914.00 TWh reaching 30.24%, with wind at 7.82% (2,304.44 TWh), solar at 5.53% (1,629.90 TWh), bioenergy at 2.30% (678.74 TWh) and hydropower generating 14.28% (4,211.01 TWh) and other renewable such as geothermal at 0.30% (89.91 TWh). Moreover, nuclear power maintained a stable share of 9.11% (2,685.74 TWh) in the global mix, slightly improving the 2022 one, contributing to a total clean generation of almost 40% and reaching a new low record for the carbon intensity of the world's electricity. However, this means that fossil fuels, the traditional source of energy, remained dominant, with oil accounting for 2.67% (788.55 TWh), gas for 22.47% (6,622.93 TWh), and coal for 35.51% (10,467.93 TWh), reaching a total of 14,131.03 TWh, for 60.65% of total electricity production. [27]




**Global Electricity Mix 2023**




**Global Electricity Mix 2023**

[27] Ritchie, H., & Rosado, P. (2024). Electricity mix: Explore data on where our electricity comes from and how this is changing. Our World in Data. Retrieved June 28, 2024, from https://ourworldindata.org/electricity-mix

The growing contribution of renewable sources paints a promising picture for a more sustainable future, with an increasing emphasis on wind and solar energy. In fact, wind and solar power generation kept growing faster than any other source of electricity. Combined, these two sources have reached a new record of 13.4 percent (3,935 TWh) in 2023, gaining another 1.5 percentage points of the overall electricity mix compared to 2022 (11.9 percent, 3,422 TWh). This boost at global levels in 2023 was determined primarily by the substantial expansion of the People's Republic of China, especially in the solar photovoltaic (+116%) and wind power (+66%) markets.[28] Global wind growth was significant also in the EU, contributing to 24% of the growth, and in Brazil (with a 7% share). For solar energy, on the other hand, in addition to China's contribution, the EU (12%) and the US (11%) helped drive global growth. Together, the solar growth of the four above-mentioned economies account for 81% of solar power growth in 2023.[29] Pursuing this trajectory, renewable energy sources will account for 42% of global electricity production by 2028, with wind and solar photovoltaics accounting for 25% of the share.[30] However, despite the achievement of this year's new records, this year's absolute growth in wind and solar (+513 TWh) remained below expectations, being slightly lower than in 2022 (+517 TWh). This decline was mainly due to lower-than-expected growth in wind power,  18% less than the 249 TWh increase expected in 2022. The United States was a major contributor to the downturn in wind power, recording a decline in its generation for the first time since the year 2000 (-9.1 TWh, -2.1%). The same was true for hydropower production, which, while continuing to be the world's leading source of clean energy, saw its share in the global electricity mix decline by 0.6 percentage points.[31] Despite reaching new record highs, the absolute growth in wind and solar (+513 TWh) fell short of expectations being slightly smaller than in 2022 (+517 TWh). This shortfall was mainly due to lower-than-expected wind growth, which was 18% lower compared to the 249 TWh increase in 2022. The US was a key contributor to the wind slowdown, experiencing a fall in wind generation for the first time since at least 2001 (-9.1 TWh, -2.1%). The same happened with hydropower generation, although it remained the largest source of clean power globally, its share in the world's electricity mix dropped 0.6 percentage points to 14.3%, the lowest level since at least 2000 and just 1 percentage point above wind and solar.[32]

What has been achieved in the past year and what is expected to be achieved in the following years is undoubtedly the result of a historical evolution in terms of renewable energy policies that have been intensified over the years. Examining this evolution of the global policies that have driven the recent advancements of this sector is essential to better understand the current state of renewable energy policy worldwide.

---

[28] International Energy Agency (IEA). (2024). Renewables 2023 Analysis and forecast to 2028. IEA. Retrieved from https://iea.blob.core.windows.net/assets/96d66a8b-d502-476b-ba94-54ffda84cf72/Renewables_2023.pdf

[29] Ember. (2024). Global Electricity Review 2024. Ember. Retrieved from https://ember-climate.org/app/uploads/2024/05/Report-Global-Electricity-Review-2024.pdf

[30] International Energy Agency (IEA). (2024). Renewables 2023 Analysis and forecast to 2028. IEA. Retrieved from https://iea.blob.core.windows.net/assets/96d66a8b-d502-476b-ba94-54ffda84cf72/Renewables_2023.pdf

[31] Ember. (2024). Global Electricity Review 2024. Ember. Retrieved from https://ember-climate.org/app/uploads/2024/05/Report-Global-Electricity-Review-2024.pdf

[32] ibid.

### C. Global Policies Advancing Renewable Energy

In our interconnected society, the advancement of clean energy solutions now relies more than ever on collaborative networks and partnerships across the globe to increase the impact of these solutions. International cooperation has always been essential in advancing global commitment to sustainable development in various sectors, especially in the energy sector. Clarifying the genesis and evolution of the concept of sustainable development as a social-political objective, provides a deeper understanding of the foundations on which green policies and, in particular, renewable energy ones have been developed over time up to the present day.[33] Originally introduced in the 1987 UN report Our Common Future,[34] commonly known as the Brundtland Report, the concept of sustainable development gained concrete political traction when it was included in Agenda 21 of the 1992 UN Conference on Environment and Development.[35] It was, however, the 1992 UN Framework Convention on Climate Change (UNFCCC), a founding treaty of the international climate negotiations, that established an explicit link between the concept of sustainable development and GHG emissions, the energy sector and the broader challenge of climate change. Subsequently, this connection was reinforced by the first Conference of the Parties (COP) held in Berlin, Germany, in 1995, an event that still represents one of the most impressive global efforts to counter global warming. This thrust eventually culminated a few years later, on 11 December 1997, in the adoption of the groundbreaking Kyoto Protocol, which, in the wake of UNFCCC, launched a radical new phase, establishing legally binding constraints and related mechanisms to reduce the costs of emission reductions.[36] Nonetheless, despite this crucial step, the concept of sustainable energy development (SED) in its entirety had yet to be fully formalized.[37] It did not take long, however, to begin to rectify this, as it was at the 1997 UN General Assembly that the need for more sustainable energy use patterns was recognized. This led to the realization of the first steps towards a sustainable energy development agenda in the following years, as evidenced by the work of organizations such as the International Energy Agency (IEA), which published the first Energy Technology Perspectives (ETP) in 2006, focusing on the role that a diversified energy mix and its related energy technologies can play in addressing the problems mentioned above.[38] Furthermore, this awareness led to the creation of several agencies focused on energy transition, such as UN-Energy in 2004,[39] an inter-agency framework to assist countries in the transition to sustainable energy and to harmonize energy efforts within the different UN organizations, as well as the foundation in 2009 of the International Renewable Energy Agency (IRENA) by 75 different states

[33] Gunnarsdottir, I. A., et al. (2021). Sustainable Energy Development: History of the Concept and Emerging Themes. Environment and Natural Resources, University of Iceland.

[34] United Nations. (1987). Report of the World Commission on Environment and Development. Our common future. Retrieved from https://gat04-live-1517c8a4486c41609369c68f30c8-aa81074.divio-media.org/filer_public/6f/85/6f854236-56ab-4b42-810f-606d215c0499/cd_9127_extract_from_our_common_future_brundtland_report_1987_foreword_chpt_2.pdf

[35] United Nations. (1992). Agenda 21. Retrieved from https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf

[36] Climate Change Secretariat. (2002). A Guide to the Climate Change Convention and Its Kyoto Protocol. Retrieved from https://unfccc.int/sites/default/files/guideconvkp-p.pdf

[37] Gunnarsdottir, I. A., et al. (2021). Sustainable Energy Development: History of the Concept and Emerging Themes. Environment and Natural Resources, University of Iceland.

[38] International Energy Agency. (IEA). (2006). IEA Energy Technology Perspectives 2006. IEA. Retrieved from https://iea.blob.core.windows.net/assets/04d79827-c301-42aa-ac60-a39c7bf25900/etp2006.pdf

[39] United Nations Development Programme. (n.d.). UN Energy. UN. Retrieved June 2, 2024 from https://www.undp.org/energy/change-network/un-energy

as an intergovernmental agency to promote the adoption and sustainable use of renewable energy.[40] Another crucial initiative, highlighting the ascent of SED to the forefront of the international agenda was, the Sustainable Energy for All (SE4ALL) in 2011.[41] This initiative aimed to provide sustainable energy for all by 2030, prioritizing energy access, energy efficiency, and sustainable energy sources. Its true impact became evident in 2015, when, in the ratification of the 2030 Agenda for Sustainable Development and the related Sustainable Development Goals (SDGs), the goals of the SE4ALL initiatives were adapted to the seventh SDG. More specifically, with the introduction of SDG7, energy was recognized as necessary for the achievement of sustainable development, firmly embedding the concept within the global discourse on climate change.[42]This milestone gained further significance during the 21st session of the COP Conference of the Parties, the Paris Agreement was adopted on 12 December 2015, with the overarching goal of holding “the increase in the global average temperature to well below 2°C above pre-industrial levels” and pursue efforts “to limit the temperature increase to 1.5°C above pre-industrial levels”. The agreement specified that it would have entered into force 30 days after at least 55 members of the UNFCCC, representing a minimum 55 percent of total GHG emissions, had submitted their ratification, acceptance, approval or accession with the UN Secretary-General. This threshold for entry into force was reached on October 5, 2016, resulting in the Paris Agreement entering into force on November 4, 2016.[43]

Since entering into force, the Paris Agreement turned into the primary benchmark for the development of all national and international sustainable development initiatives and decisions that followed, including more recent ones such as the Mission Innovation 2.0 initiative.[44] This last is a global initiative of 23 members on all continents, including the EU, promoting investment in research, development and demonstration aimed at enabling affordable, attractive and accessible clean energy. More specifically, the initiative's member countries, already accounting for more than 90 percent of global public investment in clean energy innovation, committed to further increasing the investment and partnerships needed to provide technologies capable of countering the world's daunting climate challenges.[45] From its establishment in 2015 to the present, members have maintained a steady commitment by increasing investment by €4.9 billion per year. Moreover, this has been coupled with the improvement of international networks between researchers, industry, academia, think tanks and policymakers, for instance through the Champions Program,celebrating individuals accelerating the clean energy revolution through their research work.[46] On this positive note of the first years, at the 6th Ministerial meeting in Chile, on June 2, 2021, The Mission

[40] International Renewable Energy Agency (IRENA). (n.d.). Creation of IRENA. IRENA. Retrieved June 2, 2024 from https://www.irena.org/About/History/Creation-of-IRENA

[41] Sustainable Energy for All Africa Hub. (n.d.). The SEforALL Initiative. Retrieved June 2, 2024 from https://www.se4all-africa.org/fr/the-africa-hub/who-we-are/the-seforall-initiative/

[42] Gunnarsdottir, I. A., et al. (2021). Sustainable Energy Development: History of the Concept and Emerging Themes. Environment and Natural Resources, University of Iceland

[43] United Nations Framework Convention on Climate Change. (2016.). Paris Agreement. Retrieved from https://unfccc.int/sites/default/files/resource/parisagreement_publication.pdf

[44] Mission Innovation. (n.d.). Catalysing clean energy solutions for all. Retrieved June 10, 2024, from https://mission-innovation.net/

[45] European Commission. (n.d.). International cooperation in clean energy. Directorate-General for Research and Innovation. Retrieved June 10, 2024, from https://research-and-innovation.ec.europa.eu/research-area/energy/international-cooperation-clean-energy_en

[46] ibid.

Innovation members committed to greater action in the next decade by launching the second phase of the Initiative: Mission Innovation 2.0. This new tool, while maintaining its original goal, now set to be achieved by 2030, began to implement its activities by building new public-private innovation alliances around ambitious and challenging goals through an enhanced innovation platform to strengthen the global clean energy innovation ecosystem. On the same day as this announcement and in line with it, missions on clean hydrogen, green power and shipping were launched on 2 June 2021, joining the missions for Urban Transitions, Net-Zero Industries, Integrated Biorefineries and Carbon Dioxide Removal launched at COP26.[47] Among the latest global commitments to the Paris Agreement, mention must also be made of the official COP28 resolution in general and, more specifically, the COP28 Global Renewables and Energy Efficiency Pledge. State leaders agreed that meeting the Paris Agreement targets e requires tripling renewable energy capacity to at least 11,000 GW and doubling the annual rate of energy efficiency improvement to over 4 percent per year. In particular, the pledge recognizes the progress made by various countries, including developing countries, but emphasizes the need for more ambitious policies and international cooperation to overcome energy security and affordability difficulties.[48]

Besides the broader global initiatives developed to achieve the Paris Agreement, the advancement of the green transition, with the central role of renewable energy, is also driven by recent national policies, including those introduced in 2022 in the three largest global economies, China, India, and the United States, with the expectation of greatly increasing the use of renewable energy.[49]Among the most impactful national policies on renewables is China's 14th Five-Year Renewable Energy Plan, launched in 2022, to set an ambitious target for electricity generation from renewable sources by 2025 and also, for the first time, a goal for the use of renewable heat. In detail, the plan proposes that non-hydro renewable sources (wind, solar, biomass, and geothermal) should reach a total of 18% of electricity generation by 2025, then that all renewable sources should reach a share of 33%, and finally that renewable energy should account for more than 50% of incremental energy consumption.[50] Beyond the numerical targets, the plan lists five areas of simultaneous development needed to fulfill the set numerical targets, namely centralized and distributed renewables, onshore and offshore renewables, local consumption and long-distance transmission of renewables, generation projects from a single renewable source and from multiple energy sources, and single or integrated renewable approaches.[51] Therefore, the 14th FYP focuses on the installation of distributed solar in industrial parks and public buildings and encourages the promotion of dual-use solar applications, such as agro-voltaics for fishing. The implementation of this plan is guided by a wide use of feed-in tariffs, especially when compared to those used by other economic powers. However, as of 2021, feed-in tariffs are being phased out nationwide for most onshore photovoltaic

---

[47] ibid.

[48] COP28. (2023). Global renewables and energy efficiency pledge. COP28. Retrieved from https://www.cop28.com/en/global-renewables-and-energy-efficiency-pledge

[49] International Energy Agency (IEA). (2024). Renewables 2023 Analysis and forecast to 2028. IEA. Retrieved from https://iea.blob.core.windows.net/assets/96d66a8b-d502-476b-ba94-54ffda84cf72/Renewables_2023.pdf

[50] Helveston, J. P., & Nahm, J. (2022). Guide to Chinese climate policy 2022. Oxford Institute for Energy Studies. Retrieved from https://chineseclimatepolicy.oxfordenergy.org/wp-content/uploads/2022/11/Guide-to-Chinese-Climate-Policy-2022.pdf

[51] Climate Cooperation. (2022). China released its 14th Five-Year Plan for renewable energy with quantitative targets for 2025. Retrieved from https://climatecooperation.cn/climate/china-released-its-14th-five-year-plan-for-renewable-energy-with-quantitative-targets-for-2025/

and wind projects to be able to manage the increasing tensions resulting from the breach of WTO rules.[52]

Another national policy of great significance for the development of renewables is the Inflation Reduction Act, the most significant climate legislation in US history, with project funding and incentives to facilitate the transition to an energy-efficient economy.[53] To be exact, it is estimated that this measure will advance the deployment of renewable energy by increasing investment in both power plants and equipment manufacturing through tax credits and significant grant and loan programs to support the deployment of innovative and commercially available clean energy technologies. In order to achieve this, the USA government provides the Department of Energy's Loan Program Office with $40 billion in loan authority, supported by $3.6 billion in loan guarantee grants under Section 1703 of the Energy Policy Act for innovative clean energy technologies, including renewable energy systems, carbon capture, nuclear energy, and critical minerals processing, production, and recycling.[54] Encouraging incentives such as the Investment Tax Credit (ITC) and Production Tax Credit (PTC) enable Green Power Partners to deduct a percentage of the cost of renewable energy systems from their federal taxes, thus contributing more easily to lowering GHG emissions and pushing forward the shift to a green energy system. In addition, the IRA offers new access to clean energy tax credits, with an emphasis on reaching disadvantaged populations and communities with an environmental justification.[55] In 2023 and 2024, only solar and wind technologies qualify for this financial incentive scheme, as does energy storage when linked to such projects. Eventually, of course, the goal is to expand the scope of the IRA and of its benefits for the US green industry.[56]

Lastly, another relevant national energy policy is the Renewable Energy Policy - 2023 announced by the Indian government in April 2023 to promote the implementation of new renewable generation programs based on wind, solar and wind-solar hybrids. Concretely, the policy was formulated to provide a simplified framework to facilitate the development of renewable projects in the state by attracting investment in the renewable sector.[57] The aim of the strategy is to facilitate a substantial increase in renewable energy capacity by 2030, in line with the national target of 50 percent of cumulative installed electricity capacity from non-fossil fuel-based energy resources by the year 2030, set at COP26 in Glasgow, with investments of about Rs 5,000,000, utilizing about 4,00,000 acres of land. The benefits and incentives under RE Policy 2023 will be available for a period of 25 (twenty-five) years from the date of commissioning of the plant or its lifetime, and their implementation will be overseen by the Gujarat Urja Vikas Nigam Limited (GUVNL)

---

[52] Helveston, J. P., & Nahm, J. (2022). Guide to Chinese climate policy 2022. Oxford Institute for Energy Studies. Retrieved from https://chineseclimatepolicy.oxfordenergy.org/wp-content/uploads/2022/11/Guide-to-Chinese-Climate-Policy-2022.pdf

[53] U.S. Congress. (2022). H.R. 5376 - Inflation Reduction Act of 2022. US Congress. Retrieved from https://www.congress.gov/117/bills/hr5376/BILLS-117hr5376enr.pdf

[54] The White House. (2022). Inflation Reduction Act guidebook. Retrieved from https://www.whitehouse.gov/wp-content/uploads/2022/12/Inflation-Reduction-Act-Guidebook.pdf

[55] ibid.

[56] U.S. Environmental Protection Agency. (2023). Summary of Inflation Reduction Act provisions related to renewable energy. Retrieved June 11, 2024 from https://www.epa.gov/green-power-markets/summary-inflation-reduction-act-provisions-related-renewable-energy

[57] International Energy Agency (IEA). (2024). Renewables 2023 Analysis and forecast to 2028. IEA. Retrieved from https://iea.blob.core.windows.net/assets/96d66a8b-d502-476b-ba94-54ffda84cf72/Renewables_2023.pdf

agency.[58] The scope of the policy includes all ground-mounted solar, roof-mounted solar, floating solar, canal-mounted solar, wind, roof-mounted wind and wind-solar hybrid projects, with the exception of RE projects implemented for the supply of energy to green hydrogen and green ammonia production units, as they fall under a separate policy. The plan therefore centers on the development of wind-solar-hybrid (WSH) projects being classified into Type-A and Type-B, with the difference being that the former addresses the conversion of existing or under-construction stand-alone wind and solar projects into hybrids and the latter on the development of new WSH projects.[59] Furthermore, the policy also addresses the utilization of the 1,600 kilometers of coastal area for offshore wind energy development by taking the necessary steps to exploit the full potential of offshore wind energy, such as installing advanced wind turbines through prototype projects, tax exemptions and repowering of wind projects by upgrading turbines to avoid decommissioning and loss of connectivity.[60]

In conclusion, each of the aforementioned policies has contributed to establishing a stable groundwork for the global green transition, emphasizing the vital role that major economies play in promoting the adoption of renewable energy. Amidst these influential efforts, the European Union's renewable energy policy equally stands out as a leading approach to sustainable energy. The EU has always been at the forefront of establishing an energy framework that can serve as a benchmark for other nations, enhancing the relevance of collective and cohesive measures in setting the global agenda.

# II. EU Renewable Energy Trend

## A. The Evolution of the EU Renewable Energy Policy

The advancement of renewable energy policy in the European Union has been marked by several notable achievements, to the extent that for several years now, the EU has emerged on the world scene as one of the main promoters of the importance of renewable energy as part of a green transition towards a cleaner energy system.[61] This status is quite naturally the result of decades of developments in terms of energy regulations within the EU. Most notably, it was in 1997 that the first European step in regulating renewable energy sources was taken, with the "Energy for the Future: Renewable Sources of Energy" white paper, doubling the share of RES in the energy mix by setting an indicative target of 12% renewable energy by 2010.[62] Leading this initiative was primarily Germany, which had already introduced feed-in tariffs for the development of renewable

[58] Government of Gujarat, Energy and Petrochemicals Department. (2023). *G.R. No.REN/e-file/20/2023/0476/B1*. Sachivalaya, Gandhinagar. Retrieved from https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2023/10/20231011822018424.pdf

[59] Munot, A., Kaul, K., & Nagar, T. (2023). Regulatory update on Renewable Energy Policy 2023 issued by the State of Gujarat. JSA. Retrieved from https://www.jsalaw.com/newsletters-and-updates/regulatory-update-on-renewable-energy-policy-2023-issued-by-the-state-of-gujarat/

[60] ibid.

[61] European Commission. (n.d.). Renewable energy directive. Energy. Retrieved June 14, 2024, from https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-directive_en

[62]European Commission. (1997). Communication from the Commission: Energy for the future - renewable sources of energy: White Paper for a Community Strategy and Action Plan. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:51997DC0599&from=DE

energy sources in 1991.[63] Along the same lines, the establishment of Denmark's first large-scale offshore wind farm project in 2000 - prompted the EU to introduce, just one year later, the setting of national indicative targets to encourage member states to increase their renewable energy production in the 2001 Electricity Production Directive.[64] From then on, the EU started to broaden the scope of its intervention in renewables, setting national indicative targets for renewable transport fuels in the 2003 Directive,[65] ultimately leading to the introduction of the first EU Renewable Energy Directive (RED) in 2009. [66] More specifically, this legislation, which amended and repealed the previous Directives 2001/77/EC and 2003/30/EC, established a set of common rules regarding the use of renewable energy in the EU in order to limit GHG emissions and fulfill the Kyoto Protocol. Specifically, the RED set binding national targets for all EU countries to reach 20% of the EU's energy and 10% of the transport sector's specific energy (both expressed in gross final energy consumption) by 2020. This meant that each EU country drafted a national action plan for 2020, defining how to reach the national target for renewables in gross final energy consumption and the 10% target for renewables in transport. However, Member States were encouraged to set higher targets than planned and to involve local and regional authorities in their actions. In order to count on their action plans, a central aspect of achieving the renewable energy targets concerned the improvement of energy efficiency in all sectors.[67] Furthermore, due to the inclusion of support mechanisms for cross-border renewable energy production, EU countries were able to trade renewable energy with both EU and non-EU countries, provided the energy was consumed in the EU and produced by efficient plants. To achieve these ambitious goals, the directive set out a multifaceted approach that included the promotion of advanced technologies to increase energy efficiency in various sectors, thus reducing overall energy demand, as well as the investment in public transport to reduce dependence on fossil fuels, and, ultimately, the promotion of public consciousness and involvement incentivizing the achievement of higher targets and the involvement of local and regional authorities.[68]

Taking into consideration the clear need for further progress over the years, the 2009 RED was reviewed in 2018, with the aim of establishing more ambitious targets to accelerate the green transition and strengthen the EU's commitment to sustainable development. The Renewable Energy Directive (2018/2001/EU), commonly referred to as RED II, as a component of the Clean Energy for All Europeans project, was aimed at preserving the EU's status as a world leader in energy sustainability, as emphasized in the EU's entitled "K report" published the same year.[69] Naturally,

---

[63] International Energy Agency (IEA). (2013). Electricity Feed-In Law of 1991 ("Stromeinspeisungsgesetz"). IEA. Retrieved June 14, 2024, from https://www.iea.org/policies/3477-electricity-feed-in-law-of-1991-stromeinspeisungsgesetz

[64] European Union. (2001). Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market. Official Journal of the European Communities. Brussels. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32001L0077

[65] European Parliament and Council. (2003). Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport. Official Journal of the European Union. Brussels. Retrieved from https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:123:0042:0046:en:PDF

[66] European Union. (2009). Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources.Official Journal of the European Union. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028

[67] ibid.

[68] ibid.

[69] European Commission. (n.d.). Renewable energy directive. Energy. Retrieved June 14, 2024, from https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-directive_en

the legislation aimed to reinforce the commitment already made in RED I concerning the emission reduction of the Paris Agreement, as well as to solve the dependence on imported fossil fuels. Specifically, to achieve these goals, the policy set a new binding renewable energy target for the EU for 2030 of at least 32%, with a clause for a potential upward revision in 2023. This target was a continuation of the 20% target for 2020, which had been met and exceeded by 2%, and in fact, as with the first RED, member states were required to develop and implement their National Renewable Energy Action Plans (NREAPs) outlining how they intended to achieve their renewable energy targets. These plans were to include sector-specific targets and the measures to be used to achieve them.[70] Indeed, to fully maximize the impact of renewable energies in the economy, the directive introduced new measures for various parts of the economy, specifically the heating and cooling sector and the transport sector, as these were the fields in which progress was most delayed. In detail, the objectives were to increase the share of RES supplied for heating and cooling by an indicative 1.3% as an annual average for the periods 2021-2025 and 2026-2030, and for transport a share of RES supplied for final consumption of at least 14% by 2030. To this end, for heating and cooling systems the directive suggested measures for the promotion of renewable heating systems such as heat pumps, while for transport the RED II suggested the promotion of biofuels with strong sustainability criteria as well as the electrification of the transport industry; in detail, it included a target of 1% by 2025 and 5.5% by 2030 for advanced biofuels, biogas and renewable fuels of non-biological (RFNBO), such as Green Hydrogen.[71] Furthermore, in order to optimize the impact of the policy, some arrangements called for easing of the administrative procedures for renewable energy projects. These included shortening authorization times and creating one-stop-shop solutions to ease the bureaucratic burden on project developers. In addition, the directive included new provisions to enable citizens to play an active role in the deployment of renewable energy through the regulation of self-consumption of renewable energy for the first time, thereby allowing consumers to produce, consume, store and sell renewable energy free of any disproportionate constraints.[72]

To complement the new elements, RED II reinforced several principles already established in 2009, including the promotion of the EU's technological and industrial leadership in the global renewable energy market through support schemes that ensure effective, market-based financial measures, such as feed-in tariffs, feed-in premiums and green certificates. A further element that has been strengthened is cross-border cooperation between Member States and with third countries. In particular, in order to facilitate trade between states in renewable energy, the EU has included Guarantees of Origin (GO), namely certificates certifying the origin of energy generated from renewable sources. These can also be very useful for the promotion of renewable energy projects[73]. In conclusion, RED II also enhanced the framework for monitoring and reporting on progress towards renewable energy targets. Member States are now required to submit regular progress reports to the European Commission, which assesses compliance and provides recommendations. In

[70] Eurostat. (2022). At EU level, the share of energy from renewable sources. European Commission. Retrieved June 16, 2024, from https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220119-1#:~:text=At%20EU%20level,%20the%20share,of%20energy%20from%20renewable%20sources

[71] ibid.

[72] ibid.

[73] ibid

light of possible needed changes, the directive also provides mechanisms for adjusting targets and measures according to technological advances and market developments.[74]

Since the implementation of RED II, various events have influenced the evolution of EU energy policy, and particularly of its RE policy. The institution of the new European Commission, in 2019, has played pivotal roles in shaping and advancing the EU's approach to renewable energy and overall climate goals.Notably, this approach materialized with the presentation on 11, December 2019, of the European Green Deal, in which the Union renewed the Commission's commitment to addressing climate-related challenges by respecting the 2030 Agenda and the Sustainable Development Goals as well as achieving climate neutrality by 2050, in accordance with the Paris Agreement. Indeed, the European Green Deal was conceived as a new growth strategy aimed at converting the EU into a fair and prosperous society with a green, resource-efficient, and competitive economy in which growth is decoupled from resource use. The overarching goal is to use the EU's collective capacity to achieve a complete transition towards an economy that ensures sustainability and resilience for the future, building on the EU's strengths as a world leader in climate and environmental measures, consumer protection and labor rights.[75] Specifically, the Green Deal strategy focuses on increasing the EU's climate ambition for both 2030 and 2050, ensuring clean, affordable, and secure energy, predominantly from renewable energies, mobilizing industries towards a circular economy, and improving smart mobility systems. In addition, the program also promotes the introduction of two very ambitious initiatives: "Farm to Fork" for a fair, healthy and environmentally friendly food system and a plan for the conservation and restoration of ecosystems and biodiversity. All this demands massive public investment and increasing efforts to direct private capital towards climate- and environment-friendly interventions. Furthermore, it is crucial to recognize the need to maintain the competitiveness of European industry together with the need for intensive coordination to exploit available synergies in all policy areas. Ultimately, the EGD aims to ensure a fair and inclusive transition, securing equity for all regions and citizens, by supporting those who may be negatively affected in the short term. Therefore, in the Green Deal, the EU proposes a European Climate Pact, involving citizens, communities and stakeholders in climate action to promote collective responsibility while ensuring a balance in the efforts required.[76]

The measures to concretely realize the EGD climate targets were introduced in July 2021 in the "Fit for 55" package (FF55). The latter consists of 13 interacting proposals to revise eight existing EU climate and energy laws and 5 new legislative proposals to reduce GHG emissions by at least 55% by 2030.[77] To achieve this ambitious target, the chosen policy mix comprises pricing measures, targets and standards, particularly in the transport and energy sectors. In addition, it includes supportive measures to ensure the socially equitable transition established by the EGD. In fact, a key aspect of FF55 is the reinvestment of carbon pricing revenues to address the problems of

---

[74] ibid.

[75] European Commission. (2019). Communication from the Commission: The European Green Deal (COM(2019) 640 final). Official Journal of the European Union. Brussels.

[76] ibid.

[77] Council of the European Union. (n.d.). Fit for 55. Council of the European Union. Retrieved June 23, 2024, from https://www.consilium.europa.eu/it/policies/green-deal/fit-for-55/#what

mobility and fuel poverty introduced with the €72.2 billion Social Climate Fund allocated for the period 2025-2032 to support vulnerable households and businesses affected by the transition. Within this diverse policy mix, the great majority of the laws address energy-related GHG emissions. Specific measures on energy production and use include the proposal of a new regulation on energy-related methane emissions, the reform of the EU gas markets through a recast gas and hydrogen regulation and directive, and the revision of key EU energy legislation.[78] In particular, the most important revision is that of the EU European Emissions Trading Scheme (ETS), which aims at a substantial reduction in primary and final energy consumption through a carbon price increase and a 61% reduction in GHG emissions by 2030 for the sectors concerned. This includes the extension of emissions trading to the maritime and aviation sectors, while road transport and buildings will start in 2026. This revision is coupled with the revision of the Effort Sharing Regulation (ESR), which includes a new emissions reduction target of 40 percent by 2030 for sectors not covered by the ETS. Complementing these efforts, the proposed Carbon Boundary Adjustment Mechanism addresses the risk of carbon leakage, harnessing the effectiveness of carbon pricing and harnessing the economic power of companies and markets to bring structural change to our economy. However, the key revision this report focuses on is that of the Renewable Energy Directive, already scheduled for 2018. The main goal is to contribute to an overall 55% reduction in net emissions through a 42.5-45% share of EU-wide renewable energy sources by 2030.[79]

Yet, the final revision of the Renewable Energy Directive, presented in 2023, was not the result of the FF55 guidelines alone, as it was heavily influenced by the emergence of a new EU initiative, following Russia's invasion of Ukraine. In fact, as a response to the difficulties and disruptions in the global energy market caused by Putin's act, the European Commission initiated the REPowerEU program in May 2022 with the aim of phasing out Russian fossil fuel imports, thereby promoting the diversification of energy supplies through clean energy production. This required diversifying both gas suppliers by entering into agreements with other countries and the energy mix by incentivizing alternative energy sources, such as renewables, through massive investments.[80] More precisely, the REPower EU plan proposes an increase of the EU's 2030 target to 45% renewables in the EU mix, compared to the FF55 target of 40%, adding another 169 GW to the 1067 GW. To this end, the plan introduced a strategy to double solar PV capacity to 320 GW by 2025 and install 600 GW by 2030. This is basically based on the European Solar Roof Initiative, which is underpinned by a phased legal obligation to install solar panels on new public, commercial and residential buildings. In addition, the strategy envisages shorter and simplified authorization processes and “go-to” areas, specific regions selected for the intensive development of renewable energy projects on the basis of lower environmental risks and high potential.[81]A target was also set to produce and import 10 million metric tons of renewable hydrogen by 2030 by enhancing EU low-carbon

[78] KPMG. (2021). The European Green Deal and the "Fit for 55" package. KPMG. Retrieved from https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2021/11/green-deal-and-fit-for-55-slip-sheet_v5_web.pdf

[79] European Parliamentary Research Service. (2022). Fit for 55: The EU's plan for a green transition (EPRS_BRI(2022)733513). European Parliamentary Research Service. Retrieved June 23, 2024, from https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/733513/EPRS_BRI(2022)733513_EN.pdf

[80] ibid

[81] European Commission. (n.d.). REPowerEU: Affordable, secure and sustainable energy for Europe. European Commission. Retrieved June 24, 2024, from https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en

production capacities, thus decarbonizing the industry by accelerating the shift to electrification and renewable hydrogen.[82] This was already set in the Energy system integration and hydrogen strategies published in July 2020, together to achieve at least 6 GW of renewable hydrogen electrolyses and produce up to 1 million tonnes of renewable hydrogen in the EU by 2024.[83]

Drawing on the previous directives and the new approach to change defined in Fitforr55 and the EU REPower Plan, the planned revision of the Renewable Energy Directive was published in the Official Journal on November 2023, with the aim of ensuring further development and adoption of renewable energies to reach climate neutrality and security of energy supply.[84] Specifically, the RED III sets a new headline target of at least 42.5 percent by 2030, with an invitation for Member States to aim for 45 percent, effectively doubling the current share of renewable energy sources. Additionally, this revised directive provides a strengthened policy framework to facilitate electrification across all sectors, with new and increased sectoral targets for renewables. To support renewable uptake in the transport, heating and cooling sector, the new legislation adopted and materialized the concepts outlined in the energy system integration and hydrogen strategies published by the EC in 2020. These aimed at creating an energy-efficient, circular and renewable energy system that facilitates renewables-based electrification while promoting the use of renewable fuels, including hydrogen, in those sectors where electrification is not yet a feasible option, like the transport or industry sector. More in detail, for the industry sectors, the directive sets a binding target of 42% for renewable hydrogen (RFNBO) in total hydrogen consumption by 2030 and 60% by 2035, with an indicative target of an annual average increase of 1.6 percentage points in renewable sources. To achieve this objective, Member States should have the flexibility to reduce the target for the use of renewable fuels of non-biological origin, provided that they consume a limited share of hydrogen or its derivatives produced from fossil fuels. For what concerns the transport sector, the directive sets a 29% target for the share of renewable energy by 2030 and a 14.5% reduction of GHG emissions through greater use of advanced biofuels and RFNBO. However, an even a more ambitious target is established for the building sector, with an indicative target of 49% for the share of renewable energy by 2030, with heating and cooling targets to increase by 0.8 percentage points per year until 2025 and by 1.1 percentage points from 2026 to 2030. Furthermore, the directive also regulates the area of research and innovation, with an indicative target of 5% of newly installed renewable energy capacity from innovative technologies by 2030. As for all the other directives, in relation to these targets, member states are now in the process of redesigning their NREAPs, wherein they assess their contribution to the new EU target and set new individual goals when necessary.[85] Furthermore, in RED III, the bioenergy management

[82] International Energy Agency (IEA). (2024). REPowerEU plan: Joint European action on renewable energy and energy efficiency. IEA. Retrieved June 24, 2024, from https://www.iea.org/policies/15691-repowereu-plan-joint-european-action-on-renewable-energy-and-energy-efficiency

[83] European Parliament. (2024). Renewable energy. Fact Sheets on the European Union - RENEWABLE ENERGY. Retrieved June 25, 2024, from https://www.europarl.europa.eu/factsheets/en/sheet/70/renewable-energy

[84] ibid.

[85] However, according to Politico, only four of the EU's 27 governments - the Netherlands, Denmark, Finland and Sweden - met the 30 June 2024 deadline to submit their PNECs, while a fifth, Italy, filed its plan one day late on Monday. By dragging their feet on a plan needed to turn the EU's climate ambitions into reality, governments are undermining efforts to eliminate the bloc's contributions to global warming. This is the second consecutive year of delay, as most EU countries were already late last year. These continued delays are putting the EU's Green Deal at risk, as falling behind national targets also means failing to meet international commitments.

strategy has gained greater importance as, while the Union's renewable energy policy aims to address climate change, in pursuing this goal, it is essential to also contribute to broader environmental goals such as preventing biodiversity loss, on which indirect land-use change associated with the production of certain biofuels, bioliquids and biomass fuels has a negative impact. Therefore, to prevent this kind of unfolding, the directive establishes a review by the Commission of the level of the maximum share of the average annual expansion of the global production area in high-carbon stocks, based on objective and scientific sustainability criteria, actually strengthened by the revised directive.[86] Pursuing on the administrative measures front, as the electricity purchase agreement market from renewable energy sources is currently restricted to a handful of Member States and large companies, and given considerable administrative, technical and financial barriers, existing measures in Article 15 of the 2018 Directive to encourage the adoption of agreements mentioned above have been further strengthened by including the use of credit guarantees to reduce the financial risks of such agreements, considering that such collateral, if public, should not exclude private financing. In addition, the new directive aims to combat the administrative bottleneck that hinders the deployment of renewable energy on the ground. In particular, the directive simplifies and speeds up authorization procedures for both new renewable energy projects and necessary infrastructure projects by declaring them to be of overriding public interest, except in cases where clear evidence exists showing such projects will have serious adverse effects on the environment. The directive also sets a maximum time limit of 12 months for the approval of new installations in priority areas for renewable energy, the so-called "renewable energy fast-track areas".[87] Finally, this directive emphasizes the improvement of cooperation between Member States to promote renewable energies. Robust cooperation, whether in the form of statistical transfers, support measures or joint projects, enables a cost-effective deployment of renewable energy throughout Europe and contributes to market integration. Despite its potential, this has so far been very limited, which is why this directive sets the obligation to establish a cooperation framework for joint projects by 2025 and to establish at least two joint projects by 2030, with an exception for a third project for Member States whose annual electricity consumption exceeds 100 TWh.[88]

Overall, the EU's historic dedication to the inclusion of renewable energies, reflected in numerous pioneering directives, has paved the way for the EU's energy mix to increasingly embrace them, charting a progressive course for the future.

### B. EU Energy Mix

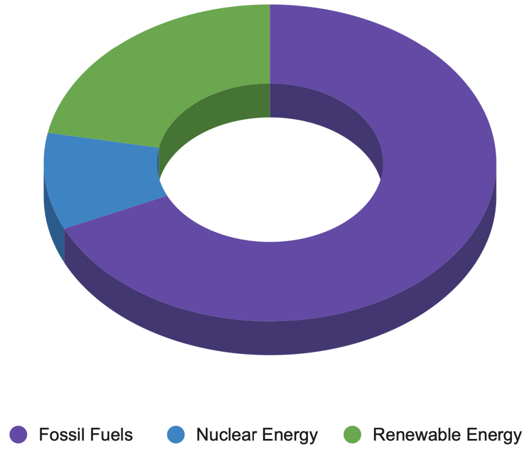
To discern the impact of the numerous European policies on the current EU energy mix, it is valuable to examine the primary energy consumption by source, just as we previously analyzed at the global level. Indeed, one of the priorities of the Union's energy strategy is to increase energy

[86] European Parliament and Council. (2023). Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652. Official Journal of the European Union. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302413.

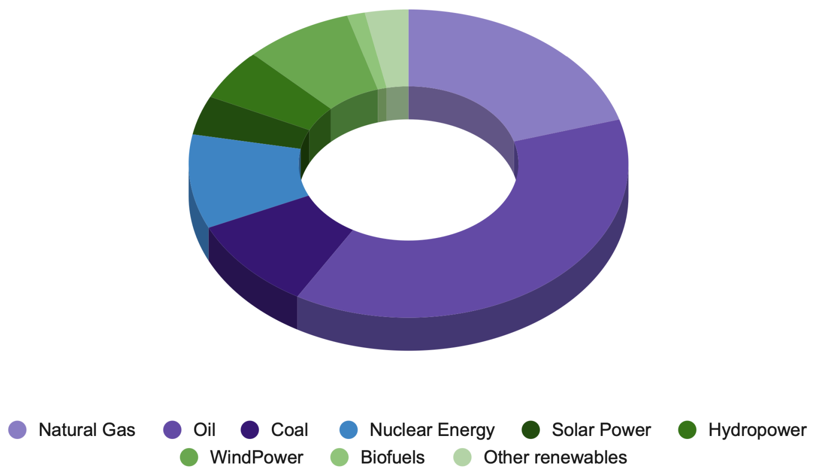
[87] ibid.

[88] ibid.

efficiency, as this contributes to ensuring energy savings, mitigating climate change and reducing the EU's dependence on external energy suppliers. In concrete terms, in order to have a more efficient energy system and thus consume far less energy, it is necessary to reduce primary energy consumption.[89] According to the Energy Institute Statistical Review of World Energy 2023, the primary energy consumption in the European Union for the year 2023 is 15,661.94 TWh. In particular, fossil fuels remained the dominant source with 10,674.94 TWh, or 68.16% of the total, with natural gas accounting for 20.40% (3,194.59 TWh), oil 38.04% (5,957.18 TWh), and coal 9.73% (1,523.17 TWh). Nuclear energy accounted for 9.86% with 1,544.09 TWh, and renewable sources accounted for 21.98% of primary energy consumption, of which 5.40% (845.98 TWh) from hydropower, 7.97% (1,248.10 TWh) from wind energy, 4.10% (642.09 TWh) from solar energy, 3.20% (501.15 TWh) from other renewable sources such as geothermal and biomass, and 1.31% (205.69 TWh) from biofuels.[90]




**EU Energy Mix 2023**




**EU Energy Mix 2023**

[89] European Commission. (2024). Shedding light on energy in Europe - 2024 edition. Eurostat. Retrieved June 28, 2024, from https://ec.europa.eu/eurostat/web/products-eurostat-news/w/wdn-20240314-1

[90] Ritchie, H., & Rosado, P. (2024). Energy mix: Explore data on where our electricity comes from and how this is changing. Our World in Data. Retrieved June 28, 2024, from https://ourworldindata.org/energy-mix

Furthermore, when assessing the EU's energy mix, it is fundamental to consider the Union's reliance on imported energy from third countries for its own consumption. In 2022, the main category of imported energy products were oil and petroleum products, representing 63% of the EU's energy imports, followed by natural gas (26%) and solid fossil fuels (7%). Notably, Russia was the EU's main supplier until 2022, with 21% of imports, followed by the US (11%) and Norway (10%).[91] However, after the sanctions imposed by the EU following Russia's war of aggression against Ukraine and following the implementation of the REPower EU plan in 2022, in 2023 the value of imported energy products decreased by 35.0%, while the volume decreased by 9.4%. As a result, suppliers shifted as well, with the majority of EU oil imports in Q4 2023 coming from the United States (17.0%), followed by Norway (13.1%) and Kazakhstan (9.2%), and more than half of the gaseous natural gas coming from Norway (53.4%), followed by Algeria (15.9%9.[92] Driven by the imperative to reduce dependence on Russian fossil fuels, the EU has increased its efforts towards renewable energy, as evidenced by the 45% target set in the REPower EU plan. As a result, the EU has witnessed a steady growth in the share of renewable energy in energy consumption, from 9.6% in 2004 to 16.7% in 2013, up to 23.0% in 2023.[93] This growth, especially from a level of 21.9% in 2021, was largely driven by the rise of solar power, although it was also amplified by a reduction in non-renewable energy consumption. Non-renewable energy experienced a drop of 2.9%, linked to higher gas prices and the decrease in nuclear energy. However, although the total RES share of 23% represents a historical peak, the growth rate of renewables has slowed down since 2020. Based on this, it can therefore be said that the policies implemented are having the right effect, but it is clear that they need to be even stronger to reach the ambitious target the EU has set itself.[94]

Nevertheless, it remains renewable energy's highest penetration in 2022 in the electricity sector, with 41.2% of all electricity generated from renewable sources, followed by the heating and cooling sector (24.9%) and transport (9.6%).[95] Indeed, this growth, together with a record drop in coal and gas in 2023, left the EU with the cleanest electricity mix on record. According to the Ember Energy Institute and the Statistical Review of World Energy (2024), in the EU electricity mix in 2023, renewable sources were able to account for 1079.90 TW, namely 38.87%, with wind at 15.12% (419.95 TWh), solar at 7.59% (210.75 TWh), bioenergy at 5.94% (165.03 TWh), hydropower 9.94% (276.24 TWh) and other renewable at 0.25% (6.93 TWh). Nuclear power maintained a stable share as the EU's single largest source of electricity with 21.93% for 609.26 TWh. While, fossil fuels, as a whole, remained dominant, at 39.20% (1088.87 TWh) with oil accounting for 3.79% (105.38 TWh), gas for 19.25% (534.72 TWh), and coal for 16.16% (448.77 TWh).[96]

---

[91] ibid

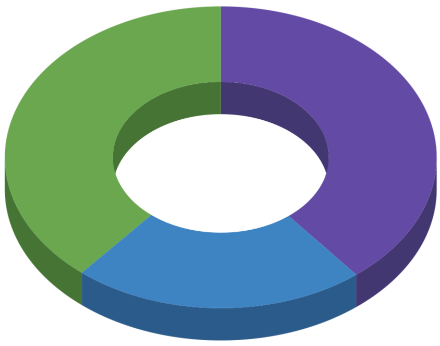
[92] European Commission. (2024). Shedding light on energy in Europe - 2024 edition. Eurostat. Retrieved June 28, 2024, from https://ec.europa.eu/eurostat/web/products-eurostat-news/w/wdn-20240314-1

[93] Ritchie, H., & Rosado, P. (2024). Electricity mix: Explore data on where our electricity comes from and how this is changing. Our World in Data. Retrieved June 28, 2024, from https://ourworldindata.org/electricity-mix

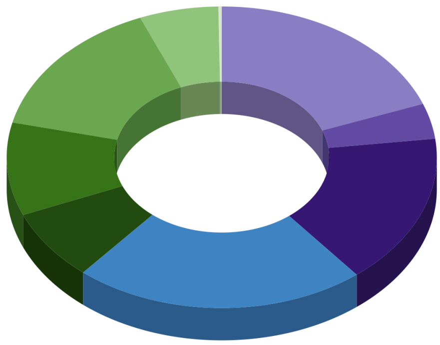
[94] European Commission. (2024). Shedding light on energy in Europe - 2024 edition. Eurostat. Retrieved June 28, 2024, from https://ec.europa.eu/eurostat/web/products-eurostat-news/w/wdn-20240314-1

[95] ibid.

[96] Ritchie, H., & Rosado, P. (2024). Electricity mix: Explore data on where our electricity comes from and how this is changing. Our World in Data. Retrieved June 28, 2024, from https://ourworldindata.org/electricity-mix




**EU Electricity Mix**




**EU Electricity Mix**

In 2023, clean generation reached more than two-thirds of EU electricity, with 24 percent of the hours with less than a quarter of electricity coming from fossil fuels, a major step up from 4 percent of the hours in 2022. In addition, falling electricity demand has also contributed to the decline in fossil fuel generation. However, this trajectory is unlikely to continue as electrification increases in the future. For this reason, in order to continue to reduce fossil fuels at the rate needed to meet the EU's climate targets, renewable energies will have to keep pace with increasing demand. In fact, although the share of renewable electricity has climbed by 14 percentage points in the past seven years, this rate will need to almost double in the next seven to reach the target proposed by REPower EU and the revised directive. As a matter of fact, the growth in renewables since 2017 has been due to the increase in wind and solar generation, while bioenergy has stagnated and hydropower has declined over the same period. Therefore, it is evident that the EU will have to focus on improving the less-performing renewables, while at the same time aiming to strengthen the two leading ones.[97] In 2023, wind generation grew by 13% and solar generation by 36% compared to 2022; however, in both cases, several concerns about possible future trajectories are emerging. For wind power, the erratic growth over the past decade is worrying, as several developments have historically negatively affected wind energy deployment. Among these, the most frequently reported

[97] European Commission. (2024). Shedding light on energy in Europe - 2024 edition. Eurostat. Retrieved June 28, 2024, from https://ec.europa.eu/eurostat/web/products-eurostat-news/w/wdn-20240314-1

is the long authorization times, which  in almost all EU countries often exceeding four years for onshore wind and twice as long for offshore wind. In addition, rising costs along the supply chain and technical problems with some wind turbines are also a cause for concern.  Furthermore, at present, even a wind power production growth rate of 13% is not sufficient to reach the REPowerEU targets, which instead would require an annual increase of at least 15% until 2030. Similarly, some concerns about solar deployment have emerged, mainly due to the figure of a 25% decrease in solar growth by 2023. These apprehensions then materialize in the difficulties of curtailment, panel stockpiling, and grid connection queues.[98]

In any case, the growth of solar and wind power, despite some limitations, is what is driving the rise of renewable energy in the EU. Of course, this is the result of a collective effort, as the trends among EU countries are very different. As far as wind energy is concerned, Denmark is strengthening its leading position, producing 58% of the country's electricity from wind. Overall, 21 countries have attained the highest-ever share of wind power in the electricity mix in 2023, with the largest year-on-year percentage increases recorded in Lithuania, the Netherlands, Germany, and Belgium. As for solar, the list of leaders changed significantly with Greece emerging as the new champion, generating 19% of electricity from solar, followed by Hungary (18%) and Spain (17%). Altogether, 24 countries have achieved a record share of solar energy in their power mix by 2023, with Latvia, Slovakia, and Slovenia being the only exceptions. In the end, in order for the EU to continue this growth in the future, it must first of all increase its efforts in terms of policy implementation as well as address issues that could limit this growth, such as the issue of raw materials. The EU's clean energy goals rely heavily on imported raw materials. In 2022, only about 10% of the solar PV modules added in the EU were made locally. By 2030, this could increase to just over 20%, assuming all planned projects are completed on time. Imports will remain essential due to cost and global manufacturing capacity, with China expected to maintain a strong role in wind and solar PV manufacturing.[99]

Therefore, while the EU's ambitions for renewable energy are admirable and the path to achieving them is heading in the right direction, their achievement requires a well-balanced approach that embraces both the increase of local production by mitigating recent difficulties and the assurance of reliable international supply chains that do not create new dependencies on suppliers.

### C. Future Pathways for Advancing RE Energy Sector

To mitigate the challenges that could threaten the future development of renewable energies while containing dependence on external forces, innovation in the sector is becoming increasingly crucial. More generally, innovation in clean energy technologies, and consequently in renewable energy technologies, must evolve to achieve the NZE scenario, since while the majority of the CO2 emission reductions needed by 2030 can be achieved with existing technologies, the attainment of the 2050 target hinges on technologies not yet available for large-scale adoption.[100] In fact, IRENA

[98] ibid.

[99] ibid.

[100] International Energy Agency (IEA). (2023). *Tracking clean energy progress 2023*. IEA. Retrieved June 30, 2024, from https://www.iea.org/reports/tracking-clean-energy-progress-2023

itself closely monitors the development of energy technologies to develop a more thorough understanding of RE opportunities and consequently disseminate them widely in the industry. Indeed, a sustainable energy system is only feasible by fully exploiting the finest innovations in energy products and services across all sectors. In particular, IRENA has created an interactive online data platform International Standards and Patents in Renewable Energy (INSPIRE), which provides insights into international standards and patents related to renewable energy technologies. This is effectively an open-access web tool developed to track innovation trends, leading countries and technology organizations through data analysis on standards and patents. Overall, INSPIRE enables assessment of whether stringent environmental targets have advanced the deployment of these technologies and related market opportunities, while offering valuable benchmark metrics that can ultimately be turned into valuable information for policymakers, entrepreneurs, and other key players in the energy sector. Overseeing the development of renewable energy technologies is a crucial part of determining the appropriate choices for the future of the sector, as a heightened understanding of the technological progress may allow for the modification of existing targets by enabling countries to assess their international competitiveness in the renewable energy sector.[101] In particular, IRENA stresses the importance of a specific type of innovation, namely systemic innovation. The latter refers to the development of innovative solutions that combine and maximize synergies between different innovations in different components of the energy system. To successfully enable the transformation of the energy sector and ultimately the energy transition, innovation is needed in market design, system operation and business models. In other words, the priority is to have the necessary technology in place, to adopt a defined regulatory framework to send the right signals to market actors, and to consider innovation at the system design stage, allowing innovative business models to capture the value of smart electrification strategies. Systemic innovation allows for a high level of flexibility of the electricity system to integrate a high share of variable renewable generation while also enabling smart electrification of end-use sectors such as mobility and heating and cooling.[102] Encouragingly, according to the IEA's Technology Assignment on the renewable energy sector, despite the global energy and macroeconomic crises, the Russian invasion of Ukraine and the long tail of the Covid-19 pandemic, technology readiness in the core sectors has advanced over the past year due to increased innovation spending in public and corporate R&D budgets and venture capital investment in clean energy. In addition, major policy initiatives such as the Inflation Reduction Act in the US and the Chinese 14th Five-Year Plan will contribute to these steps, as they aim to significantly accelerate innovation and improve the competitiveness of pre-commercial technologies. However, the right balance must be maintained, as a disproportionate focus on individual national policies would risk creating barriers to knowledge sharing.[103]

---

[101] International Renewable Energy Agency (IEA). (n.d.). *Innovation indicators*. IEA. Retrieved June 30, 2024, from https://www.irena.org/Energy-Transition/Innovation/Innovation-indicators

[102] International Renewable Energy Agency (IRENA). (n.d.). *Systemic innovation*. IRENARetrieved June 30, 2024, from https://www.irena.org/Energy-Transition/Innovation/Systemic-Innovation

[103] International Energy Agency (IEA). (2023). *Tracking clean energy progress 2023*. IEA. Retrieved June 30, 2024, from https://www.iea.org/reports/tracking-clean-energy-progress-2023

Given the scope for innovation on so many fronts, this report has chosen to focus on two main technologies that are frequently mentioned and that are interlinked, namely floating offshore wind and renewable hydrogen, also known as green hydrogen. As far as the first technological innovation is concerned, floating offshore wind is based on free-floating structures rather than stationary ones. In essence, these type of technology opens the door to sites further offshore by allowing wind turbines to be deployed in larger and deeper offshore areas with higher wind potential, as 80% of the world's offshore wind resource potential lies in waters deeper than 60m, meaning that as we continue our efforts to decarbonise, we must look to these deeper waters for opportunities. For many countries, their potential for fixed offshore wind is limited, so if true global growth in this technology is to be achieved, those countries whose best option is floating need to be supported. As a matter of fact, while most of the growth in the 2020s will be in land-based offshore wind, from 2030 it is expected to observe a rapid acceleration in the deployment of floating offshore wind. The IEA's forecast is for an increase in the share of offshore wind in total wind power generation from 7% in 2020 to more than 20% from 2021 onwards. Indeed, despite the first the installation of the first MW-scale floating turbines was in 2000 and the first commercial project, Hywind Scotlan, became operational in the UK in 2017, it is the combined technological developments with cost reductions, that is now convincing countries and companies to scale up and include floating offshore wind in their planning. Much larger projects of up to 90 MW are under construction, with floating parks of several hundred MW announced for 2025-2026, and several countries are setting more ambitious targets, such as the US (15 GW by 2035) and the UK (5 GW by 2035).[104] However, the impact of floating turbines goes beyond power generation. When integrated with hydrogen production, these wind farms can provide a powerful hydrogen ecosystem. As a clean energy source, hydrogen has immense potential, because unlike fossil fuels, it produces only water vapor when burned, making it a sustainable solution across multiple sectors. It can be used to provide electricity and renewable heat, to power long-distance transport, shipping and aviation, and to decarbonise various industrial processes. In particular, hydrogen production from deep offshore wind energy is a promising solution to deliver affordable electrolytic hydrogen on a large scale, as the majority of the energy produced by dedicated electrolytic wind farms can be used to produce economic hydrogen. More specifically, according to the latest studies, the key to unlocking the full potential of hydrogen production from floating wind farms lies in Solid Oxide Electrolyzers (SOECs), arguably the most efficient technology among electrolyser designs, as they require less power. Furthermore, these SOECs require less critical material and can operate at lower temperatures and r, making them ideal for integration with waste heat from industrial processes. Hence, with the challenge of decarbonization across various sectors, the combination of floating wind and SOEC technology offers a promising answer.[105]

Ultimately, only by developing advanced technologies such as floating wind turbines and solid oxide electrolytic cells (SOECs), it is possible to build an efficient and sustainable energy ecosystem capable of significantly reducing carbon emissions and promoting a green and safe energy future.

---

[104] Global Wind Energy Council. (2022). *Floating offshore wind – A global opportunity*. Global Wind Energy Council. Retrieved June 30, 2024, from https://gwec.net/wp-content/uploads/2022/03/GWEC-Report-Floating-Offshore-Wind-A-Global-Opportunity.pdf

[105] International Energy Agency (IEA). (2023). *Tracking clean energy progress 2023*. IEA. Retrieved June 30, 2024, from https://www.iea.org/reports/tracking-clean-energy-progress-2023

## Conclusion

In conclusion, this report confirms  that the global energy landscape is at a crucial juncture, driven by the urgent need to tackle climate change, ensure energy security, and promote economic stability amidst shifting geopolitical dynamics. The call to move away from fossil fuels and towards greener energy sources has never been more urgent. As a result, the main alternatives to fossil fuels, among which renewables stand out, are at the center of many global initiatives. An examination of the evolution of global renewable energy policies, and even more so, a focused analysis of the European Union's policies, undoubtedly reveals a transformative impact of policy frameworks in driving renewable energy deployment, characterized by particularly positive results in solar and wind energy. In particular, in this scenario, the European Union has shown strong leadership, from the Renewable Energy Directive to its recent revisions, in setting ambitious targets and promoting innovation in the energy sector. These efforts are not only reshaping the energy mix, but also positioning Europe as a beacon for sustainable development and climate action. Ultimately, the aim of this report is to illustrate the evolution of renewable energy policy at the global and European levels by highlighting the progress made by our society in terms of major initiatives and achievements towards a more sustainable society. At the same time, it seeks to recognize the need for further developments in relation to the challenges that have emerged in this geopolitical context and, consequently, the need for further innovative and improved investment programs in the field of renewable energy. With a continued focus on innovation and international cooperation, the global transition to a sustainable, renewable-based future can be accelerated, ensuring a resilient and equitable global energy system for generations to come.

# Bibliography

Sustainable Energy for All. (2013). Global tracking framework: Chapter 4: Renewable Energy. Sustainable Energy for All. Retrieved from https://www.seforall.org/sites/default/files/l/2013/09/9-gtf_ch4.pdf

International Energy Agency (IEA). (2002). Renewables Information 2002. Paris: OECD Publishing. Retrieved from https://doi.org/10.1787/9789264099531-en

International Renewable Energy Agency (IRENA). (2009). Statute of the International Renewable Energy Agency. IRENA. Retrieved from https://www.irena.org/-/media/Irena/Files/Official-documents/IRENA-Statute/IRENAstatuteenIRENAFCStatutesignedinBonn26012009incldeclarationonfurtherauthenticversions.pdf?rev=d619033053354d20884bde3aef72224f

United Nations. (n.d.). What is renewable energy?. UN Climate Action. Retrieved May 31, 2024 from https://www.un.org/en/climatechange/what-renewable-energy

International Energy Agency (IEA). (2023). Bioenergy. IEA. Retrieved from June 1, 2024 https://www.iea.org/energy-system/renewables/bioenergy

International Renewable Energy Agency (IRENA). (n.d.). Ocean energy. IRENA. Retrieved June 1, 2024 from https://www.irena.org/Energy-Transition/Technology/Ocean-energy

World Energy Council. (2013). World Energy Resources: Bioenergy. World Energy Council. Retrieved June 1, 2024 from https://www.worldenergy.org/assets/images/imported/2013/10/WER_2013_7_Bioenergy.pdf

World Energy Council. (2013). World Energy Resources: Hydro.World Energy Council. Retrieved from https://www.worldenergy.org/assets/images/imported/2013/09/Complete_WER_2013_Survey.pdf

International Energy Agency (IEA). (n.d.). Renewables. IEA.Retrieved June 2, 2024 from https://www.iea.org/energy-system/renewables

International Energy Agency (IEA). (2024). Renewables 2023 Analysis and forecast to 2028. IEA. Retrieved from https://iea.blob.core.windows.net/assets/96d66a8b-d502-476b-ba94-54ffda84cf72/Renewables_2023.pdf

Ritchie, H., & Rosado, P. (2024). Energy Mix.Explore global data on where our energy comes from, and how this is changing. Our World in Data. Retrieved June, 2 2024 from https://ourworldindata.org/energy-mix

Energy Institute. (2023). Statistical Review of World Energy. Energy Institute. Retrieved from https://www.energyinst.org/statistical-review

Ember. (2024). Global Electricity Review 2024. Retrieved from https://ember-climate.org/app/uploads/2024/05/Report-Global-Electricity-Review-2024.pdf

Ritchie, H., & Rosado, P. (2024). Electricity mix: Explore data on where our electricity comes from and how this is changing. Our World in Data. Retrieved June 28, 2024, from https://ourworldindata.org/electricity-mix

Gunnarsdottir, I. A., et al. (2021). Sustainable Energy Development: History of the Concept and Emerging Themes. Environment and Natural Resources, University of Iceland.

United Nations. (1987). Report of the World Commission on Environment and Development. Our common future. Retrieved from https://gat04-live-1517c8a4486c41609369c68f30c8-aa81074.divio-media.org/filer_public/6f/85/6f854236-56ab-4b42-810f-606d215c0499/cd_9127_extract_from_our_common_future_brundtland_report_1987_foreword_chpt_2.pdf

United Nations. (1992). Agenda 21. Retrieved from https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf

Climate Change Secretariat. (2002). A Guide to the Climate Change Convention and Its Kyoto Protocol. Retrieved from https://unfccc.int/sites/default/files/guideconvkp-p.pdf
International Energy Agency. (IEA). (2006). IEA Energy Technology Perspectives 2006. IEA. Retrieved from https://iea.blob.core.windows.net/assets/04d79827-c301-42aa-ac60-a39c7bf25900/etp2006.pdf

United Nations Development Programme. (n.d.). UN Energy. UN. Retrieved June 2, 2024 from https://www.undp.org/energy/change-network/un-energy

International Renewable Energy Agency (IRENA). (n.d.). Creation of IRENA. IRENA. Retrieved June 2, 2024 from https://www.irena.org/About/History/Creation-of-IRENA

Sustainable Energy for All Africa Hub. (n.d.). The SEforALL Initiative. Retrieved June 2, 2024 from https://www.se4all-africa.org/fr/the-africa-hub/who-we-are/the-seforall-initiative/

United Nations Framework Convention on Climate Change. (2016.). Paris Agreement. Retrieved from https://unfccc.int/sites/default/files/resource/parisagreement_publication.pdf

Mission Innovation. (n.d.). Catalysing clean energy solutions for all. Retrieved June 10, 2024, from https://mission-innovation.net/

European Commission. (n.d.). International cooperation in clean energy. Directorate-General for Research and Innovation. Retrieved June 10, 2024, from https://research-and-innovation.ec.europa.eu/research-area/energy/international-cooperation-clean-energy_en

COP28. (2023). Global renewables and energy efficiency pledge. COP28. Retrieved from https://www.cop28.com/en/global-renewables-and-energy-efficiency-pledge

Helveston, J. P., & Nahm, J. (2022). Guide to Chinese climate policy 2022. Oxford Institute for Energy Studies. Retrieved from https://chineseclimatepolicy.oxfordenergy.org/wp-content/uploads/2022/11/Guide-to-Chinese-Climate-Policy-2022.pdf

Climate Cooperation. (2022). China released its 14th Five-Year Plan for renewable energy with quantitative targets for 2025. Retrieved from https://climatecooperation.cn/climate/china-released-its-14th-five-year-plan-for-renewable-energy-with-quantitative-targets-for-2025/

U.S. Congress. (2022). H.R. 5376 - Inflation Reduction Act of 2022. US Congress. Retrieved from https://www.congress.gov/117/bills/hr5376/BILLS-117hr5376enr.pdf

The White House. (2022). Inflation Reduction Act guidebook. Retrieved from https://www.whitehouse.gov/wp-content/uploads/2022/12/Inflation-Reduction-Act-Guidebook.pdf

U.S. Environmental Protection Agency. (2023). Summary of Inflation Reduction Act provisions related to renewable energy. Retrieved June 11, 2024 from https://www.epa.gov/green-power-markets/summary-inflation-reduction-act-provisions-related-renewable-energy

Government of Gujarat, Energy and Petrochemicals Department. (2023). G.R. No.REN/e-file/20/2023/0476/B1. Sachivalaya, Gandhinagar. Retrieved from https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2023/10/20231011822018424.pdf

Munot, A., Kaul, K., & Nagar, T. (2023). Regulatory update on Renewable Energy Policy 2023 issued by the State of Gujarat. JSA. Retrieved from https://www.jsalaw.com/newsletters-and-updates/regulatory-update-on-renewable-energy-policy-2023-issued-by-the-state-of-gujarat/

European Commission. (n.d.). Renewable energy directive. Energy. Retrieved June 14, 2024, from https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-directive_en

European Commission. (1997). Communication from the Commission: Energy for the future - renewable sources of energy: White Paper for a Community Strategy and Action Plan. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:51997DC0599&from=DE
International Energy Agency (IEA). (2013). Electricity Feed-In Law of 1991 ("Stromeinspeisungsgesetz"). IEA. Retrieved June 14, 2024, from https://www.iea.org/policies/3477-electricity-feed-in-law-of-1991-stromeinspeisungsgesetz

European Union. (2001). Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market. Official Journal of the European Communities. Brussels. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32001L0077

European Parliament and Council. (2003). Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport. Official Journal of the European Union. Brussels. Retrieved from https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:123:0042:0046:en:PDF

European Union. (2009). Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources.Official Journal of the European Union. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028

Eurostat. (2022). At EU level, the share of energy from renewable sources. European Commission. Retrieved June 16, 2024, from https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220119-1#:~:text=At%20EU%20level,%20the%20share,of%20energy%20from%20renewable%20sources

European Commission. (2019). Communication from the Commission: The European Green Deal (COM(2019) 640 final). Official Journal of the European Union. Brussels.

Council of the European Union. (n.d.). Fit for 55. Council of the European Union. Retrieved June 23, 2024, from https://www.consilium.europa.eu/it/policies/green-deal/fit-for-55/#what

KPMG. (2021). The European Green Deal and the "Fit for 55" package. KPMG. Retrieved from https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2021/11/green-deal-and-fit-for-55-slip-sheet_v5_web.pdf

European Parliamentary Research Service. (2022). Fit for 55: The EU's plan for a green transition (EPRS_BRI(2022)733513). European Parliamentary Research Service. Retrieved June 23, 2024, from https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/733513/EPRS_BRI(2022)733513_EN.pdf

European Commission. (n.d.). REPowerEU: Affordable, secure and sustainable energy for Europe. European Commission. Retrieved June 24, 2024, from https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en

International Energy Agency (IEA). (2024). REPowerEU plan: Joint European action on renewable energy and energy efficiency. IEA. Retrieved June 24, 2024, from https://www.iea.org/policies/15691-repowereu-plan-joint-european-action-on-renewable-energy-and-energy-efficiency

European Parliament. (2024). Renewable energy. Fact Sheets on the European Union - RENEWABLE ENERGY. Retrieved June 25, 2024, from https://www.europarl.europa.eu/factsheets/en/sheet/70/renewable-energy

European Parliament and Council. (2023). Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652. Official Journal of the European Union. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302413

European Commission. (2024). Shedding light on energy in Europe - 2024 edition. Eurostat. Retrieved June 28, 2024, from https://ec.europa.eu/eurostat/web/products-eurostat-news/w/wdn-20240314-1

International Energy Agency (IEA). (2023). Tracking clean energy progress 2023. IEA. Retrieved June 30, 2024, from https://www.iea.org/reports/tracking-clean-energy-progress-2023

International Renewable Energy Agency (IEA). (n.d.). Innovation indicators. IEA. Retrieved June 30, 2024, from https://www.irena.org/Energy-Transition/Innovation/Innovation-indicators

International Renewable Energy Agency (IRENA). (n.d.). Systemic innovation. IRENARetrieved June 30, 2024, from https://www.irena.org/Energy-Transition/Innovation/Systemic-Innovation

Global Wind Energy Council. (2022). Floating offshore wind – A global opportunity. Global Wind Energy Council. Retrieved June 30, 2024, from https://gwec.net/wp-content/uploads/2022/03/GWEC-Report-Floating-Offshore-Wind-A-Global-Opportunity.pdf

**Written by Mara Felice**

The words expressed in this publication are the sole responsibility of the author.

PARIS ADVANCED RESEARCH CENTER