12.1 Introduction

The decarbonisation of the electricity sector has been one of the most transformative changes in Europe’s economy. Renewable energy has played a central role in substituting carbon-intensive power generation for emissions-free electricity. Between 2008 and 2018, Europe installed more renewables than fossil fuel generation. A total of 259 GW of renewables were added to the power system, of which wind energy has been the largest single technology, with 110 GW of new installations.\(^1\) During the same period, electricity generation from renewables almost

\(^1\)WindEurope, “Wind energy in Europe in 2018. Trends and statistics”, p. 14, available at: https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Statistics-2018.pdf.

I. Pineda (✉)
WindEurope, Brussels, Belgium
e-mail: Ivan.Pineda@windeurope.org
doubled, from roughly 590 TWh/year to around 1072 TWh/year.\(^2\) This reduced 21% of the CO\(_2\) emission intensity in electricity generation, from 376 gCO\(_2\)/kWh,\(^3\) to 267 gCO\(_2\)/kWh.\(^4\) At the other end, Europe has removed an average of 10 GW of fossil fuel plants every year. In the decade post-2020, further decommissions will continue, particularly those power plants fired by hard coal and lignite. Six countries in the EU are now coal-free, and 14 have announced their intentions to phase-out coal by 2030 or earlier.\(^5\) While some countries would be tempted to replace coal assets with fossil gas, the business case for building new gas-fired power plants will become very challenging.\(^6\) These developments would not have been possible without the landmark decision of EU governments in 2007 to set climate and energy targets: 20% reduction of greenhouse gas emissions, 20% renewables in final energy demand and a 20% of energy demand reduction by the year 2020.\(^7\) These targets were the first-of-a-kind globally and led the way for many other governments around the world to act accordingly. In 2018, ten years after, the EU agreed on a further set of policies to accelerate the energy transition in the decade post-2020. The EU’s 2030 climate and energy framework increased EU-wide targets and policy objectives of at least 40% reductions in greenhouse gas emissions (from 1990 levels), at least 32% share for renewable energy in final energy demand, and at least 32.5% improvement in energy efficiency.\(^8\) While policy set in

\(^2\)Agora Energiewende and Sandbag, “The European Power Sector in 2019”, p. 9, available at: https://sandbag.org.uk/wp-content/uploads/2020/02/Sandbag-European-Power-Sector-Review-2019.pdf.

\(^3\)European Environmental Agency, “Total greenhouse gas emission trends and projections in Europe”, last modified, 19 December 2019, available at: https://www.eea.europa.eu/data-and-maps/indicators/greenhouse-gas-emission-trends-6/assessment-2.

\(^4\)Agora Energiewende and Sandbag, “The European power sector in 2019”, available at: https://ember-climate.org/global-electricity-review-2020-data/.

\(^5\)Agora Energiewende and Sandbag, “The European power sector in 2019”, p. 23.

\(^6\)Peter Zeniewski, “A long-term view of natural gas security in the European Union”, International Energy Agency, 13 March 2019, available at: https://www.iea.org/commentaries/a-long-term-view-of-natural-gas-security-in-the-european-union.

\(^7\)European Commission, “Communication 20 20 by 2020”, 23 January 2008, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52008DC0030.

\(^8\)European Commission, “2030 climate & energy framework”, available at: https://ec.europa.eu/clima/policies/strategies/2030_en.
motion the departure from fossil fuels for power generation, the success of renewables is an outcome of other factors. Renewables have decreased costs at a remarkable pace. Solar PV panels have decreased costs by 75% since 2010, and onshore wind energy is today the cheapest source of power generation in many parts of the world. This has made a stand-alone business case for investors. Even in times of low oil prices, the cost competitiveness of renewables is seen as a hedge against volatile fuel commodities by many private investors. In addition, governments have other compelling reasons to move away from fossil fuels. Concerns over the security of supply and fuel import bills are crucial for many countries. Not to mention the pressing challenge to improve local air quality and to alleviate water scarcity, both issues affecting many parts of the population. Renewables can solve these issues, but their large-scale deployment still faces many challenges that policy can address. This chapter describes some of the major challenges and opportunities for renewable energy expansion with a focus on wind energy and with a European perspective. It argues that the future success of renewables is based on scaling up the electrification of the economy, facilitating permitting and administrative procedures, increasing the power system flexibility and plugging the financing gap between long-term ambitions and investment needs.

12.2 Renewables’ Future Success Depends on Scaling up Electrification

The EU’s 32% renewable energy target to 2030 in final energy demand translates into around 55% of electricity coming from renewables. This may sound ambitious, but renewables were close to 35% of electricity generation already in 2019, including hydropower. This suggests that the scale envisioned for renewables expansion could be increased further, particularly in light of the additional ambition needed to meet the Climate Paris Agreement. This is important because electricity is only around 25% of Europe’s final energy demand. Europe consumes most of its energy for heating, cooling and transport. And the vast majority of it remains fossil fuel-based. Oil products cover 94% of transport (32% of final energy demand), and 80% of heating and cooling (46% of the
final energy demand) comes from fossil fuels too. Renewables make up only 18% of the supply in heating and a mere 8% in transport. Therefore, integrating heating, cooling and transport sectors into a renewable electricity system will be the next big transformation in the economy.

### 12.2.1 Electrification

Electrification is the integration of final energy uses into the power sector. It can take place directly by substituting fossil fuels with electricity in heating, industrial processes or transport, or indirectly by converting electricity into another energy carrier, like hydrogen or hydrogen-based fuels, which then can be used by consumers. However, for electrification to contribute to climate change mitigation, it would have to come from zero-carbon energy sources. Using renewable electricity wherever is available and whenever is possible can deliver the bulk of decarbonisation needed for the economy. To achieve this, it is crucial to continue the deployment of renewable energy technologies and even accelerate it. This expansion, together with the increased number of applications and uses, will allow the continuation of technology cost reductions, which have progressed rapidly in the last years. There will be certain uses which Europe cannot electrify as fast as needed, or that would be too expensive in the short-term and could impact the competitiveness of some sectors, or that simply it is not technically possible. In these cases, known as hard-to-abate sectors, using renewables to produce other energy carriers will be necessary.

The European Commission has analysed the feasibility of different pathways to achieve net-zero emissions by 2050 as part of its communication on the European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy. The analysis found that to meet the Paris Agreement, Europe would need to increase the

---

9European Commission, “An EU Strategy on heating and cooling SWD (2016) 24 Final”, p. 3, 2016, available at: https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_ACT_part1_v14.pdf.

10European Commission, “In depth analysis in support of the Commission Communication COM (2018) 773. A Clean Planet for all. A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy”, 28 November 2018,
share of electricity in energy consumption to between 50 and 60%. The European Commission estimates that renewables would have to amount to 61–85% of that electricity generation. Wind energy would be the most dominant source of generation, 51–55%, up from 15% today. The 2050 decarbonisation strategy proposed by the European Commission shows that the other half of final energy demand, which will not come from electricity, would be met by a combination of biomass, fossil gas, hydrogen and hydrogen-derived e-fuels. Combined, hydrogen and e-fuels could meet up to 24% of final energy demand in 2050. Europe has long spearheaded the global fight against climate change, but policymakers will be facing considerable challenges to lead society towards any of these futures. Among these are the acceptability to change the way energy is produced and consumed, the pace at which this change should take place, the short-term impacts on the competitiveness of specific sectors in a globalised economy, and the amount of upfront investments needed in the short-to-medium-term compared to the long-term outcomes. While such a future represents a formidable challenge, it is also a remarkable opportunity. If policymakers make a clear choice for renewables-based electrification, Europe will hold the key to a successful decarbonisation strategy while retaining its competitive edge in clean technologies. During the transition, Europe will decrease fossil fuels imports while improving air quality and reducing energy bills for citizens and businesses. All this will secure future European’s living standards. Renewables-based electrification is therefore not only key to the decarbonisation of Europe’s energy system, but also a strategy to secure economic growth. For example, by reducing health-related economic impacts. Air pollution costs between 3 and 9% of the EU’s GDP, equivalent to €330 bn and €940 bn annually. Using more renewable electricity instead of fossil fuels would reduce the exposure of the population to dangerous pollutants like SO₂, NOₓ and other particles. Another example is the economic costs of energy dependence. 20% available at: https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf.

11European Commission, “Commission staff document. Executive summary of the impact assessment SWD (2013) 532 final”, 18 December 2013, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013SC0532&from=EN.
of all EU imports are energy-related. Imported fuels cover 54% of all the energy the EU consumes. It imports 90% of its crude oil, 66% of its natural gas, 42% of its coal and 40% of its uranium and other nuclear fuels.\footnote{European Commission, “Energy security strategy”, p. 1, 2015, available at: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52014DC0330.} Powered by renewable electricity, the EU’s economy has the potential to look very different from today. Its success will rely on making the most of Europe’s local energy resources, on its competent workforce and on its ability to innovate and stay at the forefront of nascent industries. Decarbonising Europe’s economy requires therefore activating the right policy levers. There are three broad categories of policies that could accelerate a renewables-based electrification, namely energy efficiency, electrification incentives and CO₂ pricing.

12.2.1.1 Energy Efficiency

Traditionally energy efficiency has meant ‘using less energy’, but policies should pursue a goal of ‘producing the same or more while using less’. Policymakers can shape energy efficiency with two general levers: by setting obligations on energy savings or by promoting market-based instruments that incentivise users to optimise their energy consumption. Europe has combined both approaches, with the EU Institutions mainly setting the general framework of obligations,\footnote{Energy efficiency obligations schemes for utilities of 1.5% per year to 2030 according to the International Energy Agency (IEA), “Renewable energy for industry”, 2017, available at: https://webstore.iea.org/insights-series-2017-renewable-energy-for-industry.} and individual governments implementing market-based instruments such as auctions.\footnote{According to the IEA, there are 12 market-based instruments for energy efficiency in the EU: AT, BG, DK, FR, IE, IT, LU, MT, PL, SL, ES, UK. Three more countries are to start shortly instruments: HT, HE, LT. The International Energy Agency (IEA), “Renewable energy for industry”, 2017.} The EU has a non-binding 32.5% energy efficiency target by 2030. To meet this target, policymakers will use a range of measures across different sectors. In residential and commercial buildings, it aims at boosting
energy efficiency through the implementation of the Energy Performance of Buildings Directive (EPBD). Buildings account for 40% of Europe’s energy consumption, and two-thirds of Europe’s buildings were built before energy performance standards were set up. Furthermore, the building renovation rate is only around 1% per year. Increasing this renovation rate has the potential to reduce between 5 and 6% of the EU’s total energy consumption and to reduce CO₂ emissions by about 5%. One solution is heating residential buildings with heat pumps. For every kW of electricity consumed by a heat pump, about 4 kW of energy is generated. This high coefficient of performance is expected to improve as technology progresses, while gas boilers would struggle to surpass the top end of their efficiency of 80% from the latest models. Improving energy efficiency in industry is more challenging due to the variety of energy uses, which depend on the specific industrial processes. Until now, the EU has addressed this by setting energy performance standards of manufactured products through the Eco-design Directive and energy labelling. These cover not only household appliances, but also industrial equipment, such as electric motors, water pumps, industrial refrigeration and power transformers. The Eco-design and Ecolabelling policies focus on the number of electricity machines use, rather than on the primary energy use. While the European Commission estimates that Eco-design will deliver energy savings equivalent to the annual energy consumption of Italy by 2020, the transformation of Europe’s energy system necessitates mining a greater fraction of the energy savings potential available in the industry. However, tackling energy efficiency in industry is very complex, especially in the production of base materials such as steel, cement and chemicals. The EU is just starting to plan policies for these sectors. In the transport sector, the policy has focused on tax reduction incentives, stricter emissions and fuel efficiency standards, as

---

15European Commission, Directive on the Energy Performance of Buildings (2018/844/EU), 26 April 2018, available at: http://data.consilium.europa.eu/doc/document/PE-4-2018-INIT/en/pdf.

16European Commission, “New rules for greener and smarter buildings will increase quality of life for all Europeans”, 15 April 2019, available at: https://ec.europa.eu/info/news/new-rules-greener-and-smarter-buildings-will-increase-quality-life-all-europeans-2019-apr-15_en.

17European Commission, “Putting energy efficiency first: Consuming better, getting cleaner”, 30 November 2016, available at: http://europa.eu/rapid/press-release_MEMO-16-3986_en.htm.
well as charging infrastructure deployment. Most of these policies aim at passenger vehicles rather than heavy and long-haul road transportation and shipping. Energy savings could be significant, as battery electric vehicles have 80–90% energy conversion efficiency (tank-to-wheel), which is a higher rate than internal combustion engines’ 30–40% efficiency. This means EVs can drive three to four times the same distance than a combustion engine vehicle with the same amount of energy.

12.2.1.2 Electrification Incentives

Switching energy consumption from fossil fuels to electricity generated with renewables is not possible with existing market signals. Current energy prices often do not reflect true costs. This is partly because fossil fuels benefit from subsidies and tax exemptions, in particular in the country of production.\(^\text{18}\) These subsidy regimes incentivise users to opt for fossil fuel-based heating and transport over electricity. Policymakers, therefore, hold a key lever to address market distortions through fuel and electricity pricing. For example, the ratio between electricity versus gas and oil prices has remained quite stable over time, to the detriment of electric appliances. By revising taxes and levies in retail electricity prices, which average 38% of the final price to consumers, policymakers could reverse this.\(^\text{19}\) Especially because some taxes and levies are unrelated to the energy use. Governments use them for wider tax collection. These taxes hinder the electrification of households and industries. In contrast, tax breaks could shape consumer demand towards clean technologies. Many countries have introduced tax reductions (Germany,

\(^{18}\)According to NGOs, the G20 nations provide four times more public financing to fossil fuels than to renewable energy. Oil Change International, Friends of the Earth, WWF and the Sierra Club, “Talk is cheap: How G20 governments are financing climate disaster”, 5 July 2017, available at: http://priceofoil.org/2017/07/05/g20-financing-climate-disaster/.

\(^{19}\)European Commission, “Energy prices and costs in Europe—Commission staff working document”, p. 38, 2018, available at: https://ec.europa.eu/energy/sites/ener/files/documents/swd_-_v5_text_6_-_part_1_of_4.pdf.
Austria) or bonus payments/premiums for the buyers of electric vehicles (France, the UK, Norway), leading to a significant rise in sales, but recent attempts towards a European approach to energy taxation have stalled. In 2011, the European Commission presented a proposal to revise the Energy Tax Directive to support the EU’s wider environmental and energy goals. The proposal was withdrawn in 2015 following unsuccessful negotiations in the Council of the EU. The European Commission has re-opened discussions in 2019 and could present new policies in 2021.

12.2.1.3 CO₂ Pricing

For many years, the European Emissions Trading System (ETS) has been characterised by a structural imbalance between the demand and supply of CO₂ allowances. This resulted in low carbon prices, which made the system unable to incentivise investments in clean technologies. Instead, investments in renewables have been driven by other policy interventions. In 2018 the EU Member States and the European Parliament agreed on a series of measures to address this. First, they introduced a Market Stability Reserve (MSR), which will remove some of the surplus allowances from the market. This started operating in 2019. In addition, EU lawmakers adopted a broader reform of the ETS to bring it in line with the EU’s 2030 greenhouse gas emissions reduction target of 40%. From 2021 onwards, the linear reduction factor will increase from 1.74 to 2.2%. This political deal also included a considerable strengthening of the MSR. EU lawmakers agreed to double the annual surplus permit take-out rate and cancel those that sit in the MSR from 2023 onwards. This should help to restore demand and supply balance in the carbon market and push carbon prices up. These new policies combined could see prices go up to €30/tCO₂ by 2030. The EU ETS will remain

---

20 100,000 registered EVs in France in 2017 following the introduction of a ‘superbonus’ up to €10,000 in 2015. Vivian Zhou, “3 electric car incentives you need to know in Europe”, The Current, 4 July 2017, available at: https://blog.evbox.com/electric-car-incentives.

21 European Commission, “EU Green Deal - Revision of the Energy Taxation Directive”, 2021, available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12227-Revision-of-the-Energy-Tax-Directive
the central EU policy instrument to regulate CO₂ emissions and deliver effective transition signals. The recently adopted reforms have sent a clear message to the market that scarcity is on the way. An additional tightening of the ETS cap is essential to align the EU’s CO₂ reduction trajectory with the Paris climate goals. A strengthened linear reduction factor will ensure the ETS can drive out Europe’s most polluting assets more quickly bringing the EU’s CO₂ reduction trajectory in line with its long-term climate goals. In addition to properly pricing CO₂ emissions, the ETS could ensure a fairer distribution of costs among energy users. Today, the ETS primarily covers electricity generation, some large industrial plants and emissions from flights between airports located in the European Economic Area. This puts electricity at a competitive disadvantage for energy use in sectors not covered by carbon pricing. For example, the electricity used for shore-side electricity (SSE) is more expensive than the tax exempted fuel commonly used in the auxiliary engines of ships. Sweden asked for—and obtained—a derogation from the energy taxation directive, in order to make SSE tax-free. This put electricity usage in ships on a level playing field with other fuels.

12.3 Bridging the Gap Between Scale and Implementation: Permitting and Administrative Procedures

Energy and climate change policies may set very high long-term ambitions, but policymakers need to ensure they address current and future challenges to realise their objectives. Particularly at the national level if there is a general lack of political support for renewable energy, this could translate into restrictive planning conditions such as stringent minimum distances to housing for wind energy projects. On the

---

22Ecofys, “Potential for shore side electricity in Europe”, 7 January 2015, available at: https://www.scribd.com/document/366724117/Ecofys-2014-Potential-for-Shore-Side-Electricity-in-Europe.

23European Council Implementing Decision authorising Sweden to apply a reduced rate of electricity tax to electricity provided to vessels at berth in a port, 8 April 2011, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52011PC0158.
contrary, when there is political support for developing renewables, then the permitting is facilitated through best practices and more science-based regulation. In general, obtaining permits for building infrastructure is becoming tougher all-around Europe. Especially for wind energy projects and particularly in places where installations started 20–30 years ago: France, Germany, The Netherlands, the United Kingdom and Spain. Spatial planning constraints that limit wind farm developments include strict minimum setback distances to housing, stringent noise limits, high nature safeguarding distances, radar (civil and military) safeguarding distances, wind turbine blade tip height restrictions or long lead times to obtain the necessary permits and authorities and communities consent to build projects, especially in the case of onshore wind.

As renewables scale-up, stakeholders’ expectations could become challenging to meet in every single project. Unfulfilled expectations and poorly managed impacts could cause project opposition. Despite this, renewables benefit from a positive perception across most of the population in Europe; Nearly half of Europeans think that the EU should invest and develop in clean energy technologies as a priority in the next ten years. Nevertheless, developers face increasing delays in obtaining permits to build projects. This delays the pace at which renewables are deployed and jeopardises the achievement of policy targets. The main impacts of permitting delays are linked to increased project costs, limited use of the latest available technology and bank financing. Regarding increased project costs, for example, a legal dispute causes the total project cost to increase due to diverging from the planned construction schedule, and modifying some contracts could be subject to penalties. Concerning the limited use of the latest available technology, the application for building a project submitted to the permitting authority includes, among other items, the proposed wind turbine model. If the proposed project is blocked for several years, the proposed turbine model becomes obsolete. Consequently, the project developer may need to file a new permit application if it wants to use a different (e.g. the latest) wind turbine model. This leads to additional costs and time. Moreover,

---

24European Commission, “Eurobarometer survey confirms public support for energy policy objectives”, 11 September 2019, available at: https://ec.europa.eu/info/news/eurobarometer-survey-confirms-public-support-energy-policy-objectives-2019-sep-11_en.
in many countries, permits are issued for a determined period and may expire before even getting the consent to start building. Regarding bank financing, it has to be noted that banks are more likely to lend money for projects if the consenting risks are lower, or if there would be financial mechanisms in place, e.g. insurance to cover the risk of being denied consent, or longer consenting periods than initially envisaged. There are key indicators for planning and consenting wind energy projects that could facilitate or make more difficult their deployment. These are the setback distance, nature safeguard distances, noise limits and overall timing to obtain a permit. In some countries, restrictions imposed by civil and military aviation are critical too, but for simplicity, these are left out from this text.

12.3.1 Setback Distance

The minimum distance to housing (also known as ‘setback distance’) means the necessary minimum distance between the wind turbine generators and residential properties. Minimum distances can be a fixed distance or a distance relative to the turbine height (e.g. ten times the turbine tip height or rotor diameter). The rationale for setting minimum distances to housing is usually to avoid health hazards that may result from noise exposure, shadow flickering or accidents. Landscape (visual) impacts from siting wind farms close to communities are also considered in the planning phase. However, setback distances may be prone to subjective judgements and in some cases to serve political agendas despite evidence of no hazards imposed by wind energy projects to surrounding settlements or individual houses/buildings.

12.3.2 Nature Safeguard Distances

Most countries have established nature safeguarding distances to protect endangered species of birds and bats, including nesting, roosting and nursery areas in the vicinity of wind farms. Distances range between 1 and 10 km. However, legislation across countries varies significantly.
12.3.3 Noise Limits

Most European countries have national legislation in place to deal with the noise caused by all human activities, including wind turbines. Allowable environmental noise limits are usually categorised by area and timing. Maximum levels vary from 39 to 55 decibels dB(A) during the day and 5 to 10 dB(A) at night. However, maximum allowable noise limits vary widely between countries. One of the reasons for the large spread is the various methodologies used to measure noise (where, when, how is the measure done). Many bases their noise limits on international bodies’ recommendations, but this approach has shortcomings. For example, the World Health Organisation’s (WHO) Environmental Noise Guidelines set recommendations on environmental noise exposure for five relevant sources: road traffic, railway, aircraft, wind turbine and leisure. For wind turbines, it recommends noise levels to below 45 dB (A). However, this recommendation is only conditional because it recognises there is not enough scientific evidence. Moreover, the guidance does not specify a methodology to measure or assess compliance. And it does not include recommendations for night noise exposure. WHO recognises that the quality of evidence of night-time exposure to wind turbine noise is too low to give a recommendation. It only specifies that authorities should implement suitable measures to reduce noise exposure from wind turbines in the population exposed to levels above the guideline values. However, it falls short of recommending any particular type of intervention over another.

---

25World Health Organisation, “Environmental noise guidelines for the European Region”, 2018, available at: http://www.euro.who.int/__data/assets/pdf_file/0008/383921/noise-guidelines-eng.pdf?ua=1.

26According to WHO, a conditional recommendation requires a policy-making process with substantial debate and involvement of various stakeholders. There is less certainty of its efficacy owing to lower quality of evidence of a net benefit, opposing values and preferences of individuals and populations affected or the high resource implications of the recommendation, meaning there may be circumstances or settings in which it will not apply.
12.3.4 Time for Permitting

The overall permit granting process takes into account both the administrative (or planning) procedure and the grid access procedure. These two procedures could run in parallel or one after the other. The overall time for permitting starts when the first application is made to a permitting authority or grid operator and ends when all main permits and grid access is obtained. Article 16 of the revised Renewable Energy Directive states that the permit granting process shall not exceed ‘2 years for new projects with a maximum delay of 3 years (“2+1” rule)’, and ‘1 year for repowered projects with a maximum delay of 1 year (“1+1” rule)’. These permit granting deadlines include neither Environmental Impact Assessment nor legal challenges. 27

12.4 Bridging the Gap Between Scale and Implementation: Increase the Power System Flexibility

The market design legislative proposals in the 2018 ‘Clean Energy Package for All’ from the European Commission, comprised a wide set of changes across four main areas: power system flexibility, institutional framework, playing-level field, investment environment. It introduced an emphasis on short-term trading, the role of demand response and storage. And it focused on improving regional cooperation, reinforce regulatory oversight, and the access, operation and planning of the power grids through European Network Codes. The package, comprising eight pieces of regulation, was meant to level playing field participation conditions for renewable market players. It addressed balancing responsibilities, dispatch and re-dispatch rules and access to ancillary services. Also, it was supposed to address resource adequacy and capacity mechanisms. This set of regulations made significant progress in integrating

27EU Directive on the promotion of the use of energy from renewable source (recast) EU 2018/2001, 11 December 2018, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG.
more renewables into the power system under the policy goal of setting an electricity market for renewables and renewables set for the market.

12.4.1 Market for Renewables and Renewables for the Market

One of the key issues for integrating renewables in a liberalised energy market is to adapt the rules for electricity trading so that these reflect the intrinsic characteristics of renewable energy generation. Wind speed and solar radiation are variable across different time frames, and their intensity needs to be forecast for electricity generation. Therefore, the rules for electricity trading needed to address this variability and uncertainty of forecast across different time frames. This is important as market rules set the way electricity prices are formed, determining the revenues for all generators. The EU-funded project MARKET4RES was one of many studies that identified the adaptations needed to facilitate renewable energy integration into the market. It recommended the following:\(^\text{28}\).

12.4.2 Faster Markets

Large amounts of wind and other variable renewables in the power system require that the timing of markets allow for changes such as updated power demand, weather patterns variations and the consequent changes in electricity generation. Concretely, this means that Transmission System Operators (TSOs) should operate the system as close as possible to real time (gate closure time) while ensuring system security and stability assessments. This gives variable generators the opportunity to correct their deviations as their forecast improves considerably closer to the time of energy delivery.

\(^\text{28}\)Daniel Fraile et al., “Guidelines for implementation of new market designs in Europe with high shares of RE-E penetration (post-2020)\)” MARKET4RES D6.2, October 2016, available at: http://market4res.eu/wp-content/uploads/Market4RES_WP6_D6-2-FINAL.pdf.
12.4.3 Larger Markets

The variability of wind power output smooths out when the generation profile of several wind farms is aggregated across large geographical areas. To take advantage of this, system operators need close cooperation to enlarge markets and connect these areas. System operators also need sophisticated methods to allocate transmission capacity closer to real time.

12.4.4 Smaller Products

Traditionally fossil fuel-fired power generation sells electricity with very large blocks of energy days, weeks, months and even years ahead of delivering it. Trading wind energy, on the other hand, is easier using small timeframe products. This is because its predictability improves at shorter timeframes. Smaller products allow for the possibility to adjust offers closer to real time. For example, in Germany, the 15-min electricity trading in the intraday market has successfully facilitated the management of renewable energy variability compared to the previous hourly based contracts. It has also helped to reduce the risks from balancing responsibilities. Wind energy forecast errors reduced by half between a day-ahead forecast and one hour-ahead forecast.

12.5 Bridging the Gap Between Scale and Implementation: Financing Renewables

Up to now, the wind industry remains a major investment opportunity, with €19 bn raised in 2019 for the construction of new wind farms. But most EU countries are failing to provide investment predictability beyond 2020 despite being required to do so by the Renewable Energy

---

29WindEurope, “Wind energy in Europe in 2019. Trends and statistics”, p. 23, 2020, available at: https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Statistics-2019.pdf.
Directive and the Governance Regulation. Such uncertainty slows downs the commitment of funds available for investing in renewables and threatens the realisation of climate objectives. Another key issue for the integration of renewables in liberalised energy markets was the compatibility of state aid instruments to support the deployment of technologies. These instruments needed to become more market-based so that any distortion to the competition is minimised. Renewable energy support mechanisms moved away from feed-in tariffs, to market premiums awarded through competitive auctions. This means that as technologies mature, investors are in a better position to take on more risks that used to be covered by governments. As seen in Fig. 12.1, more than 65% of the installed capacity will be partially exposed to power markets, and more than 25% will be fully exposed. Some projects are even expected to be built without any financial government support.

Short-term spot market prices on their own may not provide a basis for investment. In the absence of policies that address structural market failures, there would be no merchant investments in any power generation asset, including conventional technologies. The bar for investment in wind energy assets is even harder to clear. They are upfront capital-intensive assets, and current hedging options are limited or not widely used. Full exposure to merchant conditions raises financing costs by deterring low-risk investors. In addition, the market value of wind energy

![Fig. 12.1 Share of new wind capacity per type of support (Source WindEurope [2018])]
tends to decrease as its penetration rate increases as wind farms capture lower spot market prices than other generators. This revenue attrition of wind energy projects requires to complement, their spot market revenues with a long-term revenue stabilisation mechanism.

12.5.1 Revenue Stabilisation Mechanisms

Because an Energy-only Market approach is unlikely to deliver long-term investment signals, market-friendly revenue stabilisation mechanisms will still be needed by investors to secure their revenues. There are two main approaches: production-based and investment-based mechanisms. The former provides operators with an operating premium for the actual output sold on the market, which can be fixed and defined ex-ante (Denmark, onshore), or sliding, i.e. evolving as the difference between a strike price and a reference market price. The investment-based scheme provides compensation based on the installed capacity and the expected energy production (Spain). The former exposes more to the volume risk and the latter expose more to the price risk. Both fill the gap between the anticipated project costs, and it is expected revenues over a given period. The delivery conditions of the mechanisms will influence the risk allocation between investors and consumers. The key features to consider are: (a) whether the support remunerates all the energy produced (France, Germany) or only a certain number of full load hours (Denmark). The former minimises investors’ risks while the latter incentivises demand-oriented feed-in and facilitates participation in markets such as balancing or re-dispatch (although at a higher risk for investors). (b) the benchmark against which the reference market price is calculated, either the average baseload price (the Netherlands) or the specific price received in each specific hour (e.g. Italy), and (c) the frequency that

---

30 See WindEurope, “Creating a business case for wind after 2020”, January 2017, available at: https://windeurope.org/wp-content/uploads/files/policy/position-papers/WindEurope-Long-Term-Investment-Signals.pdf.
31 MIT Energy Initiative, “Revisiting support policies for RES-E adulthood”, 2016. Green certificates are excluded since their use is restrained to a few countries.
32 Germany (Market Premium), The Netherlands (SDE+), France (“complément de remuneration”), the UK (CfD) etc.
the premium is adjusted to: Investors’ risk is minimised if the premium covers hourly price deviations, while longer periods encourage to perform better than the market outcome with sophisticated bidding strategies (month in Germany, year in Spain). To ensure greater control of policy costs, some countries are also implementing a price floor over the whole contract period, as seen in Fig. 12.2 for the Netherlands. Others, like the UK seen in Fig. 12.3, have a two-sided Contract for Difference, whereby the premium can become negative, i.e. the operator pays back any excess revenues above the strike price.

These revenue stabilisation mechanisms are awarded via competitive auctions. Since 2014, Member States have launched auctions for wind energy and other renewables as prescribed by the EU’s State Aid Guidelines. However, the transition to auctions was not straightforward. Many countries struggled with auction design and made changes in view of accommodating different policy objectives. EU Governments

**Fig. 12.2** Netherlands SDE+ scheme (Note The compensation (blue bars) is determined as the difference between the expected projects costs (green dotted line) and the yearly average electricity price (orange line). A price floor (red dotted line) is determined as 2/3 of the long-term average electricity price (orange dotted line). During years 7–11, the compensation is capped and does not suffice to cover expected projects costs (red bars). However, during years 13–15, the plant income is larger than expected (green bars). Source Adapted from Energy Research Centre of The Netherlands [2011])**
and industry are still learning, and additional practice will be necessary to make auctions fit national circumstances. In addition to the good practice tender design principles, there are non-regret features of auction design for immediate application by national policymakers: These include:

- **Visibility on future auctions**: Long-term forward visibility is key to industrial planning. This allows players to realise long-term investments in factories, skills development, test facilities, research and innovation. These investments optimise economies of scale and efficiencies across the supply chain that allow the industry to drive costs down. A long-term schedule for public support allocation over multiple years, including the timing, capacity and budget for auctions as prescribed in the post-2020 Renewable Energy Directive.

- **Transparent auction design and rules**: When auction rules are complex, there is more risk for participants, who reflect this in their bids. This increases final prices. Transparency, simplicity and clarity of

---

33EWEA, “Design options for wind energy tenders”, December 2015, available at: http://www.ewea.org/fileadmin/files/library/publications/position-papers/EWEA-Design-options-for-wind-energy-tenders.pdf.
rules instead go a long way in attracting bidders and cutting costs. The process towards launching an auction should include consultation and open dialogue between governments and investors on the auction design. Stakeholders should strive to secure simple and straightforward selection criteria, for example, payment arrangements and awarding mechanism. Price-only is the preferred award mechanism. It offers an objective comparison between bids as opposed to qualitative assessment between projects. Crucially for investors, is that the remuneration awarded is not subject to retroactive modifications.

- Technology baskets: Auctions could be technology-specific or technology-neutral. Regardless of their design, auctions must take into account the technical characteristic of technologies, for example, their risk profile, project lead times, size and costs, and put into comparable competition technologies. Member States should have the possibility to run technology-specific auctions to tap into a broad mix of technologies with different generation profiles that complement each other on the grid.

- Compulsory consented permits to participate in the auction: auctions are successful only if awarded projects are built. Having the consent and other relevant permits from authorities to build the project, ensures that bidders compete against each other on a level playing field and projects will be delivered if awarded. Mandatory permitting is of particular importance to onshore wind. In contrast, governments should apply flexibility on compulsory permitting for offshore wind due to longer lead times. Crucially, the simplification of administrative and permitting procedures is key to the investors’ ability to participate in auctions. Authorities should strive to shorten permitting timelines and align them with auction schedules.

- Set construction deadlines: These guarantee the construction of projects to meet government objectives. Taking into account lead times ensures that there would be no mismatch between the latest technology available on the market and what is installed. The consequences of missing construction deadlines because of unforeseen events, however, should be calibrated and should not result in disproportionate penalties for the developers.
As technologies and markets evolve, future auction design should consider:

– Geographically balance of projects: Locational signals depending on proximity to demand, wind resource availability or grid infrastructure availability could balance the geographic distribution of wind energy projects in line with national circumstances.

– Repowering: Many wind energy projects will reach the end of their operational lifetime between 2020 and 2030. Future auctions should ensure that the decommissioned projects are added on top of the announced auction volumes. Moreover, auctions should allow repowered projects to compete for state aid compatible support schemes.

– Increased grid connection requirements: Current auctions do not reflect the increasing set of grid connection requirements. The lack of clarity regarding future grid connection requirements might undermine the ability of developers to realise their projects at the costs foreseen in their bids today. Reducing the lead time for projects and introducing a reasonable transition period to comply with grid codes could form part of future auction qualification criteria.

– Cross-border auctions: With increased emphasis on regional cooperation in the post-2020 European targets for renewables, cross-border auctions could increase. The voluntary opening of support schemes between countries could serve as a first step for exploring new ways for deploying renewables. However, Member States should tackle the impact of different regulatory regimes on the competitiveness of projects if they are to attract bidders.

### 12.5.2 Availability and Cost of Capital

Financing costs make up a considerable portion of the overall cost of a project. Therefore, it is critical for policymakers to understand the availability of capital and the implications in the cost of capital of their policies. The majority of the installed wind capacity in Europe has been financed on a non-recourse basis, typically referred to as project finance. Around 75% of Capex for onshore wind and 30% for offshore
wind projects are raised with project finance.\footnote{\textit{WindEurope}, “Financing and investment trends. The European wind industry in 2017”, April 2018, available at: https://windeurope.org/wp-content/uploads/files/about-wind/reports/Financing-and-Investment-Trends-2017.pdf.} Due to the non-recourse characteristic, meaning that in case of bankruptcy lenders do not have recourse to other assets but the project asset itself, is generally considered a lower-risk investment, as demonstrated here in Fig. 12.4, and therefore comes with lower-cost financing compared to equity.

A merchant environment might introduce limitations on the availability of debt. Lenders are used to some elements of merchant financing, predominantly in the certificate-based support scheme countries such as the Nordic markets or the now discontinued UK’s ROC regime. However, full merchant exposure might tighten the requirements for raising debt, introduce higher cover ratios and financial covenants that a project might not be able to fulfil. Sponsor equity will then have to fill this gap. But in economic conditions when debt costs less than equity,
as today is the case, this would translate into a higher cost of capital for the project. A merchant environment will also introduce limitations on equity by making it harder for investors to exit projects post-construction and recycle capital in additional projects. While many investors are becoming more comfortable with the risks that wind and other renewables have, they remain risk-averse to full merchant exposure. Many financial investors cannot hedge merchant risk with large portfolios of assets given that their primary business is not energy production like large utilities. Financial investors would typically own smaller portfolios of assets geographically spread over a few countries.

12.5.3 PPAs

Some emerging merchant financing in the wind sector will require some form of additional revenue stabilisation complementary to support mechanisms. Corporate renewable power purchase agreements (PPAs) come with certain benefits for generators to hedge the volatility of their revenues like price visibility over a long period and a guaranteed offtake of their energy. These elements are important to lower the cost of debt financing. Lenders would typically need protection to ensure debt repayment obligations are met. Consequently, lenders tend to prefer lower revenues over a long period rather than higher but uncertain ones. Corporate renewable PPAs to date is still a niche market and not to the scale necessary to replace other policy-driven revenue stabilisation mechanisms. They limited to a handful of countries. The Nordic region followed by the UK and the Netherlands are the biggest markets for such deals. These markets share a good track record in renewable energy development, coupled electricity markets, sufficient demand for green electricity from corporates and, the legislation does not pose a barrier to signing these PPAs. Another key factor is the existing government support mechanism for renewables in the country. In countries with feed-in tariffs, the developer would not need to lock in long-term power prices with a corporate off-taker. The government feed-in tariff guarantees the price. Conversely, green certificate-based support regimes such as in the Nordic region or the (now phased-out) UK ROC scheme need
a long-term power hedge to secure price certainty. This explains the significant uptake of corporate renewable PPAs in these countries. For corporate PPAs to continue growing, it is key is to ensure that future revenue stabilisation mechanisms allow for the revenue from a corporate renewable PPA to stand in conjunction with any form of government support. To ensure there are no double compensation project owners factor-in both the expected revenue of the PPA and the Guarantees of Origin (GO). Off-takers will tend to buy these two bundled products: the electricity produced as well as the GO that verifies the source of electricity. The of a government off-taker with a corporate off-taker comes with the benefit of reduced government expenses for renewable energy support.

### 12.6 Conclusions

Europe has been a pioneer in the deployment of renewable energy. These technologies have been known to humans for a long time, but it has taken a few crises for policymakers and investors to put them at play on a large scale. For example the 1973 oil crisis, when governments around the world realised the fragility of the supply chain of this fossil fuel, or the current climate change crisis, which is demanding urgent mitigation and adaption measures to avoid dangerous temperature increases and other meteorological phenomena. During the drafting of this book, another crisis, this time health-related due to the COVID-19 pandemic, is hitting the world. The repercussions are still unknown, but the global economy is expected to hit the worst recession since the end of the last world war as countries locked down and stopped all economic activities for months. Against this background, there are calls for the economic recovery to be based in line with policies implemented to mitigate or avoid previous crises. A ‘green recovery’ is touted and Europe is again pioneering it. As seen in this chapter, Europe is facing formidable challenges to meet its international commitments to mitigate climate change. It will be even harder to do so during a new economic crisis. Still, the opportunities stand even stronger and Europeans should grab them to not lose their first-mover advantage.
First, European policy should pursue an renewables-based electrification. Using renewable electricity wherever it is available and whenever it is possible, can deliver the bulk of decarbonisation needed for the economy. The investments such strategy requires can lift economies from crises. So, setting only energy policies to this end will not suffice. As analysed in this chapter, economic, environmental, trade and even fiscal policies would need to align towards this strategy. I presented three levers to start with: energy efficiency in buildings and industry, electrification incentives including taxation and a stronger CO\textsubscript{2} pricing. Second, deploying renewables at the speed and scale needed to significantly flatten the climate change curve will require streamlined administrative procedures and permitting. Even if we achieve the proper economic and energy policies, governments need to ensure that they address issues ‘on the ground’. Obtaining permits for building, and improving, infrastructure is becoming tougher all-around Europe. As renewables scale-up, stakeholders’ expectations could become challenging to meet in every single project. Unfulfilled expectations and poorly managed impacts can cause project opposition and policymakers react with even more stringent permitting requirements. Third, as renewables expand, the flexibility of the energy system will need to be increased. Policy should be adapted nimbly to adjust the rules for electricity trading to reflect the characteristics of renewable energy generation. Larger and faster markets and smaller energy trades are more suitable to address uncertainty and variability of weather-dependent renewables.

Lastly, enabling the conditions for the continuation of investments will be critical. Renewables are high capital-intensive assets, with low operational costs and marginal costs of electricity generation close to zero. Because an energy-only market approach is unlikely to deliver long-term investment signals, market-friendly revenue stabilisation mechanisms will still be needed by investors to secure their revenues. Together with the availability and cost of capital, revenue stabilisation is a crucial enabler for expanding renewables. As new approaches to finance renewables emerge, such as corporate PPAs, Europe will face new risks and challenges, but none of these will be greater than the dangers posed by
climate change and the destruction of our economies due to recurrent crises.

References

Agora Energiewende and Sandbag, “The European power sector in 2019”, 2020, available at: https://sandbag.org.uk/wp-content/uploads/2020/02/Sandbag-European-Power-Sector-Review-2019.pdf.

Agora Energiewende and Sandbagm, “The European power sector in 2019”, 2020, available at: https://ember-climate.org/global-electricity-review-2020-data/.

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions—20 20 by 2020—Europe’s climate change opportunity, 23 January 2008, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52008DC0030.

Ecofys, “Potential for shore side electricity in Europe”, 7 January 2015, available at: https://www.scribd.com/document/366724117/Ecofys-2014-Potential-for-Shore-Side-Electricity-in-Europe.

Energy Research Netherlands, “Aanvullend onderzoek correctiebedragen SDE+-regeling”, 2011, available at: https://publicaties.ecn.nl/PdfFetch.aspx?nr=ECN-E–15-070.

EU Directive on the promotion of the use of energy from renewable source (recast) EU 2018/2001, 11 December 2018, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG.

European Commission, “2030 climate & energy framework”, https://ec.europa.eu/clima/policies/strategies/2030_en.

European Commission, “An EU Strategy on heating and cooling SWD (2016) 24 Final”, 2016, available at: https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_ACT_part1_v14.pdf.

European Commission, “EU Green Deal - Revision of the Energy Taxation Directive”, 2021, available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12227-Revision-of-the-Energy-Tax-Directive.

European Commission, “Commission staff document. Executive summary of the impact assessment SWD (2013) 532 final”, 18 December
European Commission, Directive on the Energy Performance of Buildings (2018/844/EU), 26 April 2018, available at: http://data.consilium.europa.eu/doc/document/PE-4-2018-INIT/en/pdf.

European Commission, “Energy prices and costs in Europe—Commission staff working document”, p. 38, 2018, available at: https://ec.europa.eu/energy/sites/ener/files/documents/swd--v5_text_6--part_1_of_4.pdf.

European Commission, “Energy security strategy”, p. 1, 2015, available at: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52014DC0330.

European Commission, “Eurobarometer survey confirms public support for energy policy objectives”, 11 September 2019, available at: https://ec.europa.eu/info/news/eurobarometer-survey-confirms-public-support-energy-policy-objectives-2019-sep-11_en.

European Commission, “In depth analysis in support of the Commission Communication COM (2018) 773, A Clean Planet for all. A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy”, 28 November 2018, available at: https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf.

European Commission, “New rules for greener and smarter buildings will increase quality of life for all Europeans”, 15 April 2019, available at: https://ec.europa.eu/info/news/new-rules-greener-and-smarter-buildings-will-increase-quality-life-all-europeans-2019-apr-15_en.

European Commission, “Putting energy efficiency first: Consuming better, getting cleaner”, 30 November 2016, available at: http://europa.eu/rapid/press-release_MEMO-16-3986_en.htm.

European Council Implementing Decision authorising Sweden to apply a reduced rate of electricity tax to electricity provided to vessels at berth in a port, 8 April 2011, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52011PC0158.

European Environmental Agency, “Total greenhouse gas emission trends and projections in Europe”, last modified, 19 December 2019, available at: https://www.eea.europa.eu/data-and-maps/indicators/greenhouse-gas-emission-trends-6/assessment-2.

EWEA, “Design options for wind energy tenders”, December 2015, available at: http://www.ewea.org/fileadmin/files/library/publications/position-papers/EWEA-Design-options-for-wind-energy-tenders.pdf.
Fraile, Daniel et al., “Guidelines for implementation of new market designs in
Europe with high shares of RE-E penetration (post-2020)”, MARKET4RES
D6.2, October 2016, available at: http://market4res.eu/wp-content/upl
oads/Market4RES_WP6_D6-2-FINAL.pdf.
International Energy Agency (IEA), “Renewable energy for industry”, 2017,
available at: https://webstore.iea.org/insights-series-2017-renewable-energy-
for-industry.
MIT Energy Initiative, “Revisiting support policies for RES-E adulthood”,
2016.
Oil Change International, Friends of the Earth, WWF and the Sierra Club,
“Talk is cheap: How G20 governments are financing climate disaster”, 5 July
2017, available at: http://priceofoil.org/2017/07/05/g20-financing-climate-
disaster/.
UK Government White Paper. EMR Settlement Limited, “Contracts for differ-
ence explained”, available at: https://www.emrsettlement.co.uk/about-emr/
contracts-for-difference/.
WindEurope, “Creating a business case for wind after 2020”, January
2017, available at: https://windeurope.org/wp-content/uploads/files/policy/
position-papers/WindEurope-Long-Term-Investment-Signals.pdf.
WindEurope, “Financing and investment trends. The European wind industry
in 2017”, April 2018, available at: https://windeurope.org/wp-content/upl
oads/files/about-wind/reports/Financing-and-Investment-Trends-2017.pdf.
WindEurope, “Sustaining a cost efficient energy transition in Europe”, June
2018, available at: https://windeurope.org/wp-content/uploads/files/policy/
position-papers/WindEurope-Sustaining-a-cost-efficient-energy-transition-
in-Europe.pdf.
WindEurope, “Wind energy in Europe in 2018. Trends and statistics”, 2019,
available at: https://windeurope.org/wp-content/uploads/files/about-wind/
statistics/WindEurope-Annual-Statistics-2018.pdf.
WindEurope, “Wind energy in Europe in 2019. Trends and statistics”, 2020,
available at: https://windeurope.org/wp-content/uploads/files/about-wind/
statistics/WindEurope-Annual-Statistics-2019.pdf.
World Health Organisation, “Environmental noise guidelines for the European
Region”, 2018, available at: http://www.euro.who.int/__data/assets/pdf_file/
0008/383921/noise-guidelines-eng.pdf?ua=1.
Zeniewski, Peter, “A long-term view of natural gas security in the European Union”, International Energy Agency, 13 March 2019. https://www.iea.org/commentaries/a-long-term-view-of-natural-gas-security-in-the-european-union.

Zhou, Vivia, “3 electric car incentives you need to know in Europe”, The Current, 4 July 2017, available at: https://blog.evbox.com/electric-car-incentives.