

The EU Clean Energy Policy under the European Green Deal and COVID-19 pandemics – how the renewables historically won the majority share in the EU's electrical energy mix

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Abstract

The paper presents a regional case study of the European Union's clean energy policy impact on the European electricity market transformation reaching a tremendous milestone for the EU as confirmed by the European Commission's Directorate-General for Energy (ENER) on 9th April 2021 – the renewable energy sources for the first time in the history overcoming the combined fossil fuels in electrical energy generation mix of the year 2020. This achievement, although influenced by exceptional circumstances of the COVID-19 pandemics and the electricity demand shock, is primarily an effect of the Clean Energy for all Europeans Package implementing the European Green Deal strategy designed to position the EU as a global leader in the green transformation, leading by example and turning climate challenges into a growth opportunity, as such presenting optimistic policy perspective for a global transformation towards a 100% renewable energy world, thus mitigating dire threats of the global warming by drastically cutting greenhouse gases emissions.

Keywords: European Green Deal, EU energy policy, renewable energy sources in electricity generation

1. Climate change drivers for the European clean energy transformation

In view of the scientific consensus for the global warming and induced climate change with dynamic weather patterns influence, confirmed among others by the scientific evidence based Paris Agreement's declarations of 2015, it becomes clear that the longer no action is taken, the more difficult and more expensive it becomes to reach the emission and climate goals at estimated temperature targets to counter this serious situation.

It has been concluded by multiple analyses that without an action taken on the climate change, the EU will experience, during the lifetime of our children, unbearable social and economic costs. Europe notes ca. 400 thousand premature deaths per year today due to air pollution (cf. Air quality in Europe by the European Environment Agency, 2019). In regard to weather patterns dynamic shifts the impact is also overreaching with multiple induced natural disastrous events including unprecedented heatwaves, fires, droughts and floods. In Europe alone in the recent few years there have been noted ca. 90 thousand annual deaths as a result of heatwaves (cf. European Commission's Joint Research Centre PESETA IV). About 16% of species were assessed at risk of extinction at 4.3°C temperature increase (as estimated by Missirian and Schlenker in 2017). According to the same authors there is already 40% less available water in southern regions of the European Union, while on the other hand as much as 0.5 million of people in Europe are now exposed to river flooding each year and as much as circa 2.2 million people are exposed to coastal inundation each year.

In regards to the climate change induced by the global warming, carbon dioxide levels are predicted to double by the year of 2030 with Europe's temperature expected to increase by 2-3 °C in the summer season (cf. European Environment Agency - Problems - April 2016). Accordingly to the same study Europe is responsible for nearly one third of the world's gas emissions that deplete the ozone. More than 50% of all surface area where ecosystems are in Europe are presented with threats from climate change induced management problems and stresses. On average, 700 thousand hectares of woodland are burnt by fires each year in the EU, leading to the degradation of the European forests and further diminishing the natural ecosystems CO₂ absorption rates. Other studies (International Resource Panel - Global Resources Outlook - 2019) have also shown that on the scale of the last 50 years the world's annual extraction rate of fossil energy resources has tripled, which in consequence has been estimated as leading to as much as 90% loss in biodiversity.

The European Union's industrial sector is responsible for circa 20% of the total European greenhouse gas emissions (cf. European Commission - EU Climate Action Progress Report – 2019). With about 50 thousand of industrial locations in the EU, up to €189 billion is spent on health issues related to pollution from these installations (cf. Schaible, 2020).

Further 25% of the European greenhouse gas emissions come from the transportation sector. Road transport clearly dominates in emissions, taking 71.7% of the total figure, followed by 13.9% from aviation, 13.4% from water transport, along with railways and other transportation branches accumulating the remaining part (European Commission – Sustainable mobility – 2019).

The progress of electrification of cars, dynamically scaling in Europe is thus a major contribution to the green transformation providing the electricity generation mix involves dominating share of the clean renewable energy sources. In Europe the demand for electrically chargeable vehicles (ECVs) has grown impressively throughout 2020 despite the pandemic induced crisis, with almost 0.5 million of new ECVs registered in the EU at large (marking the highest figure so far and resulting with an unprecedented 17% market share, which is over 2 times higher as compared to China and over 6 times higher as compared to the United States).

The climate system of our planet is complex, strongly interdependent and by no means easily simulated. Decades spanning observations noting unusual weather escalations getting more frequent in the recent years show that the global warming might induce a climate destabilization that can possibly scale very profoundly in a feedback loop of complex interdependent factors, which when set in motion might be difficult to stop. This is a well-known property of very complex, interdependent systems.

The 2021 Nobel Prize in Physics has been awarded to climatologists Syukuro Manabe of Princeton University, Klaus Hasselmann of Max Planck Institute for Meteorology, and physicist Giorgio Parisi of Sapienza University for their groundbreaking contributions to our understanding of complex physical systems, for the discovery of the interplay of disorder and fluctuations in environmental systems from atomic to planetary scales as well as for setting foundations for physically modelling the Earth's climate, quantifying variability and reliably predicting global warming.

Although the sheer economics of the climate change and destabilization is a strong factor driving the clean energy change, notably in Europe, it is hard to measure in money the values such as health and wellbeing of mankind's next generations, as well as of animals and ecosystems. Beyond such economically unmeasurable threats for the future of the life on our planet, as much as ca. €190 billion annual losses were projected for a 3°C increase in global average temperature (cf. Ciscar et al., 2014). Globally, the number of people at risk of being forced from their homes by river flooding could increase to 50 million a year (cf. Internal Displacement Monitoring Centre, Assessing the impacts of climate change on flood displacement risk, 2019) and the climate change could lead to at least 20% food price rise in 2050 (COACCH, The economic cost of climate change in Europe, 2018). It has been also estimated that there will be ca. 660 thousand of additional asylum applications per year in the EU at 5°C temperature increase (Missirian and Schlenker, 2017). Economic costs of the heat-related mortality could amount to more than €40 billion per year (cf. COACCH).

The dominating role of energy is confirmed by more than 75% of greenhouse gas emissions being related to the production and use of energy within the EU (cf. European Commission - Clean Energy, 2019). Thus the general reasons for the European Green Deal and the clean energy transformation are based upon the environmental issues (such as climate change, loss of biodiversity, ozone depletion, water pollution or waste production) but also as much upon their economic consequences.

The strategy in continuing Europe's previous sustainable growth assuring clean energy policies of the EU has turned out successful – with the hallmark of the renewables winning electricity mix share over fossil fuels in the EU was based on the renewable resources providing for 17.5% of the EU's overall gross energy consumption in 2017, while simultaneously stimulating economic growth of the EU's green energy sector.

The paper discusses the progress of the EU's clean energy transformation along with the climate change drivers for the European clean energy transformation policy and the European Green Deal implementation, which have recently resulted in the historic for the EU renewable energy dominating share in the electrical energy generation mix for 2020.

2. The EU climate and energy policy context

Europe has a strategic ambition to become the first climate-neutral continent by the year 2050. In previous European climate strategies and goals, the EU has set out on a path to gradually reduce its greenhouse gas emissions. The most important climate and energy goals were defined in the 2020 climate and energy package and in the 2030 climate and energy framework. These goals were set in order to put the EU on a road to a climate neutral economy, as described in the long-term strategy 2050 and proposed in the form of the European Climate Law. The EU is tracking its progress in reducing emissions through regular monitoring and reporting, reviewing and constantly adjusting its policies towards the goal of becoming a climate resilient society by 2050, fully adapted to the inevitable effects of the climate change driven by greenhouse gases emission. The plan to achieve this far-reaching goal of the climate neutrality was set out in the EU Strategy on Climate Adaptation. The 2020 policy package defined a set of laws that needed to be passed in order to ensure that the EU meets its climate and energy goals for 2020. The package contained three main objectives: 20% less greenhouse gas emissions (compared to 1990 levels), 20% of EU energy from renewable sources, 20% improvement in energy efficiency.

These goals were set by leaders of the EU in 2007 and implemented into law in 2009. The EU has taken action in a number of areas to ensure that these objectives were successfully achieved. These efforts had particularly concerned establishment of the Emissions Trading System (ETS) as a central instrument for reducing greenhouse gas emissions from large-scale plants in the energy and industrial sectors as well as in aviation. In 2019, the ETS covered around 40% of total EU emissions (excluding international aviation). In 2020, the target was set that emissions from these sectors should be 21% lower than in 2005. Another aspect of this effort were the national emission reduction targets. These targets covered the burden sharing sectors (i.e. non-ETS and no agriculture), which constitutes approximately 60% of the total EU emissions (also excluding international aviation) in 2019 – such as non-ETS industry, housing, agriculture, waste and traffic (excluding air traffic). As part of the so-called effort-sharing decision, the EU countries have set binding annual targets for reducing emissions in these sectors by 2020 (compared to 2005).

These goals were set to vary accordingly with national prosperity and wealth levels - from a 20% reduction for the richest countries to a maximum of 20% increase for the least prosperous countries (although these member states will need to make efforts to limit emissions) by 2020. Progress on NERT is monitored every year by the Commission, with each country being obliged to report its emissions.

The EU has also included the renewable energy targets at national level. In this initiative, the EU member states have set binding national targets in order to increase the share of renewable energies in their energy consumption by 2020 within the framework of the Renewable Energy Sources Directive. These targets varied to reflect different countries' starting points for renewable energy production and their ability to increase it (e.g. from 10% in Malta to 49% in Sweden). The overall effect allowed the EU as a whole to meet its 20% target for 2020 (more than double the 2010 level of 9.8%) and a 10% share of renewable energy in the transport sector.

The innovation funding programs in the 2020 package have proven to be taking the decisive role. The EU supported the development of low carbon technologies through many programs, e.g. the NER300 program for the renewable energy technologies and carbon capture and storage, as well as through the Horizon 2020 funding for research and innovation programs along with several other EU co-funded programs run by dedicated networks as well as programs cofounded by the European funds at national levels.

Part of the effort was also aimed at energy efficiency, and measures to increase these were set out in the Energy Efficiency Directive. Achieving the 2020 package goals has helped to increase the EU's energy security as well, by reducing dependence on traditional energy imports and contributing to the development of the European Energy Union (also creating jobs and promoting green growth, while making Europe more competitive globally in renewable energy technologies).

The Commission's proposal, following the 2020 package, to reduce greenhouse gas emissions by at least 55% by 2030 has set Europe on a road towards becoming climate neutral by 2050 in undertaking a globally leading role in responsibility for the planet.

On the basis of a comprehensive impact assessment, the European Commission proposed to expand the EU's

ambitions to further reduce greenhouse gases emissions and continue on this more ambitious path for the subsequent 10 years. Undertaken evaluations have shown in what ways different sectors of the economy can contribute and defined policies needed to support these actions. Objectives include setting a more ambitious and cost-effective path to climate neutrality by 2050, promoting green job creation and maintaining the EU's track record in reducing greenhouse gas emissions while growing the economy and encouraging international partners to share their ambitions for limiting the rise in global temperatures to 1.5 °C and to avoid the most serious consequences of the climate change.

The 2030 climate target that the Commission proposed in increasing the EU's ambitions to reduce greenhouse gas emissions by 55% below 1990 levels by 2030 was a substantial increase compared to the previous target of at least 40% (cf. European Commission 2030 climate & energy framework). Raising the 2030 ambition supports policymakers and investors with certainty, so that decisions made in the coming years do not cut in emission levels inconsistently with the EU's goal to become fully climate-neutral by 2050. This proposal delivered on the commitment made in the Communication on the European Green Deal to put forward a comprehensive plan to increase the European Union's target for 2030 towards 55% in a responsible way. It is also in line with the Paris Agreement (2015) objective to keep the global temperature increase to well below 2°C and pursue efforts to keep it to 1.5 °C. The impact assessment (European Commission, Stepping up Europe's 2030 climate ambition, September 2020) accompanying the proposal prepared the ground for adapting climate and energy policies to help decarbonise the European economy. This includes determining the future role of carbon pricing and its interaction with other policies. The European Commission launched legislative proposals on how to achieve these objectives. It declared to be reviewing and revising all relevant policy instruments to achieve the additional emission reductions.

In October 2020, the European Commission published inception impact assessments, followed in November 2020 by the four open public consultations to prepare these revisions: 1) EU Emissions Trading System Directive (European Commission, Updating the EU Emissions Trading System ETS, November 2020), 2) Effort Sharing Regulation (European Commission, National emissions reduction targets – review based on 2030 climate target plan, November 2020), 3) Land Use, Land Use Change and Forestry Regulation (European Commission, Land use, land use change & forestry – review of EU rules, November 2020) and CO₂ standards for cars and vans Regulation (light-duty vehicles - CO₂ emissions for cars and vans – revision of performance standards, November 2020).

Furthermore, the Climate Law Regulation, proposed by the European Commission in March 2020 and finally adopted on 9th July 2021 (European Commission, European Climate Law, July 2021), aimed to incorporate into the EU law the 2050 climate-neutrality target agreed by EU leaders in December 2019 and set the direction for all EU policies. In September 2020, the Commission proposed to include the increased 2030 target in the mentioned regulation as a whole by co-legislation under the ordinary procedure. The new 2030 target also formed the basis of discussions on revising the EU's nationally determined contributions of the individual member states to reducing emissions under the Paris Agreement.

As the 2030 climate and energy framework included EU-wide targets and policy objectives for the period from 2021 to 2030 it has been an important part of the European Green Deal, that the European Commission proposed in September 2020 to raise the 2030 greenhouse gas emission reduction target, including emissions cut to the mentioned value of at least 55% compared to 1990. The European Commission has assessed actions required across all sectors, including increasing energy efficiency and deployment rates of renewable energy, as well as started the process of making detailed legislative proposals to implement and achieve these increased ambitions. The strategy to move Europe as a whole continent towards a climate-neutral economy is very part of the Paris Agreement and stimulating in terms of leading by example the international cooperation in this regard. The key targets for 2030, beyond the mentioned 40% cuts in greenhouse gas emissions (from the 1990 levels) also featured at least 32% share for renewable energy and at least 32.5% improvement in energy efficiency. The 40% greenhouse gas target is to be implemented by the EU Emissions Trading System, the Effort Sharing Regulation with Member States' emissions reduction targets and the Land Use and Forestry Regulation. In this way, all sectors will contribute to the achievement of the target by both reducing emissions and increasing efficiencies. All three pieces of climate legislation will be continuously updated with a view to implement the proposed at least 55% net greenhouse gas emissions reduction target. The Commission came forward with the proposals in summer 2021.

Under the Regulation on the Governance of the Energy Union and the Climate Action, the EU has hence adopted integrated rules to ensure planning, monitoring and reporting of progress towards its 2030 climate and energy targets and its international commitments under the Paris Agreement. Based on the better regulation principles, the governance process involves consultations with citizens and stakeholders.

Summarizing, the EU aims to be climate-neutral by 2050 – that is to form an economy with net-zero greenhouse gas emissions. This objective is at the heart of the European Green Deal and in line with the EU's commitment to global climate action under the Paris Agreement.

The transition to a climate-neutral society is both an urgent challenge as well as a great opportunity to build a better future for all and to secure highly competitive position globally for the European Union. All parts of society and economic sectors will take a role in this endeavor – from the power sector to industry, as well as transport, buildings, agriculture and forestry. The EU can lead the way by investing into innovative but realistic technological solutions, empowering citizens and aligning action in key areas such as industrial policy, finance and research, while ensuring social fairness for a just transition, supporting highly impact regions (e.g. coal or heavy-industry regions).

The European Commission has articulated its vision for a climate-neutral EU back in 2018 (European Commission, A Clean Planet for all - a European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, November 2018), looking at all the key sectors and exploring possible paths towards the green transition. The European Commission's vision covered all EU policies and was strictly in line with the Paris Agreement objective to keep the global temperature increase to well below 2°C and pursue efforts to keep it up to 1.5°C. As part of the European Green Deal.

All Parties to the Paris Agreement were invited to communicate by 2020 their mid-century, long-term greenhouse gas emission reduction strategies. The European Parliament endorsed the net-zero greenhouse gas emissions objective in its resolution on climate change in March 2019 (European Parliament resolution of 14th March 2019 on climate change – a European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy in accordance with the Paris Agreement 2019/2582-RSP, March 2019) and resolution on the European Green Deal in January 2020 (European Parliament resolution of 15th January 2020 on the European Green Deal 2019/2956-RSP, January 2020).

The European Council endorsed in December 2019 the objective of making the EU climate-neutral by 2050 (European Council, Conclusions on climate change, the MFF, the Conference on the Future of Europe, EU relations with Africa, the WTO, Turkey and Albania, 12th December 2019). The EU submitted its long-term strategy to the United Nations Framework Convention on Climate Change (UNFCCC) in March 2020 (United Nations, Long-term low greenhouse gas emission development strategy of the European Union and its Member States, 6th March 2020). Under this strategy the EU Member States are required to develop their own national long-term strategies on how they plan to achieve the greenhouse gas emissions reductions needed to meet their commitments under the Paris Agreement and the EU objectives (European Commission, National long-term strategies – EU countries' long-term strategies to meet their Paris Agreement commitments and the energy union objectives, 30th September 2021).

3. Introducing the European Green Deal

The European Green Deal is a package of political initiatives of the European Commission with the strategic goal of transforming Europe to fully climate neutral by the year 2050.

Along the lines of the Emissions Gap Report 2020 by United Nations Environment Program, meeting the Paris Agreement target of a 1.5 °C temperature increase with a probability of 66% requires 57% global emission reduction of CO₂ from 2019 to 2030 and therefore well above the preceding policies with 40% of the EU target as described in the previous chapter. In this way, the European Green Deal has been complemented with an impact assessment plan for increasing the EU's greenhouse gas emissions reduction target by 2030 to at least 50% and up to 55% compared to 1990 levels. In the context of the Paris Agreement, and therefore using today's emissions as a benchmark, since EU emissions have already decreased these levels by over 30% since 1990, the 55% reduction target, using 1990 as reference value, means in terms of 2019 reference, a 40% reduction target.

This emission reduction target of 57% by 2030 represents average global reductions, while advanced economies are already for over 20 years proven in necessity to make a greater contribution (Heil, M., Wodon, Q., 1997).

The plan for the European Green Deal implementation is thus to review each existing law in the EU in terms of its climate benefits as well as to review economy in this regard, along with the issue related sector-specific policies such as renovation of buildings for energy efficiency, biodiversity, agriculture and innovation.

European Commission President Ursula von der Leyen indicated the European Green Deal was Europe's man on the Moon moment as the plan would make Europe the first climate-neutral continent. Von der Leyen has appointed Frans Timmermans as the Executive Vice President of the European Commission for the European Green Deal. On December 13, 2019, the European Council decided to push the initiative forward (with an opt-out for Poland however). On January 15, 2020, the European Parliament has also voted in support of the agreement and called for undertaking even higher ambitions in regard to the climate change.

The European Green Deal aims to improve people's wellbeing by making Europe climate neutral and hence protecting a natural ecosystem of Earth's climate proposing a solution for an existential threat for people, our planet and the economy due to the climate change caused by the currently scientifically proven and undisputed global warming. The EU will become climate neutral by 2050 to protect the life on Earth for all humans, animals and plants by reducing greenhouse gas emissions and pollution. It will also help European companies become world leaders in clean energy, products and technologies, hence positioning Europe with a competitive edge for the new economy, with an aim to overturn the challenge of the clean transition into an economic opportunity.

As much as 93% of Europeans see climate change as a serious problem and a similar percent of Europeans have taken at least one action to counter the climate change on their own. About 79% agree that action against climate change will lead to innovation and development. The European Green Deal is about climate and energy, and for most, the European Green Deal is a strategic policy to ensure a fair and inclusive transition for Europe to clean energy, as energy from traditional fossil fuels plays a role in the challenges global warming introduces. Yet another important goal of the European Green Deal policy is to turn the challenge into an opportunity and to base a new dynamic economic growth in Europe on the transformation towards 100% clean energy.

The European Green Deal is thus planned as a new growth strategy for the whole Union. It is meant to help cut emissions while creating jobs and advancing the clean energy industry to place EU in the forefront of innovation where the global market uptakes clean energy technologies. It is also meant to propose an inclusive transition securing life on Earth as we know it for the generations to come. Accordingly with the objectives of the European Green Deal the EU will be climate neutral in 2050 to assure the above.

On the way towards this strategic objective, the European Commission has proposed a legal framework called the European Climate Law that makes political engagement transformed into a legal obligation and a legal framework of incentives for the investments. Achieving this goal requires action from all sectors of the European economy: energy (decarbonizing the energy sector - the generation and use of energy accounts for more than 75% of the EU's greenhouse gas emissions), buildings (renovating buildings to support citizens in cutting their energy bills and their energy consumption - buildings account for circa 40% of the energy consumption in the EU), industry (helping industry to innovate and leading the global green economy, European industry currently uses only 12% recycled materials), mobility (making it cleaner, cheaper and healthier within both private and public transport - transport accounts for circa 25% of the EU emissions). With these actions the European Green Deal is projected to improve health of citizens now and in the future.

In a nutshell, the strategy has two objectives: clean and efficient energy (including clean energy, better alternatives to public transport and the transition to electrification, development of electromobility and charging infrastructure for transport with electric vehicles, renovated houses, schools and hospitals in terms of energy efficiency) and less impact on the environment for health and wellbeing (towards assuring the clean air, water and soil, reusable or recyclable packaging, less waste, less pesticides and fertilizers, healthier food, more environmentally friendly products in EU stores for better health for present and next generations).

Preparing a large-scale policy for the climate-neutral, circular economy on a continental scale is an ambitious

and difficult task. To become the first climate neutral continent by 2050 will require huge investment from both the public and private sectors. Public finances will lead the way with private actors following and providing the benchmark for the policy success.

The European Green Deal's investment plan involves mobilizing of at least €1 trillion of investments over the course of 10 years, thanks to the combined: capital from EU and national budgets, public and private investments, additional measures to facilitate and boost green public and private investment, attractive investment conditions, technical assistance to help investors in selecting sustainable projects. Further funding channels involve: 30% of InvestEU to projects that fight climate change, 25% of all European Union funding for climate measures, Stimulating green investments with support from the EIB Group

As part of the Sustainable Europe Investment Plan, the Just Transition Mechanism will mobilize at least €100 billion over the period of 2021-2027, to provide targeted support to regions, workers and sectors that are most affected by the transition towards the green economy. The EU will provide financial support and technical assistance to help those that are most affected by the move towards the green economy.

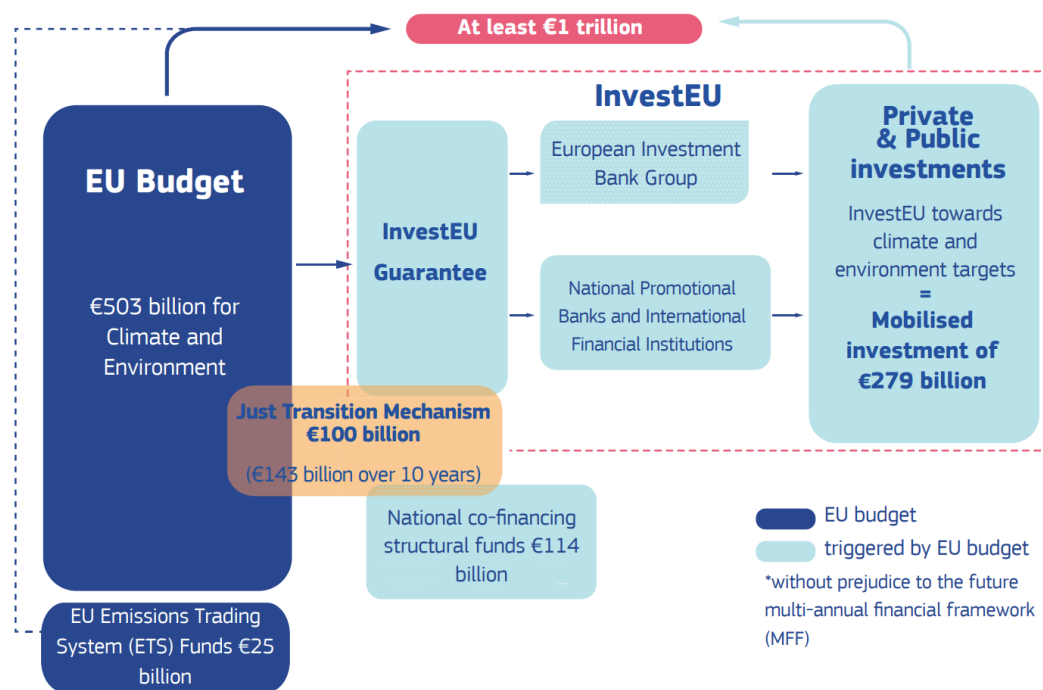


Fig. 1. European Green Deal funding scheme. The numbers shown here are net of any overlaps between climate, environmental and Just Transition Mechanism objectives. Source: European Commission

In terms of competition it should be stressed that all those acting first and fastest will also secure the advantage of the ecological turnaround. But public finances alone will not be enough.

It is well understood on the level of the EU Commission that there is a need to unlock private investment by setting green and sustainable finance at the center of the EU investment chain and financial system. For the EU the pursued transition to the climate-neutral economy on a level of a continent, it is critical that the political commitment must be accompanied by a huge scale investment.

The European Green Deal shows the determination in Europe to fight the climate change, which is currently being underpinned with a financing plan. In opinions of the policy makers, similarly as the European Union was not built overnight, the new green Europe will also not come to be in a matter of day. Setting sustainability in clean energy at the center of the EU investments requires joint efforts on the level of policy and industry. The European Green Deal aims to facilitate it.

It should be also stressed another important aspect, i.e. the need to show solidarity with the most clean energy transformation policy involved regions in Europe, such as coal-mining regions and other industrial regions, to ensure that the Green Deal has a uniform support and its implementation is a common success.

The Just Transition Mechanism (JTM) is a key tool to ensure that the transition towards a climate-neutral economy happens in a fair way with solidarity involved and not leaving any region behind. It provides properly targeted support with a mobilization of at least €150 billion planned for the years 2021-2027 in most affected regions, to alleviate socio-economic impacts of the clean transition.

The JTM hence addresses both the social and economic effects of transition, focusing on the regions, industries and workers facing the greatest challenges, and mobilizing at least €150 billion through the following 3 pillars: a new fund of €40 billion for a just transition generating at least €89-107 billion investment, the InvestEU Just Transition program mobilizing further €30 billion in investment, the EIB public sector loan facility of €10 billion in loans, additionally supported by €1.5 billion from the EU budget to also mobilize €30 billion in investment.

As part of its Green Deal commitment, the EU is fighting climate change not only through its ambitious internal policies but also through its close cooperation with international partners, as it is well understood that countering global warming must be a global effort.

Europe is determined to lead by example (it has already met its 2020 greenhouse gas reduction target and has presented a plan to cut emissions by at least 55% by 2030 and by 2050 it aims to become the first climate-neutral continent in the world) and motivate other developed countries to take responsibility, along with providing financial and technological support to the developing countries in clean energy transformation.

Climate protection is at the heart of the European Green Deal, which includes measures that range from an ambitious reduction in greenhouse gas emissions to investing in cutting-edge research and innovation to preserving Europe's natural environment – all this requires massive investment and differentiated efforts in relation to less and more affected regions, as well as energy and industrial centers.

The primary climate protection initiatives as part of the European Green Deal include: European Climate Law to anchor the goal of climate neutrality 2050 in the EU law, European climate pact to involve citizens and all parts of the European society in the climate protection effort, climate target plan for 2030 to further reduce net greenhouse gases - emissions by at least 55% by 2030, and the new EU strategy on adaptation to the climate change to make Europe a climate resilient society by 2050, fully adapted to the inevitable effects of pollution and the greenhouse effect.

At the international level, the EU will continue to conduct negotiations to increase ambitions of major emitters in the run-up to the United Nations Climate Change Conference in Glasgow (COP26).

4. The European Green Deal's implementation results

As the European Green Deal has been designed to position Europe as a global leader, leading by example on the global warming and the climate change front and to simultaneously turn the environmental challenge into a growth and economic recovery opportunity for the EU, the question to ask is what are its current results.

Answering this question, the immediate effects of the 2018 recast Renewable Energy Directive (2018/2001/EU) and other related clean energy policies under an umbrella of the European Green Deal, including the evolving Emission Trading System with emission caps on the EU level, the EU coal regions in transition initiative, the European Green Deal Investment Plan (with the Just Transition Fund, the InvestEU dedicated scheme of unprecedented scale of €1 trillion, the Modernisation Fund and the Innovation Fund, supported by Horizon R&D programme and the financial instruments of the Connecting Europe Facility and the European Investment Bank) influencing the clean energy transition economic and technical factors – have led to the coal and lignite electric generation falling in 2020 by as much as 22% (i.e. -87 TWh) and the nuclear output dropping by 11% (-79 TWh), with natural gas less affected due to its favorable prices (hence supporting coal-to-gas and lignite-to-gas switching) but still noting an annual drop of 3%.

This is an impressive result and a hallmark of the European Green Deal initial success.

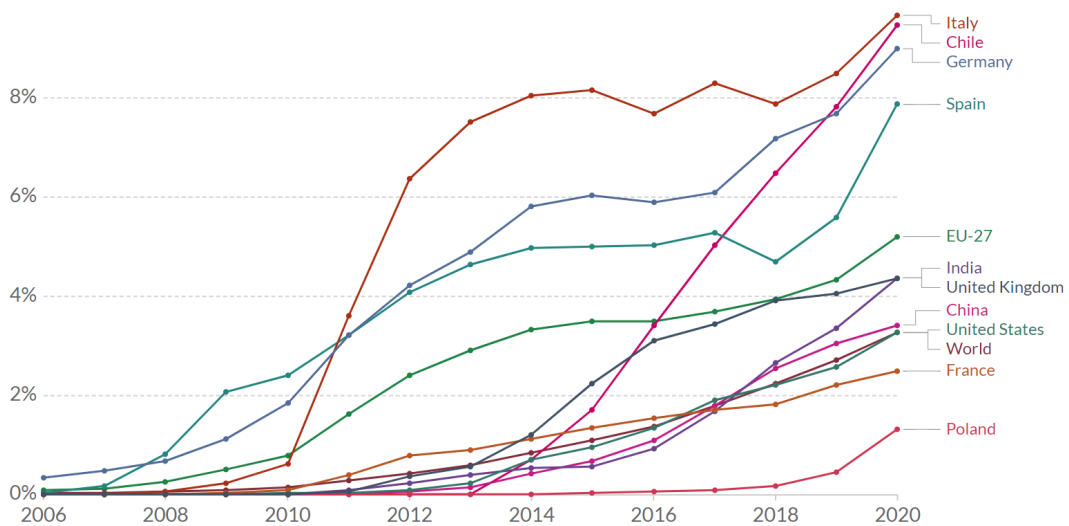


Fig. 2: Solar energy share in electricity mix of the EU and reference countries in 2020, showing the EU reaching 5,2% share from just 0.08% share in 2006. Italy, Greece and Germany are leading the solar energy electricity-share race, all reaching impressive 9%, with Spain closely following (at almost 8%). The EU exceeded in this area both the US (3.2%) and China (3.4%). Source: chart by the author, based on statistical data by BP Statistical Review of World Energy & Ember.

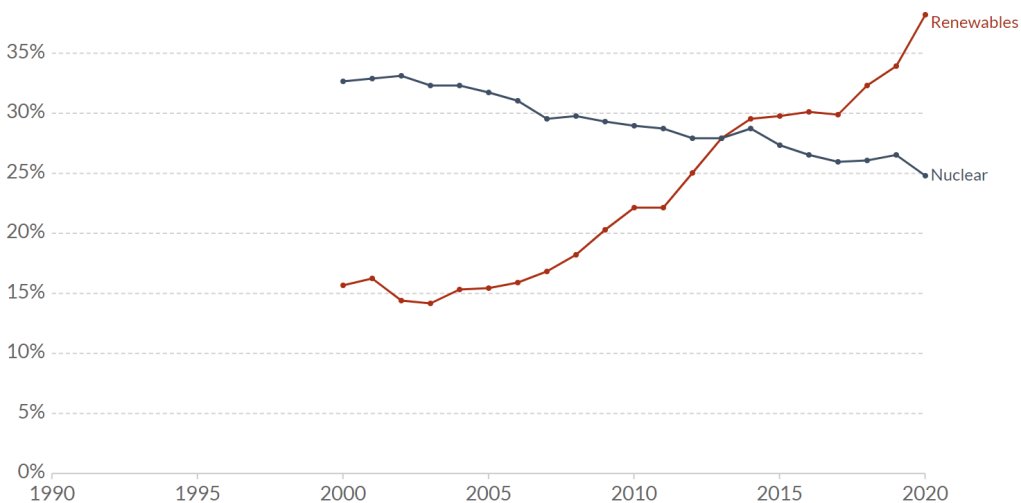


Fig. 3: Competition between renewables and nuclear power share in electricity mix for the EU, with a crossing in 2013 (nuclear power is being phased down due to the risk of serious environmental impact in case of an incident, but is also considerably more expensive, currently estimated at 11 times more costly than photovoltaic energy, mainly due to necessary security investments – in the EU only France largely relies its electricity generation on nuclear power, with ca. 70% share stable for decades and renewables at ca. 23%). Source: chart by the author, based on data by BP Statistical Review of World Energy & Ember.

Meanwhile the rising renewable share in electricity generation in the EU was supplemented by ca. 29 GW of solar and wind grid deployments in 2020 (at levels comparable to those of 2019, proving that the pandemic did not strongly impact the renewable energy sources investments expansion, and as a matter of fact even supported its historical triumph in the European Union, by causing an overall electricity consumption drop).

These clean energy transition successes in the EU are certainly due to the current EU strategic policy and other factors, circumstances and actions, involving climate change drivers together with the estimated costs of not taking the action and the perspectives of the progress of the European Climate Law combined with the revision of the European Energy Law (including the European Commission’s June 2021 scheduled recast of the Energy Taxation Directive, paying a close attention to the fossil fuel subsidies and tax exemptions).

The Directorate-General for Energy of the European Commission (ENER) confirmed in its communication of 9th April 2021 a historical success for the EU and the world at large. The share of electricity generated from renewable sources in the EU for the first time in the history exceeded the share of combined fossil fuels in 2020. The clean energy sources dominating share in the EU's electricity generation mix reached 39%, exceeding by 4% the combined share of fossil fuels amounting to 36%. It is an impressive result if taken into account that globally the electricity is generated at 63.3% from fossil fuels (excluding nuclear energy) and at 26.3% from renewables. The breakdown to different renewables in the electricity mix of the EU is presented on the Fig.1, showing an impressive growth rates of solar energy and wind power vs. a decline of fossil fuels.

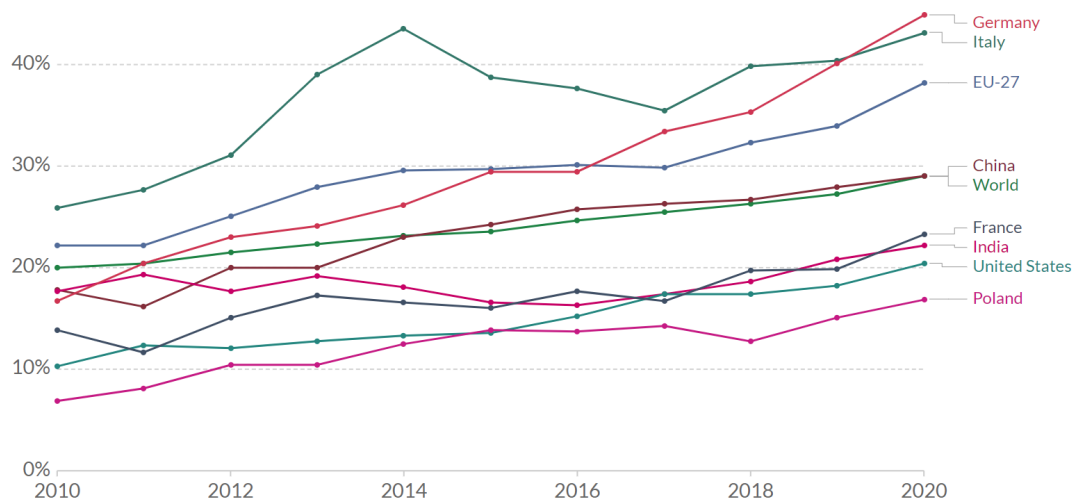


Fig. 4: Electricity mix renewables share for the EU and reference countries in 2020, showing the EU reaching 39% share from 22% share in 2010. Source: chart by the author, based on statistical data by BP Statistical Review of World Energy & Ember.

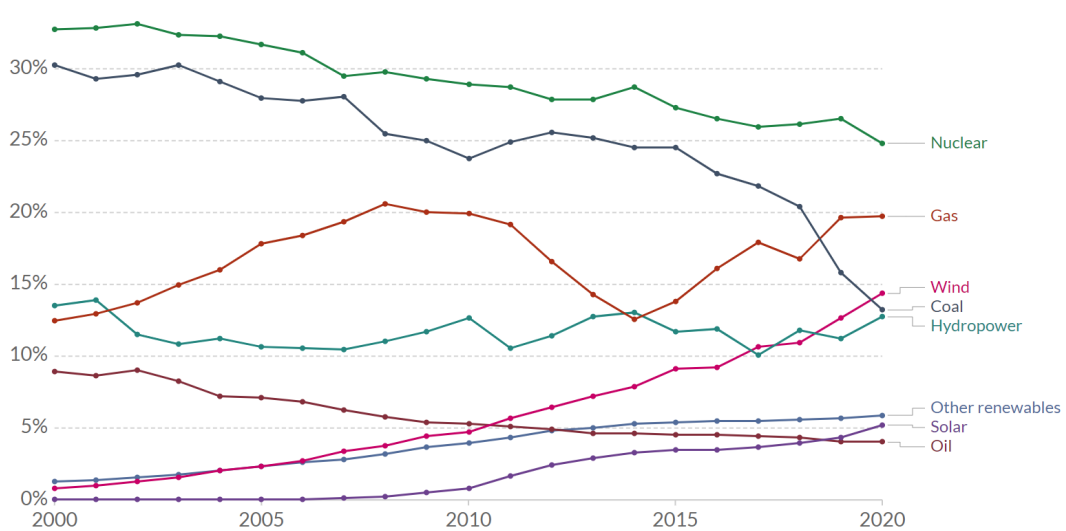


Fig. 5.: The breakdown for energy sources in electricity mix for the EU in 2020 (showing decline in fossil fuels, e.g. the worst CO₂ and pollution emitter - coal from 30% to 13%, oil from 9% to 4%, gas on a stable level of below 20% after averaging – confronted with a steady growth of renewables: notably solar energy from 0.01% to 5.2% and wind power from 0.8% to 14.3%). Source: chart by the author, based on statistical data by BP Statistical Review of World Energy & Ember.

Although it is understood that decisive factors for achieving this breakthrough for the European Union in 2020 partially involved the exceptional situation of the COVID-19 pandemic and its overarching impact on energy markets (the demand shock lowering the EU overall electric consumption level by 4% in comparison to 2019),

combined with the favorable weather conditions for the renewable energy and most notably for solar and hydro power, figures for the 4th quarter consumption levels (despite continued lockdowns in Europe) were getting closer to their usual values in contrast to the first 3 quarters of 2020 thus pointing towards normalization. This situation, in detail discussed in the Quarterly Report on European Electricity Markets (cf. EC's Directorate-General for Energy, unit A4, Market Observatory for Energy, April 2021), admits a well-justified expectation that the European Union is able to hold its newly gained ground in clean energy, especially as we observe how the European Commission's Clean Energy for all Europeans Package of policies (cf. CEP in references) gains momentum as the major pillar of the European Green Deal implementation.

Despite it being difficult to accurately estimate in quantitative terms on exactly what contribution to the success in renewables dominating the combined fossil fuels in electricity mix in the EU has been directly due to the immediate results of the European Green Deal policies, and what part of it follows from a general economic advantage of renewables, some discussion in this regard is certainly needed. One of immediate effects of the 2018 recast Renewable Energy Directive (2018/2001/EU) that is considered to be a part of the current European Green Deal package is certainly related to increase of funding in renewables related research and development on many levels affecting the efficiencies of the renewable energy generation. E.g. for the solar power, multiple industrial research projects funded by the EU resolved to significantly decreasing costs of fabrication of, on the other hand, increasingly efficient solar cell devices, driving down the costs per Watt of electric energy generated. PV related research results include also plasmonic enhancements of solar cells (c.f. Jacak et al. 2018-2020) which allow for cost-efficient increases of energy generated from solar cell devices by surface nano-modifications. Also improvements in smart grids and energy production decentralization towards enabling the prosumer model indirectly extend potentials and economic advantages of renewable energy sources and is most certainly driven by relevant Green Deal policies in the EU, such as to enable prosumers to sell their produced energy to the grid (along with following investments and technological developments in renewables in general). Furthermore it should be emphasized that one of major impact factors that makes renewable energy sources more cost efficient than traditional fossil fuels in electricity generation comes from the Emission Trading System which has been imposed upon a climate-related political agreement in the EU and ever since introduces kind of an artificial (yet justified by climate goals) burden for the fossil fuels, further assisted by economic speculation in terms of emissions market trading. Other political factors contributing to economic advantage of renewables in the EU was a German anti-nuclear policy imposed in 2011 after the Fukushima incident, resulting with a complete phasing down of nuclear power in this country, strongly driving renewables growth in the EU. Due to a high level of climate awareness already in 2011, the new energy sector direction in Germany has been shifted towards increasing share of renewables (along with controversial increasing of natural gas supply dependence from Russia in Nord Stream 1 & 2) rather than upscaling polluting electricity generation from coal (which also has a significant share in Germany, but started losing ground to renewables because of the ETS economic pressure, which is however directly rooted in the climate policy). On a level of the European Union these policies are now encapsulated in the European Green Deal package, with new climate-neutrality initiatives and ambitious developments that will be surfacing in upcoming years.

Although the funding of the European Green Deal is currently programmed at €1 trillion (as mentioned the plan involves mobilizing of at least €1 trillion of investments over the course of 10 years in the EU), such value nominally is rather corresponding to an estimated amount of the necessary annual spending in the EU required to reach the net zero emissions target in 2050 (hence it is by one order smaller from what is actually needed). Certainly it is hence an initial investment plan, that will require to be further extended and most importantly trigger increasingly growing private investment, that in total should be at least 10 times greater in scale of a corresponding time frame of ten years (and by a factor of ca. 30 when we consider almost three decades left to 2050). Already in September 2020 the European Commission (along the lines of the communication entitled Stepping up Europe's 2030 climate ambition - Investing in a climate-neutral future for the benefit of our people - Impact assessment, COM(2020) 562, September 2020) has predicted that meeting the 2030 climate objective would necessitate additional investments of almost €360 billion in the EU alone each year. This increases the relevant investments scale for the EU from an average of €683 billion per year in the previous decade to about €1 trillion per year. The transportation sector accounts for ca. a third of the required investment, and is by far the greatest component due to a massive combustion engines vehicles replacement necessity that would facilitate reaching the climate neutrality goal. However major magnitude upon this investment is on a consumer level, i.e. depending on average EU citizens transiting from buying combustion engine cars to electric vehicles.

This transition rate will scale increasingly in upcoming decade (even with a discussed ban on combustion engines cars production) but will be closely tied to investments needed for widespread electric cars charging infrastructure (quite differentiated in the EU, and in need to be specifically enhanced in the Eastern European member states). Apart from the transportation sector, also the focus is also set on tripling home heating investments which falls under a scope of the buildings modernization EU policy, while other important components of the EU energy policies (minor in terms of investments magnitudes) such as electricity grids and power plants must still be increased by at least a factor of two. These estimates were produced by the European Commission only in regard to reaching more modest 2030 targets, while the 2050 target for a full carbon neutrality will certainly exceed these costs even further, with a remark that large part of these investments will be in a transportation sector with consumers' major shift to its electrification.

The scale of the global energy investment magnitudes for achieving net zero emissions by 2050 is of course correspondingly larger. According to the International Energy Agency, it currently amounts by rough estimates to well over \$2 trillion per year, or 2.5% of the world GDP (Net Zero by 2050, A Roadmap for the Global Energy Sector, Flagship report, International Energy Agency, May 2021). This is quite an optimistic estimation that only considers immediate future of up to few years. After this short term time scale in order to achieve net zero CO₂ emissions by 2050, according to the mentioned model of the IEA, the investment will have to climb to \$5 trillion globally per year (or ca. 4.5 percent of GDP) by 2030 and stay at least at this level, until 2050. Significant amount of this investment will also need to go towards electricity generation and infrastructure in order to electrify new economic areas and make the electric grid more capable for dealing with much higher volumes and variability of renewable energy, especially concerning the widescale electrification of the transport. The International Renewable Energy Agency along the lines of the World Energy Transitions Outlook: 1.5°C Pathway, International Renewable Energy Agency, June 2021, projects similar estimates in terms of the required expenditures to be made in the current decade, resulting in annual spending of \$5.7 trillion until 2030, with an expected minor decrease in a period between 2030 and 2050. Finally, according to the Bloomberg New Energy Finance (New Energy Outlook NEO, July 2021), global investment needs will range between \$3.1 trillion and \$5.8 trillion each year until 2050. According to these estimations, the goal of achieving climate neutrality globally by 2050 will also require ca. 2% of GDP in increasing of additional investments in energy and transportation infrastructure from the current levels (i.e. close to a figure of 2.5% estimated by the IEA). Because of the size and scope of the required investments, they will have major macroeconomic effects, both in a global scale, as well as in the EU. These policies will hence be strongly conditioned by the macroeconomic situation in the world. In this regard it is certainly crucial to point at major risks glooming on the horizon. One of such risks is a currently developing global crisis triggered by the 2022 invasion of Russia on Ukraine. The western economic sanctions (significantly increased by the EU on 27th February 2022) may be a major factor in necessity to rescale the climate policy, in view of dire challenges the world now faces with Russian aggression and risks for the conflict to upscale, along with strong global economic impacts, that have only begun.

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