DECARBONISING THE ENERGY SYSTEM

The role of Transmission System Operators

Terna Driving Energy

Rte Le réseau de transport d'électricité

elia group Elia | 50Hertz | EGI

TenneT

amprion connects

RED ELÉCTRICA DE ESPAÑA

swissgrid

Austrian Power Grid APG

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Front page image from 50Hertz/Jan Pauls

EXECUTIVE SUMMARY

European electricity transmission system operators (TSOs) contribute to the objective of mitigating global warming, which is outlined in the 2015 Paris Agreement. This was signed by the European Union (EU) and its neighbouring countries, including Switzerland. TSOs are fully committed to enabling a secure and efficient transition towards a greener Europe - one in which renewable energy sources (RES) are widely available and in which energy is used as efficiently as possible.

The EU and Switzerland are set to become climate-neutral by 2050, delivering on their commitment to achieving an inclusive, fair and green transition. This objective is at the heart of the European Green Deal, which includes the goal of cutting greenhouse gas emissions by at least 55% (when compared with 1990 levels) by 2030. The related “Fit for 55” package comprises a set of legislative adaptations covering wide-ranging policy areas, including renewables, energy efficiency, energy taxation and greenhouse gas (GHG) emission schemes, among others.

Reaching this ambitious goal requires all parts of society to actively work together. A systemic, integrated approach to decarbonisation, where demand and supply are matched at the least cost, needs to be adopted. The production and use of energy across all sectors of the EU economy account for more than 80% of the EU’s GHG emissions[1], with similar levels in strongly interconnected neighbouring countries.

Direct electrification coupled with energy efficiency and the growing share of renewable generation are the primary tools for decarbonising the energy sector.

Electricity will play a key role in the decarbonisation of the economy thanks to the higher efficiency of electrical end uses and the integration of mature renewable generation sources into the system (such as wind, solar, hydro and biomass). This has been confirmed by all long-term energy scenarios[2], which predict that there will be a widespread adoption of electrical assets (such as electric vehicles and heat pumps) and electrification of industrial processes. All future energy scenarios also confirm that the electricity network will become the backbone of a greener energy system. Replacing fossil fuels with electricity produced by low carbon energy sources is already the fastest and most mature solution for decarbonising most sectors of the European economy, including the light transport, residential and service sectors. Electricity is expected to cover more than 50% of end use consumption in 2050, as outlined in EU long-term energy scenarios[2] (in comparison with 23% today[3]).

However, in order for carbon neutrality to be reached in some “hard-to-abate” sectors (in which technical and economic constraints prevent the use of electricity), direct electrification will need to be complemented with the production and/or import of green molecules, such as hydrogen and green fuels. These molecules will be mostly produced via Power-to-X technologies, thus bolstering the importance of integrating low carbon electrical sources - especially renewable generation sources - into the system.

The central role that TSOs will play in this increasingly complex, interconnected and variable energy system means that their contribution is crucial for achieving Europe’s climate goals.

This is why a group of leading European TSOs including Terna (IT), RTE (FR), Elia Group (BE and DEU), TenneT (NL & DEU), Amprion (DEU), Red Eléctrica (ES), Swissgrid (CH) and APG (AUT) have worked together to clarify and assess the contribution of TSOs to the decarbonisation of the energy system.

TSOs will provide the EU and Member States with their unique and neutral expertise in order to promote the establishment of a secure and efficient interconnected power system that will support socioeconomic prosperity.

They have welcomed Europe’s work and efforts towards decarbonisation and have embedded sustainability in their approach to the development and operation of their electricity networks. TSO contributions to reducing GHG emissions fall under two categories.

Firstly, TSOs are contributing to the decarbonisation of Europe by reducing and limiting the carbon footprint of their own activities and value chains respectively.

In line with international GHG emission standards, TSOs monitor their direct and indirect GHG emissions and implement measures to reduce them. They do this through reducing SF_6 leaks, replacing SF_6 gas with less harmful alternatives when technologically feasible; they efficiently develop their infrastructure to limit grid losses and partially offset the expected increase which occurs in proportion to electricity flows on the network; and they undertake energy efficiency measures in their switching stations and buildings, implement green procurement procedures and adopt circular economy approaches.

1. Emissions of the energy sector compared to total EU28 emissions in 2019 (Source: Eurostat – Data Explorer – June 2021).
2. Based on EU long term energy scenarios and in particular the scenario 1,5 Tech of the EU long term strategy (Source: JRC Technical Reports - Towards net-zero emissions in the EU energy system by 2050).
3. Based on 2019 Eurostat energy balance (version 2021).

Secondly, TSOs are playing a leading role in enabling the energy transition by taking on the major challenge of integrating renewable generation and flexibility resources into the energy system and supporting the direct and indirect electrification of different sectors of the economy.

The core of TSO activities and responsibilities is to ensure the secure and high-quality delivery of electricity across national and interconnected transmission grids which are the backbone of the European electricity system they operate. TSOs are responsible for maintaining the electrical frequency at 50Hz every second across the European interconnected synchronous system. They apply their independent expertise to develop reliable and efficient interconnected grids and related grid access mechanisms under the supervision of regulatory agencies. However, the role TSOs play has been widening. They have to manage an increasingly complex and digitalised energy system on the path towards carbon neutrality; this system is one in which the share of intermittent RES is growing and consumers are gradually being empowered to take on active roles. TSOs are, therefore, currently playing the role of energy transition enablers, since they are facilitating the decarbonisation of the European electricity system and, consequently, the decarbonisation of society as a whole, using complex and innovative tools to do so.

The main tools used by TSOs in their role as enablers include the expansion and development of the power transmission grids; the integration of flexible assets and services into the system (to facilitate demand side response, storage and sector coupling), encouraging associated developments in market design and regulatory frameworks; and participation in debate and analytical assessment related to the future design of electricity markets, capacity mechanisms and congestion markets, so playing a pivotal role in assessing challenges and proposing solutions for an efficient integration of renewables into markets and grids.

Digitalisation and investments in research and development are additional key approaches used to ensure effective RES integration and the electrification of consumption. These tools either directly contribute to GHG emission reduction or indirectly contribute to enhancing system reliability, ensuring a high level of security, the proper functioning of markets and delivering value to end users as the system adapts to higher levels of renewables. For example, interconnections can be used to carry RES surplus from one country to another which still relies on fossil fuels generation, thus directly contributing to a reduction in the overall emission factor of its generation mix. More broadly, the interconnection of electricity systems means that local variations in electricity generation are averaged out, which is particularly useful for integrating increasing shares of renewable sources into national electricity mixes. Interconnections also indirectly contribute to enhancing system reliability on a broader geographical scale, mutualising flexibility resources too.

It seems clear, then, that the crucial role TSOs are playing in the energy transition can only be fully appreciated when their contribution to the system as a whole is considered. Indeed, whilst the magnitude of an individual TSO's direct and indirect emissions currently reaches 1 million tCO_2eq per year on average, the decarbonisation impact that all European TSOs could have on the energy system as a whole could reach up to 3 billion tCO_2eq. per year[4].

Given this crucial role, an assessment of the performance of a TSO with regards to sustainability and decarbonisation should not stop at annual evaluations of its carbon footprint. Instead, the impact that a TSO has on the decarbonisation of the system as a whole, which will ultimately also contribute to the reduction of its carbon footprint, should be considered. The expansion and development of TSO activities are therefore to be recognised as active contributions to furthering the electrification and decarbonisation of society.

As a concrete example, whilst the development of a new line connecting a TSO's onshore grid to a wind farm will lead to an increase in its individual carbon footprint, there will be a net decrease in carbon emissions across the system due to the integration of carbon-free electricity over the lifetime of the farm.

To bolster their activities, TSOs need to be recognised as enablers of the energy transition at European level.

TSO activities, which lead to system-level emission reduction, need to be explicitly mentioned in GHG emission inventories under common assessment and monitoring frameworks, in addition to GHG emission sources already associated with their carbon footprint.

4. EU28 GHG emissions in 2019 for the energy sector according to Eurostat (3,3 billion tons of CO_2eq emissions of the energy sector vs approximately 3,8 billion tons of CO_2eq emissions across all sectors).

Table of contents

01

Introduction 5

02

The role played by electricity in the decarbonisation of the energy system 7

03

How TSOs contribute to GHG emission reduction 9

Introduction 9

Reducing the carbon footprint of TSO activities 11

Contributing to system-level GHG emission reduction 14

Revealing the full decarbonisation potential of TSOs 21

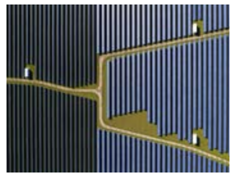
04

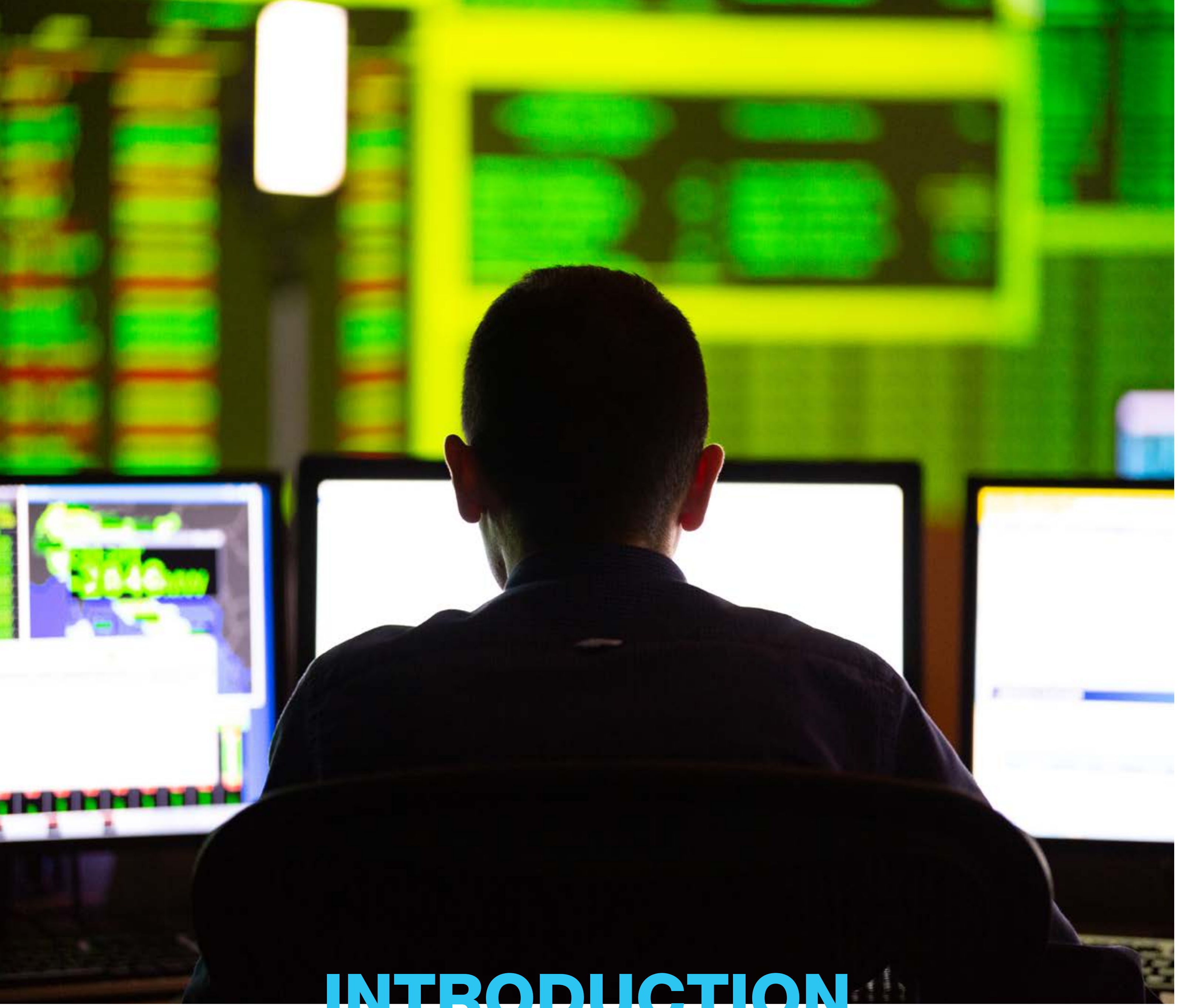
Annex 22

Glossary 22

Introduction to the European cost-benefit analysis 23

Direct electrification: focus on France 23





INTRODUCTION

The persistent increase in greenhouse gas emissions, their harmful effects on ecosystems and the growing attention paid to climate and environmental issues highlight that the energy model that fuelled the growth of the global economy during the last century is no longer sustainable. A worldwide commitment is required to progressively reduce natural resource consumption, increase energy efficiency and decarbonise all energy sectors. Acting now is essential.

The EU has been at the forefront of international efforts to fight climate change since 1990. As part of this work, it played a leading role in the realisation of the 2015 Paris Agreement, which was the first universal, legally binding global climate change agreement. 190 governments agreed on the long-term goal of keeping the global average temperature increase to well below 2°C (preferably to 1.5°C) in comparison with pre-industrial levels.

In seeking to meet the objectives of the agreement, in 2019 the EU completed an update of its energy policy framework by publishing its Clean Energy for all Europeans package. This package sets binding targets for Member States to be reached by 2030 in relation to decarbonisation, the future RES share, energy efficiency and interconnection capacity. Member States have submitted National Energy and Climate Plans (NECPs) to the European Commission, outlining the measures they plan to implement in order to meet the 2030 climate targets.

At the end of 2019, the EU published the Green Deal, which outlined its goal of making Europe the first carbon-neutral continent by 2050 and its growth strategy for transforming Europe into a modern, resource-efficient and competitive economy. At the end of 2020, the EU decided to revise the 2030 European GHG emission reduction target, increasing it from 40% to 55% (compared with 1990 levels).

Undergoing the energy transition, reaching carbon neutrality and establishing an affordable, secure, and cost-effective energy system requires the adoption of a *System of Systems* view of all sectors of the economy and strong policy coordination between the EU and its Member States. Investments across each sector should be focused on a pragmatic, integrated and inclusive approach, with the aim of minimising decarbonisation costs in the social interest.

While all societal actors are working towards decarbonisation by reducing their carbon footprint, some players are actually enabling Europe's transition to a greener and more sustainable economy. In the energy sector, electricity transmission system operators (TSOs) play this role: they are enabling the electrification of consumption and facilitating the integration of RES into the system while ensuring the efficient operation of their grids and guaranteeing the quality and security of electricity supply.

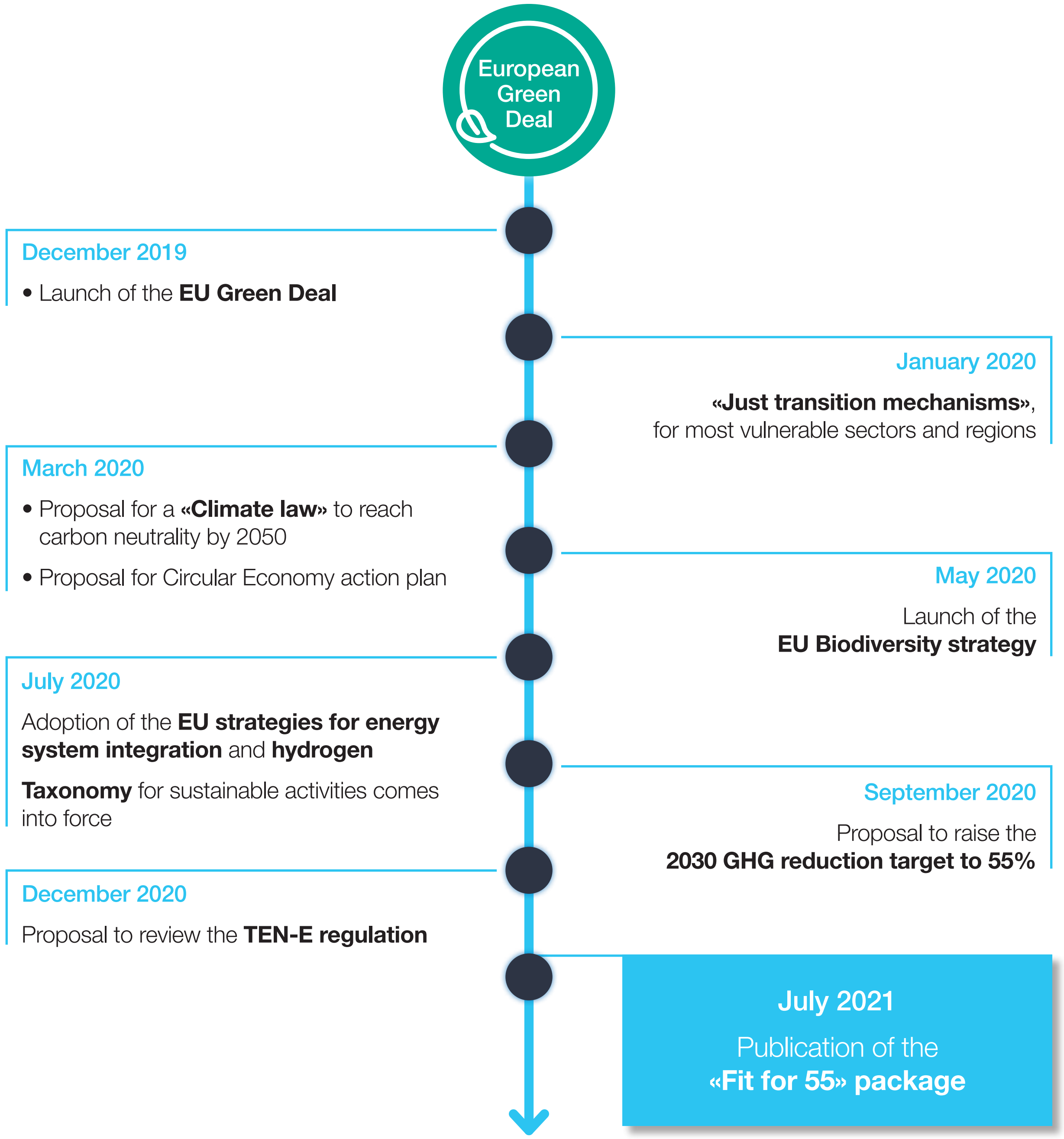
This paper, which was written by 8 European TSOs[5], explains and assesses the key role TSOs are playing in the energy transition and Europe's transformation into a carbon-neutral society. It addresses the role of electricity carriers, the ways in which TSOs are contributing to the decarbonisation of society and the need for adopting a system-wide approach when assessing the impact of their activities. Clarifying the role of TSOs in this way is crucial for maximising their sustainability strategies and minimising the costs of decarbonisation for European society.

5. Elia Group acts as a holding company which owns both Elia (the Belgian TSO) and 50 Hertz (one of the 4 TSOs in Germany; TenneT represents both the TSO of the Netherlands and one of the 4 TSOs in Germany.

THE EU GREEN DEAL

The European Green Deal is the EU's growth strategy to transform the EU economy into a sustainable economic model. Published in December 2019, the overarching objective of the strategy is for the EU to become the first climate-neutral continent by 2050, resulting in a cleaner environment, more affordable energy, smarter transport, new jobs and an overall better quality of life for European citizens. The plan involves the introduction of a coherent legislative framework to guide the continent's transition towards a carbon-neutral economy.

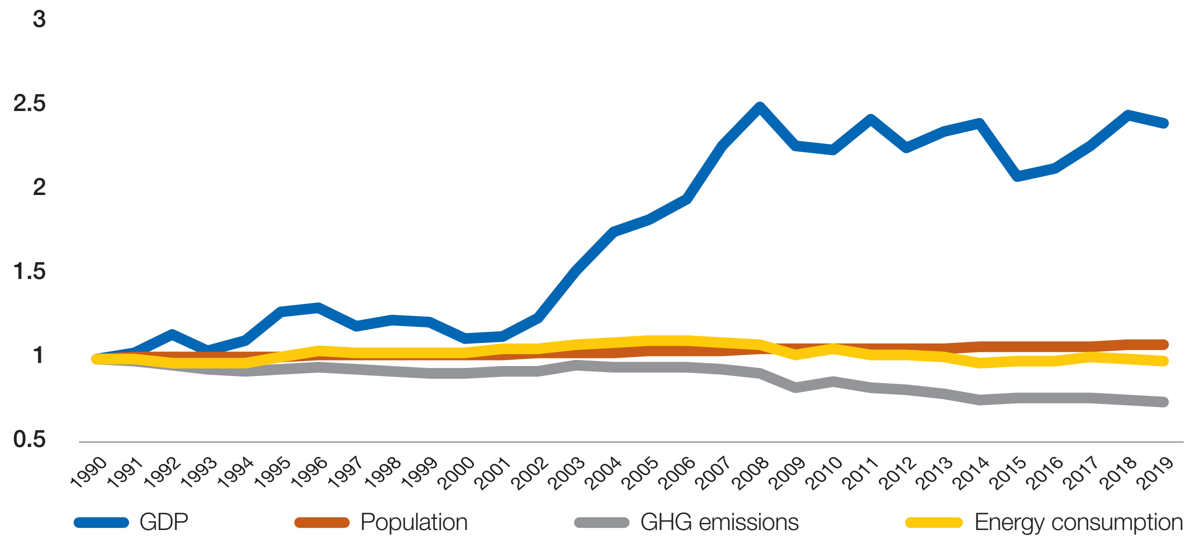
FIGURE 1 EUROPEAN GREEN DEAL ROADMAP



The EU's next objective is the delivery of the "Fit for 55" legislative package in the summer of 2021. This aims to fundamentally overhaul the EU's climate policy architecture and put the EU on track to deliver on its 2030 climate target to reduce GHG emissions by 55% (compared with 1990 levels). The package comprises a wide set of new or recast directives touching on several topics such as renewables, energy efficiency, energy taxation, carbon emission trading schemes, gas market and infrastructure (including hydrogen production and use), etc.

EU CONSUMPTION TRENDS

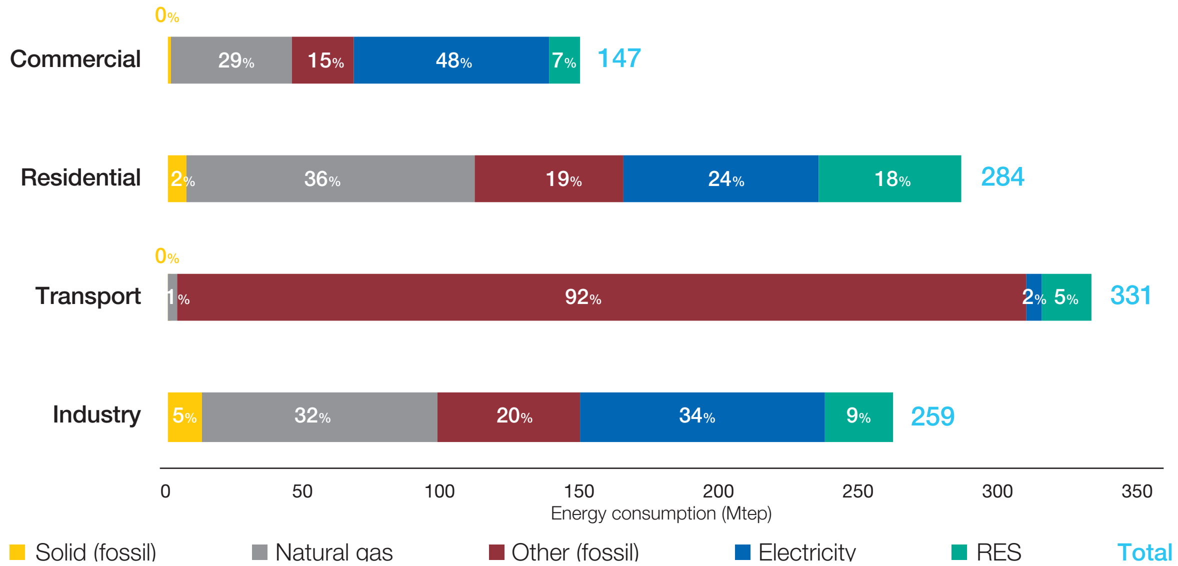
FIGURE 2 ANNUAL VARIATION RATIO VS 1990



Thanks to the adoption of climate policies such as the Clean Energy for all Europeans package, over the last three decades Europe has been able to both reduce its total end use consumption and replace harmful fossil fuels (such as coal and oil) with renewables. The combination of energy efficiency mechanisms and subsidies for the integration of renewables into the system has led to a significant reduction in the EU's carbon intensity and to an observable decoupling between energy consumption and macroeconomic trends.

Over the last 15 years, the share of RES in the final energy consumption has increased from 9% to 19%, while the share of RES in the electricity generation mix has increased from 14% to 34%[6]. However, the use of renewable energy varies in different sectors. While the commercial, residential and industrial sectors today use a significant amount of thermal renewables, biofuels and electricity (which is partially decarbonised), the transport sector is still dominated by fossil fuels[7].

FIGURE 3 ENERGY CONSUMPTION MIX IN MAIN SECTORS OF THE ECONOMY IN 2019



(Source: Eurostat)

6. Based on Eurostat RES Share methodology (Directive 2009/28/EC).
7. Based on 2019 Eurostat energy balance (version 2021).

THE ROLE PLAYED BY ELECTRICITY

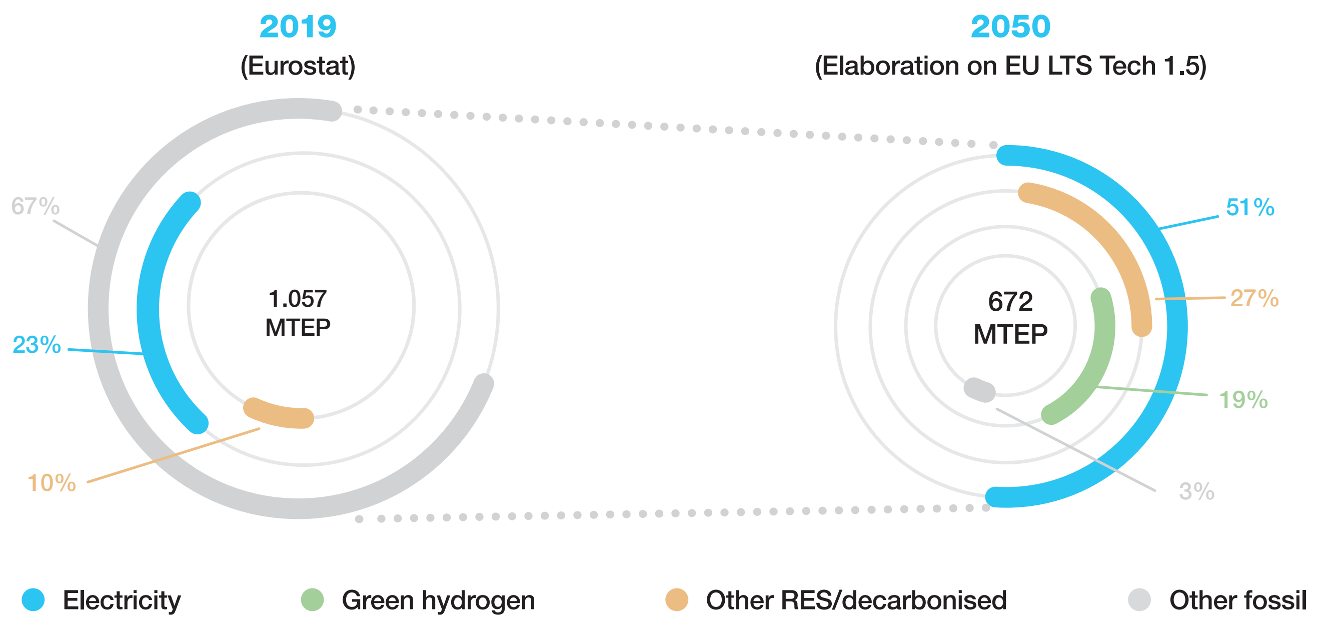
IN THE DECARBONISATION OF THE ENERGY SYSTEM

Reaching the ambitious climate objectives laid out in the European Green Deal requires the active participation of actors from across all sectors of society. The energy sector should lead the way, since it accounts for approximately 82% of total European GHG emissions[8].

In line with the provisions of the Green Deal, carbon neutrality should be reached through the realisation of cost-optimal coupling between supply and demand whilst minimising decarbonisation costs for society.

8. Emissions of the energy sector compared to total EU28 emissions in 2019 (Source: Eurostat – Data Explorer – June 2021).

Figure 4 EVOLUTION OF FINAL ENERGY CONSUMPTION AND KEY INDICATORS



~2800 TWh	Electricity End Use Demand	~4000 TWh
34%	RES share in electricity	85%
960 TWh		3400 TWh
24%	GHG emissions reduction (vs 1990)	Net-zero

(Sources: Eurostat and elaboration on the EU Long-Term Strategy Tech 1.5[9]).

A first common element included in all future energy scenarios is that energy efficiency will be the primary instrument for reaching carbon neutrality. By introducing the “energy efficiency first” principle, the European Commission invited Member States to include energy efficiency in all of their planning, policy and investment decisions. As a consequence and as confirmed by the EU’s long-term strategy, the aim is for Europe’s final energy consumption to decrease by (a minimum of) 35% by 2050 in comparison with 2019 levels.

A second common element of all future energy scenarios is that electricity will become the dominant energy carrier and that the European electricity grid will function as the backbone of the decarbonisation of other energy sectors. Electricity is a major building block of a climate-neutral energy system because of the higher efficiency of electrical end uses and the maturity of renewable electricity technologies.

To exploit the full decarbonisation potential of electricity, the share it occupies in the energy sector must be increased. This process, typically referred to as the direct electrification of energy consumption, also contributes to reducing primary energy needs. According to the EU’s long-term strategy, electrification of consumption is expected to increase from 23% in 2019 to more than 50% by 2050. This, coupled

9. JRC Technical Reports – Towards net-zero emissions in the EU energy system by 2050.

with the increase in renewables in the energy mix (they are predicted to make up more than 85% of the generation mix by 2050, based on Eurostat's RES share calculation), will allow over half of the energy consumption in 2050 to be completely decarbonised.

Electricity is an extremely valuable form of energy that can be converted into useful power (e.g. mechanical traction) with a very high level of efficiency. By contrast, thermal energy reaches thermodynamic limits quite quickly, meaning it holds lower levels of efficiency. This can be easily observed by comparing the overall efficiency of different types of light transport or heating systems, which are all supplied by electricity generated from renewables (see info box below).

These examples show that from an energy use perspective, direct electrification of consumption is the most effective way to decarbonise the energy system and should always be chosen as the first option when it is technically and economically feasible.

A third common element included in future energy scenarios is that green molecules will also play an important part in the decarbonisation of the whole energy system. Despite the efficiency of electrical technologies and their direct coupling with renewable generation sources, direct electrification is in fact not sufficient for reaching carbon neutrality. This is because there are “hard-to-abate” sectors, for which direct electrification is not technically or economically possible. In addition to electrification and the use of biofuels, such sectors can be decarbonised through Power-to-X (P2X) processes, where electricity is used to produce either heat or synthetic gases (such as hydrogen) and liquid fuels.

This process, also referred to as the indirect electrification of consumption, can support the decarbonisation of sectors like heavy industry (where molecules are also used as feedstock, for example in the refinement and production of ammonia), heavy duty transport, maritime transport and aviation, which all require high energy density fuels.

Besides energy efficiency measures, the decarbonisation of the energy system will require the direct and indirect use of the electricity carrier, making transmission system operators key actors in the energy transition.

EXAMPLES OF THE INTRINSIC ENERGY EFFICIENCY OF ELECTRICAL ALTERNATIVES IN THE LIGHT MOBILITY AND HEATING SECTORS

The use of an electric vehicle makes it possible to travel 3 times the distance travelled with a hydrogen fuel cell vehicle and up to 4 times the distance travelled by a vehicle supplied by methane (obtained from the methanation of hydrogen), starting from the same kWh of electricity produced by RES. The conversion of electricity into hydrogen (and eventually methane) and its subsequent use in fuel cells (or combustion engines) inevitably result in a reduction in overall efficiency.

Figure 5 COMPARISON OF EFFICIENCY: ELECTRIC VEHICLES VS H_2 FUEL CELL VS SYNTHETIC METHANE (ICE)

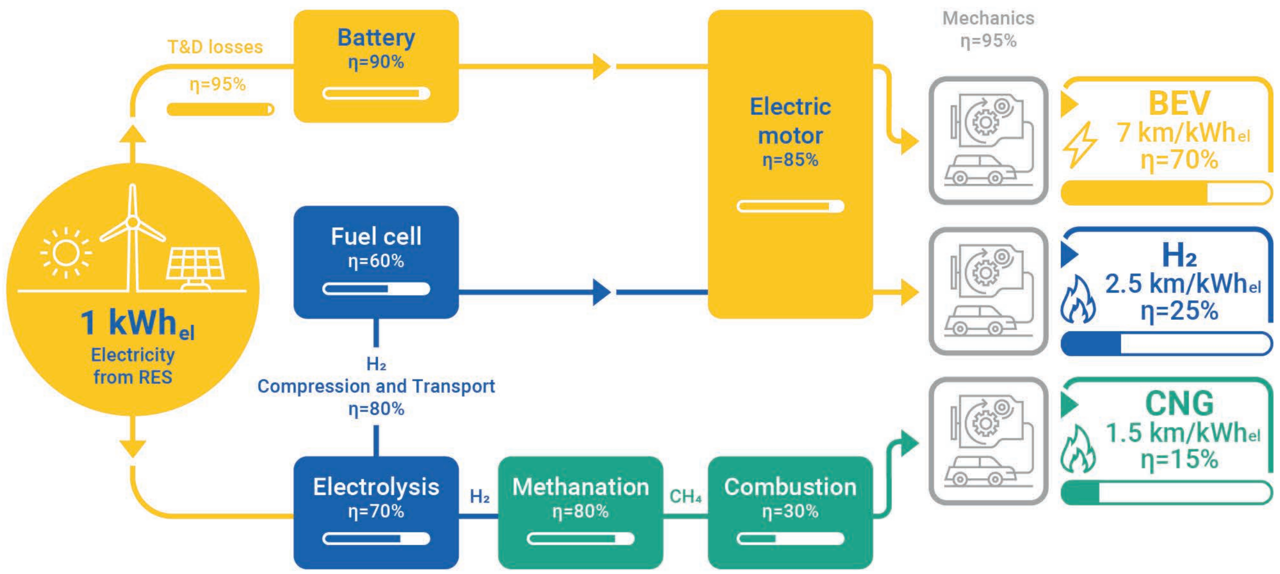
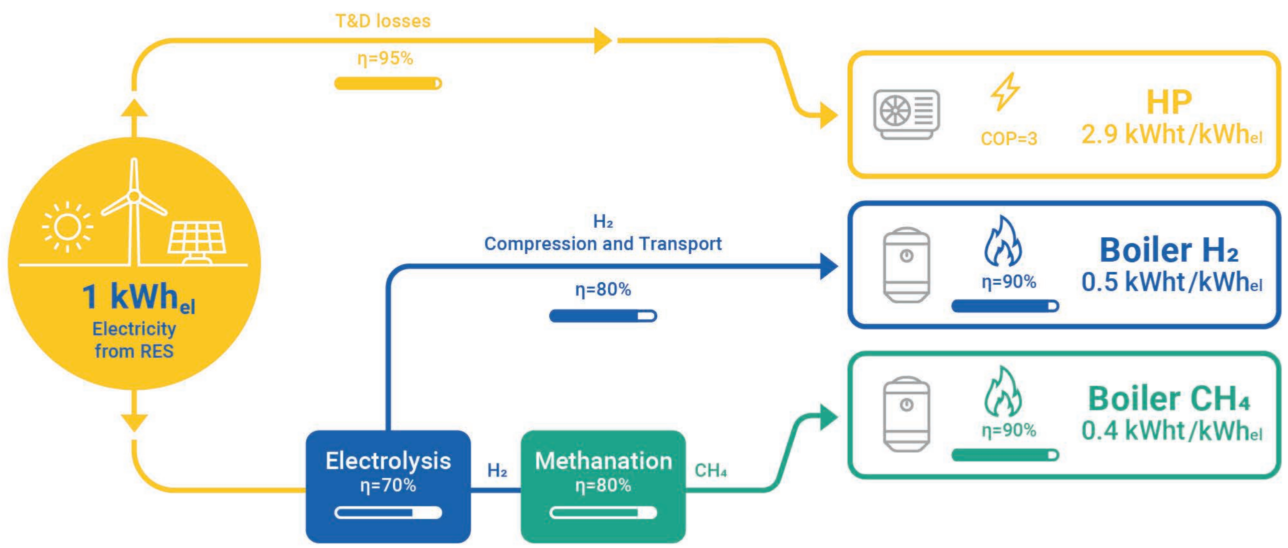


Figure 6 COMPARISON OF EFFICIENCY: HEAT PUMP VS H_2 BOILER VS SYNTHETIC METHANE BOILER

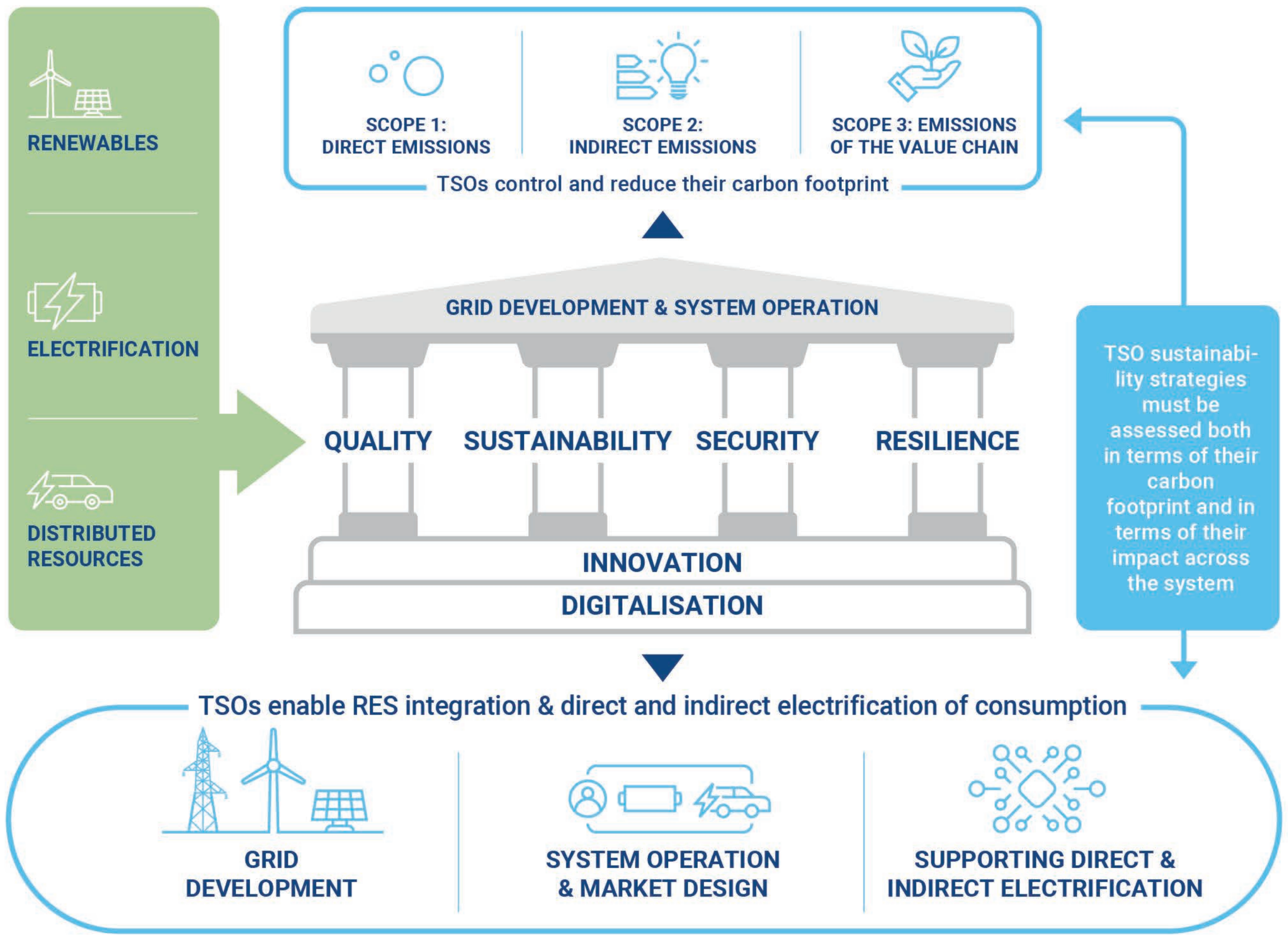


The same comparison can be applied to the residential heating sector. With the same primary energy input, the use of a conventional boiler supplied by hydrogen or synthetic methane results in a much lower energy output when compared with the energy generated by an electric heat pump. In particular, when assuming an energy input of 1 kWh of electricity produced by RES and using standard values for the Coefficient of Performance (COP) of the heat pump (e.g. COP = 3) and for the efficiency of the boiler (e.g. 90%), the use of a heat pump produces about six times the energy of a synthetic gas boiler (hydrogen or methane).

HOW TSOs CONTRIBUTE TO GHG EMISSION REDUCTION

INTRODUCTION

As a result of European climate policies, the power sector is undergoing a major change as it shifts from a unidirectional system with a few big power plants and passive consumers to a fragmented and bidirectional system comprising both large-scale and small-scale intermittent renewable generation facilities and thousands or even millions of small, flexible electrical consumption assets.



In this evolving context, the role played by electricity carriers is growing in importance. At the same time, TSOs will continue to be responsible for the efficient development and operation of their electricity transmission grids in accordance with the following key pillars:

- **Security of supply:** electricity systems need to manage disturbances with minimum service disruption, i.e. without violating the operating limits of the system. This includes providing information on adequacy requirements to ensure that generation, storage and transmission assets always match demand.
- **Quality of supply:** TSOs need to ensure continuity of service and high-quality standards (in terms of voltage levels, harmonics, etc.).
- **Resilience:** the electricity system must be able to react to extreme and rare events and promptly return to normal operating conditions.
- **Sustainability:** TSOs need to operate and develop the electricity system while minimising the impact of their activities (direct and value chains) on the environment (including GHG emissions but also biodiversity, consumption of raw materials or resources, waste management, etc.), looking at the interactions between the grid and the ecosystem.

Sustainability lies at the heart of all TSO activities: it provides a framework for the fulfilment of their roles whilst minimising the economic and environmental costs for society. As part of their commitment to sustainability and their work towards carbon neutrality, TSOs play a major role in the reduction of the energy sector's GHG emissions. TSOs are supporting society's transition to a low-carbon future by:

1. acting to ***reduce, avoid or limit GHG emissions*** linked the carbon footprint of their own activities (scopes 1, 2 and 3 of the GHG emission protocol);
2. ***enabling the decarbonisation of the wider economy*** by facilitating the replacement of fossil fuels with RES and the electrification of consumption.

Whilst both types of actions are necessary to reach carbon neutrality by 2050, the decarbonisation potential held in actions included in the second point is much more far-reaching than the first. Indeed, whilst the magnitude of a single TSO's direct and indirect GHG emissions currently reaches 1 million tCO_2eq per year on average, the decarbonisation impact that all European TSOs could have on the energy system as a whole could reach up to 3 billion tCO_2eq. per year[10].

10. Aligned with the overall GHG emissions of the EU28 energy sector in 2019 according to Eurostat.

REDUCING THE CARBON FOOTPRINT OF TSO ACTIVITIES

TSOs contribute to decarbonisation by reducing or limiting the carbon footprint of their own activities and encouraging other actors across the value chain to limit theirs. This involves tracking and classifying their own GHG emissions in line with the GHG emission protocol. The latter establishes a comprehensive global standardised framework for measuring and managing GHG emissions produced as a result of private and public sector operations and actions. This framework divides emissions into 3 categories, as outlined below.

Scope 1

This comprises direct emissions that occur from sources that are owned or controlled by the company. For a TSO, this includes emissions produced as a result of the consumption of fossil fuels in activities related to construction, grid development and maintenance (i.e. transport and machinery repair), SF_6 leaks in facilities, etc.

Scope 2

This includes GHG emissions that are produced as a result of the generation of purchased electricity/heat that are consumed by the company. These are defined as the forms of energy that are purchased or otherwise brought into the organisational boundary of the company. For a TSO, scope 2 emissions are mainly related to losses during the exploitation of the grid, with minor emissions also occurring due to the electricity consumption of buildings and TSO activities.

Scope 3

This corresponds to indirect emissions produced as a result of upstream and downstream activities. Scope 3 emissions are an indirect consequence of the activities of the company and are caused by sources not owned or controlled by the company. For example, for a TSO, indirect emissions are caused by the construction of parts of its infrastructure, products or services by other companies. Indirect emissions from downstream activities occur as a result of waste treatment.

TSOs have identified and implemented a wide range of instruments to reduce or mitigate their scope 1, 2 and 3 emissions. This includes, but is not limited to adopting sobriety and efficiency measures in their activities and managing the impacts of their value chains and those related to existing and future interactions between the grid and connected ecosystems. An overview of the main instruments is provided in the diagrams below, alongside related flagship projects.

For more information, click on this icon to learn more about each project.

SF_6 IN CIRCUIT BREAKERS (SCOPE 1)

SF_6

SF_6 is an inert gas which has a high dielectric strength and thermal stability and is widely used in circuit breakers. Due to its high global warming potential, SF_6 leaks are the main source of a TSO's direct emissions. To reduce or limit such leaks, TSOs use a wide range of tools and approaches, including:

- *enhanced monitoring and awareness-raising initiatives*
- *leak detection and prevention solutions*
- *replacing equipment with alternatives with lower leakage rates*
- *use of alternative low-emission gases and Air-Insulated Switchgear (AIS).*

In-house SF_6 monitoring application

Terna Driving Energy

Completed in ***2021***

Monitoring SF_6 consumption is the first way to estimate leaks and implement effective reduction strategies. To this end, Terna has devised an in-house application that allows the monitoring of equipment that contains SF_6 gases throughout its lifecycle (installation, maintenance and dismantling). This will allow Terna to identify and prioritise measures to replace or minimise the use of SF_6.

RTE GIS plan

Rte Le réseau de transport d'électricité

To be completed in ***2035***

RTE has reinforced its leakage treatment policy to reduce emissions from existing facilities with systematic leak detection, immediate treatment using increasingly effective sealing techniques, preventive renovation of the airtightness, treatment of circuit breakers (replacing the whole leaking pole) and maintenance professionalisation. RTE is reducing its installed SF_6 mass by building new substations using AIS technology as a priority.

Innovative sealing technique for GIS compartment repairs

RED ELÉCTRICA DE ESPAÑA

Completed in ***2019***

REE has developed a new methodology to repair SF_6 leaks in GIS compartments, based on flexible sealing systems and clamps tailored to and installed on each leakage point. This process does not require the dismantling of GIS compartments or final tests and can be applied to compartments built by different GIS suppliers (traditional methodologies require these and must be carried out with the supplier's cooperation). The procedure therefore allows leaks to be repaired much more quickly; in turn, this leads to the quantity of SF_6 emitted between the detection of the leak and its repair to be greatly reduced.

Pilot installation of SF_6-free GIS at Station Westerlee

TenneT

To be completed in ***2023***

GWP of used technology <1

In line with TenneT's climate strategy, its goal of becoming climate-neutral by 2025 and in order to develop sustainable technical solutions, TenneT resolved a bottleneck in an existing high-voltage substation with an SF_6-free GIS installation of 50 kV. The project was a pilot intended to test SF_6-free alternatives; the current solution has a Global Warming Potential (GWP) which is lower than 1.

Pilot project "SF_6- and mineral oil-free 110 kV substation bay"

Austrian Power Grid APG

To be completed in ***2023***

GWP of used technology = 0

In order to keep GHG emissions as low as possible, APG intensified its search for alternatives to SF_6. As part of a study, APG analysed the market for existing high-voltage SF_6-free technologies and their potential application across the Austrian transmission grid. APG will shortly undertake a pilot installation of an SF_6-free and mineral oil-free bay in a 110 kV substation. This pilot project will focus on testing applications built by different suppliers of air-insulated instrument transformers and circuit breakers.

DIRECT EMISSIONS PRODUCED AS A RESULT OF TSO ACTIVITIES (SCOPE 1 & 2)

*As is the case for many businesses, the day-to-day activities of TSOs result in GHG emissions. This mainly includes direct emissions from fossil fuels used for transport and heating **(Scope 1)** and indirect emissions, produced as a result of buildings consuming electricity **(Scope 2)**.*

Decarbonisation strategies involve energy sobriety and efficiency measures, direct electrification of consumption and the use of renewable and low emission energy sources.

Terna E-mob programme

Ongoing

616 t CO_2/year in reduced emissions

Decarbonising TSO activities includes reducing the emissions of company cars and vans. This is why Terna is currently running a pilot project aimed at replacing an increasing number of fossil fuel cars with electric vehicles over the next two years.

Remote outdoor lighting in substations

Completed in ***2020***

236 t CO_2eq/year in reduced emissions

Since 2020, the installation and improvement of remote lighting control systems has enabled the outdoor lighting of 426 REE substations to be switched off during the night. Thanks to these new systems, lighting is switched on only when it is needed, thus reducing electricity consumption and associated emissions.

UPS with Fuel Cell technology

To be completed in ***2025***

>160 t CO_2eq/year in reduced emissions

Uninterruptible Power Supply (UPS) secures the availability of critical infrastructure in the event of power failure. To ensure functionality, the aggregates must be operated several times a year. The aim of one current project is to replace diesel-powered UPS with fuel cell technology that obtains its energy from regenerative low-carbon hydrogen. The feasibility of the project will be investigated through the running of a pilot, which will end in 2025.

Source: Thomas Eder / Shutterstock.com

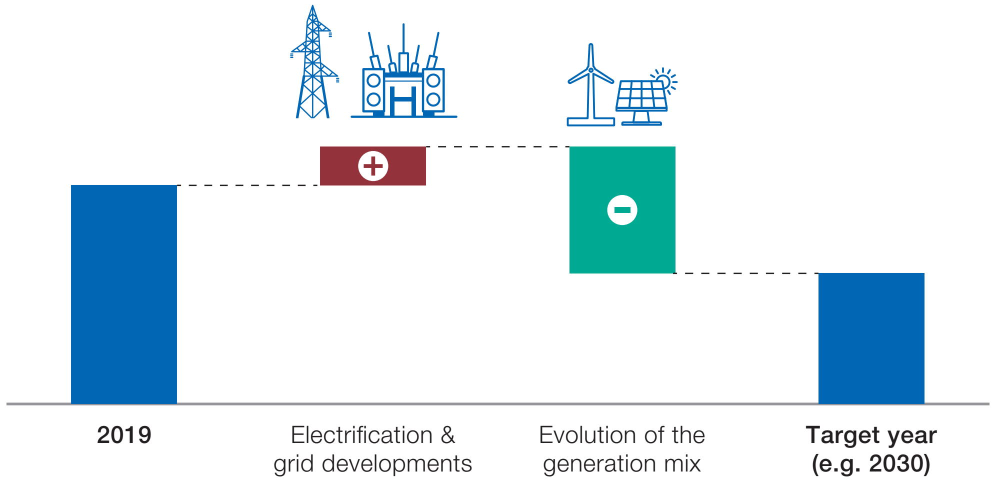
ELECTRICITY GRID LOSSES (SCOPE 2)

Grid losses are currently the biggest source of TSO emissions. They are an inevitable consequence of electricity flowing through transmission lines and grid assets, but their impact on GHG emissions is entirely dependent on the electricity generation mix. For TSOs that purchase the electricity corresponding to their grid losses, the associated carbon footprint can be reduced through green procurement approaches. For all other TSOs, the main way to reduce the GHG emissions produced by grid losses in the long term is by enabling the integration of low-carbon energy sources into the system, while limiting grid loss increases through efficient grid development and energy efficiency measures.

EMISSIONS OF GRID LOSSES

In absolute terms (without considering the application of green procurement processes), GHG emissions associated with grid losses are proportional to the overall amount of grid losses measured by the TSO and to the specific emission factor of the local energy mix. Assuming that European climate policy is progressively implemented over the next few years, emissions associated with grid losses will change in line with two contrasting trends.

FIGURE 7 EVOLUTION OF EMISSIONS ASSOCIATED WITH GRID LOSSES



On the one hand, electrification and grid developments will increase the GHG emissions caused by grid losses, since the amount of electricity flowing into the whole system and the number of assets required to operate it in a secure way will increase. On the other hand, the integration of RES and low-carbon generation sources into the electricity generation mix will: i) reduce emissions by lowering its emission factor; and ii) lower overall emissions caused by the system due to the electrification of end demand (not accounted for in grid losses).

VALUE CHAIN – GRID DEVELOPMENT (SCOPE 3)

Minimising the environmental footprint of TSOs also involves changes being made along the electricity grid value chain. Indeed, aside from the GHG emissions resulting from grid losses, most GHG emissions associated with transmission lines and grid assets are generated during their manufacturing and on-site construction phases. The main reduction tools for such emissions involve the introduction of green procurement approaches, according to which suppliers are chosen based on their carbon footprint, commitment to eco-design principles and use of circular economy approaches.

The Greener Choice

Completed in ***2020***

Greener choice consortium, including:

The Greener Choice open letter was produced as a result of a collaboration between 7 TSOs aiming to leverage their central position in the energy transition and deliver a common message to their suppliers. In the open letter, all suppliers - established and new - were encouraged to move towards the adoption of increasingly sustainable activities; TSOs made clear they will take actions in this vein into consideration when selecting partners with whom to work and awarding contracts.

Sustainable criteria in tenders

To be completed in ***2023-2026*** ***(4 projects)***

As part of TenneT's recent tender, launched with regard to four Dutch and German offshore platforms (Hollandse Kust Noord, West Alpha, West Beta and BorWin6), TenneT included criteria encouraging suppliers to take steps to reduce their impact on the environment and climate by using instruments like 'raw material passports', internal CO_2 prices, environmental cost indicators, CO_2 performance ladders and nature inclusive designs.

VALUE CHAIN – CORPORATE ACTIVITIES (SCOPE 3)

Reducing value chain emissions also covers corporate activities, particularly in the areas of mobility and the distribution of purchased goods. Key tools falling under the former category include choosing low-carbon travelling options, promoting the use of public transportation and, where possible, implementing smart working approaches. Key reduction tools falling under the latter include the introduction of green procurement, circular economy approaches and employee awareness campaigns.

Low emission commuting

Completed in ***2018***

>500 t CO_2eq/year in reduced emissions

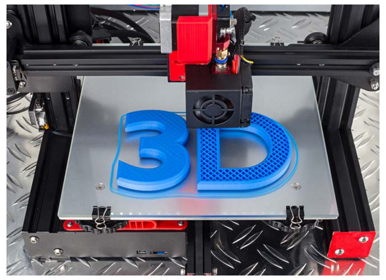
For staff travelling to its headquarters, Swissgrid has introduced sustainable commuting practices by granting them with easy access to public transport and providing them with underground parking facilities. The latter includes space for bicycles, charging stations for electric bikes and additional facilities such as checkrooms, showers, rest rooms and a drying room for wet clothes. Swissgrid has also launched a special app that allows employees to carpool.

Spare parts via 3D print

To start in ***2021***

GWP of used technology = 0

To increase the lifetime of equipment and reduce GHG emissions associated with the purchasing of new pieces of equipment, repairing such equipment (instead of replacing it) is a sound solution. However, this is only possible if spare parts are available at short notice. For this reason, APG intends to explore the possibility of using of 3D printing. It will start by identifying and testing appropriate use cases in cooperation with a 3D printing service provider.



MAINTENANCE (SCOPE 1, 2 & 3)

Maintenance projects contribute to the reduction of a TSO's carbon footprint by extending the life of network assets, thus reducing GHG emissions along their whole value chain. Over the last few years, maintenance practices have been boosted through digitalisation, as a shift towards predictive maintenance has been taking place; this involves remotely monitoring the condition of machines and analysing the data obtained. The use of digital tools shall be carried out efficiently and they shall be implemented through low-carbon practices.

Drones for monitoring vegetation

To be completed in ***2021***

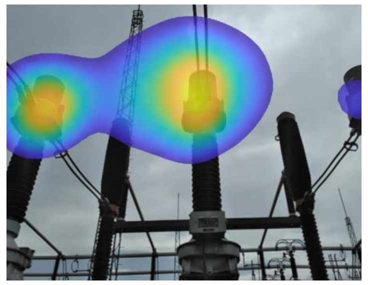
300 t CO_2eq/year in reduced emissions

A study was conducted in 2021 to assess the impact of using drones coupled with helicopters for monitoring vegetation under overhead lines (compared to using helicopters alone). The results show that employing drones that use digital data analysis allows for a 33% reduction in greenhouse gas emissions (approximately 300 t CO_2e), due to a reduction in the use of kerosene. This gain is mainly due to a sober, efficient and low-carbon use of digital technology.

Detecting anomalies via sound patterns

Completed in ***2020***

Unusual sounds are very often an indicator of the imminent failure of grid assets and their components. APG uses acoustic sensors to identify and locate the sources of such unusual noises. To date, APG has implemented four "sound scanners" and has already prevented potential damage caused by loosened bolted connections and failed components. Preventive repair and maintenance increases the life cycle of appliances and prevents serious damage from occurring.



CONTRIBUTING TO SYSTEM-LEVEL GHG EMISSION REDUCTION

Given the central role that TSOs play in the power sector and their potential to reduce GHG emissions at the level of the energy system, their actions are enabling the energy transition and allowing Europe to fulfil its Green Deal ambitions. Ensuring security and continuity of supply while enabling the energy transition are, therefore, the key activities of every TSO.

These activities are growing in importance since the landscape of the energy sector is changing at an extraordinary pace. The introduction of an increasing amount of RES into the system and more decentralised electricity production is creating many new challenges for TSOs. In the medium-term, the distribution of generation across the electricity grid will completely change as injected energy will come both from small-scale decentralised solar, wind and biomass generation sources and from large-scale green generation facilities such as offshore and onshore wind farms and solar plants. As a consequence, the transmission infrastructure and the operation of the system and markets need to be adapted in order to match this more variable, flexible and smarter system. Moreover, backbone corridors must be reinforced to transport green energy over long distances.

The increasing fragmentation of the sector, characterised by decentralised energy sources and the increasing number of market players due to electrification, is making the system increasingly complex. On the one hand, the system will shift from being organised around a small number of power plants and inelastic demand to one which encompasses a portfolio of small, decentralised generation sources and flexibility means (such as electric vehicles, batteries and heating systems). On the other hand, the high presence of variable renewable generation sources will result in daily cycles of oversupply and under-supply of energy compared to load needs. This will make the already complex management of evening residual load ramps even harder.

The efficient management of decentralised means will become crucial for guaranteeing the adequacy and flexibility of the network; TSOs will need to be more flexible to keep the system in balance.

To tackle this increase in complexity and maintain a reliable and affordable energy supply, new investments and innovative tools are needed. These will need to encompass the complete value chain of TSOs, stretching across each area of their core business (grid development, asset management, market design and system operations) and address both the technologies themselves, but also underlying factors, such as company structures and processes.

Digital technologies will be key for enabling TSOs to handle the increasingly complex system and become more efficient, whilst operating as part of an interconnected European energy system.

TSO investments will have to be accompanied by a coherent European industrial strategy, which is able to industrialise the production of innovative technologies and meet the demand for them, and by new approaches for societal acceptance of new infrastructures and a more flexible use of electricity.

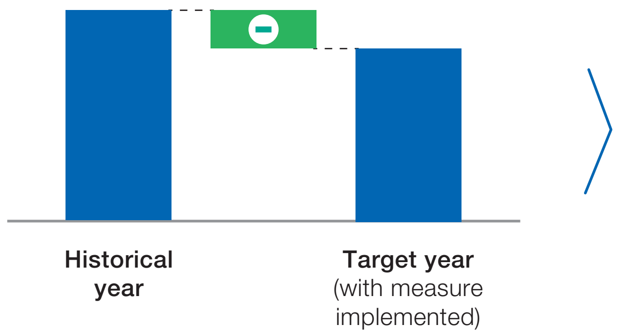
All these tools are necessary for ensuring an effective transition to a carbon-free European economy, since they either directly contribute to RES integration and the electrification of consumption or support their realisation.

The following diagrams provide an overview of the main tools and flagship projects carried out in these areas.

For more information, click on this icon to learn more about each project.

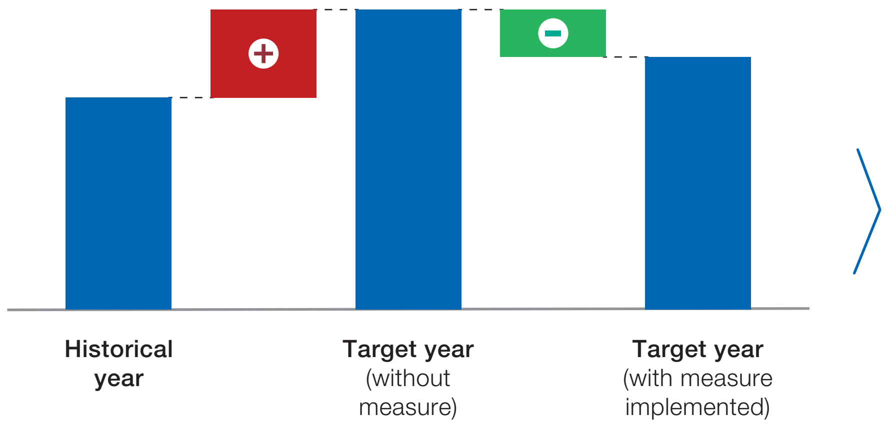
REDUCED VS AVOIDED EMISSIONS

FIGURE 8 EMISSION REDUCTION AND AVOIDANCE



Emission reduction
The implemented measure reduces emissions, as can be seen when compared with a condition under which the measure has not been implemented.

This is the approach used to assess, for example, the achievement of Science-Based targets.



Emission avoidance
The implemented measure reduces emissions, as can be seen when compared with a forecast condition under which the measure has not yet been implemented.

This is the approach used in national and European development plans to assess the benefits of a grid development.

Grid development

The development of the electricity transmission grid is one of the main ways to transform the energy system into a carbon-neutral one. Over the last few years, national network development plans developed by TSOs have become increasingly driven by sustainability. Additional factors such as market efficiency, ensuring the security of the electricity system, ensuring quality of service and establishing an increasingly resilient system (which is capable of dealing with critical events) are other important drivers. Grid development can have a direct impact on the reduction of system-level GHG emissions when it involves connecting RES to the grid or reducing RES curtailment. It can also support decarbonisation indirectly by improving the secure operation of the grid when high amounts of RES are present in the system. Creating an integrated European network is one of the key objectives of the Clean Energy for all Europeans Package and is fundamental for achieving long-term decarbonisation and security of supply targets.

CROSS-BORDER INTERCONNECTIONS

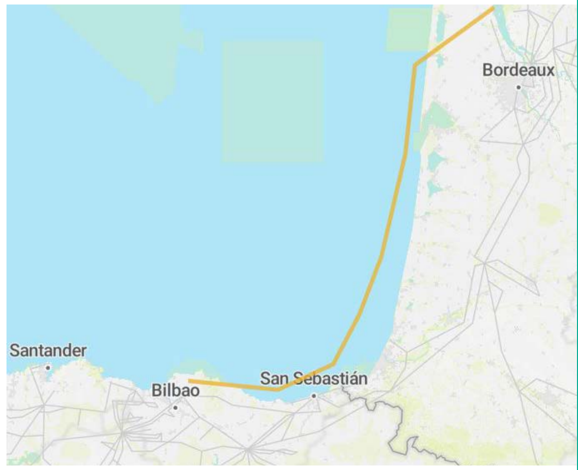
Interconnectors, which are used to increase the transmission capacity between two countries, aim to support RES integration, improve security of supply and boost market efficiency in the social interest. They directly contribute to reducing RES curtailment (by enabling renewable energy surpluses generated in one country to be transported to another). They also indirectly enable the secure management of an electrical system which contains a high volume of RES. Based on the power system needs analysis carried out by ENTSO-E as part of its Ten Year Network Development Plan (TYNPD) in 2020, the 93 GW of cross-border capacity needed by 2040 will enable the integration of 110 TWh of RES generation (which would otherwise have been curtailed) - and avoid 53 Mton of CO_2 emissions per year.

Spain-France submarine interconnection

To be completed in **2026-27**

1,2 M CO_2eq/year in avoided emissions

2x1,000 MW underwater and underground HVDC link (±400 kV) through the Biscay Gulf, between Gatika (Spain) and Cubnezais (France), almost 400 km long. It will strengthen the interconnection between Spain and France by allowing a greater integration of renewable energies (7,431 GWh/year by 2030), improving security of supply and increasing the efficiency of both systems. The project has been part of the PCI list since 2013.



(Source: ENTSO-E)

ALEGrO

Completed in **2020**

The ALEGrO high-voltage line is an interconnector linking Belgium to Germany with a transmission capacity of 1,000 MW. It is the first HVDC interconnector that is implemented via the novel Evolved Flow Based approach. The approach allows for an optimal utilisation of the interconnector in the day-ahead market timeframe optimising the entire Central West European (CWE) region. Furthermore, as a fully controllable DC device, it is able to influence congestions in the European meshed AC grid.

ONSHORE AND OFFSHORE RES CONNECTION & HYBRID PROJECTS

Connecting onshore and offshore RES directly contributes to reductions in system-level emissions by enabling the integration of renewable energy into the system.

The benefits of such connections double in the case of hybrid projects, since offshore hybrid assets are sea cables that serve as connections to offshore RES (typically, offshore wind energy) and interconnectors at the same time.

Hybrid projects allow one or more offshore wind farms to be linked to more than one onshore grid.

Kriegers Flak Combined Grid Solution

elia group

Completed in **2020**

0,2 Mt CO_2eq/year in avoided emissions

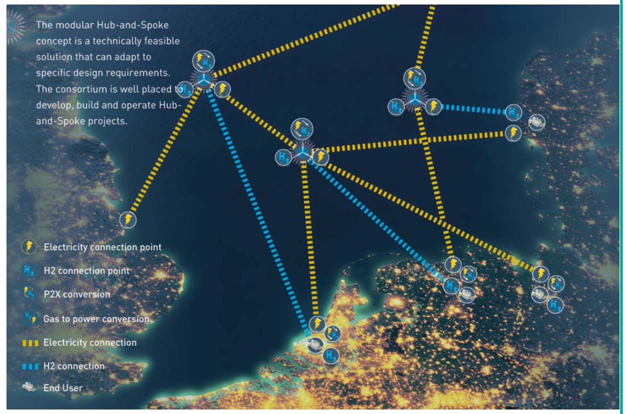
The Kriegers Flak Combined Grid Solution (KF CGS) is the first hybrid project (400 MW in each direction) in the Baltic Sea. Depending on system conditions, KF CGS is able to transport offshore wind power to the grids in Germany and Denmark and/or provide transmission capacity for cross-border electricity trading all in one combined technical facility.

North Sea Wind Power Hub

NSWPH Consortium, including:
TenneT

To be completed in **early 2030**

The modular Hub-and-Spoke concept is key to large-scale offshore wind energy deployment in the North Sea, which involves a low environmental impact and low costs for society, while maintaining security of supply. Central to the vision is the construction of modular hubs in the North Sea with interconnectors to bordering North Sea countries and sector coupling through power-to-hydrogen conversion.



Eurobar

Eurobar consortium, including:
elia group, Terna Driving Energy, Rte, amprion, RED ELÉCTRICA DE ESPAÑA

To be completed in **2023**

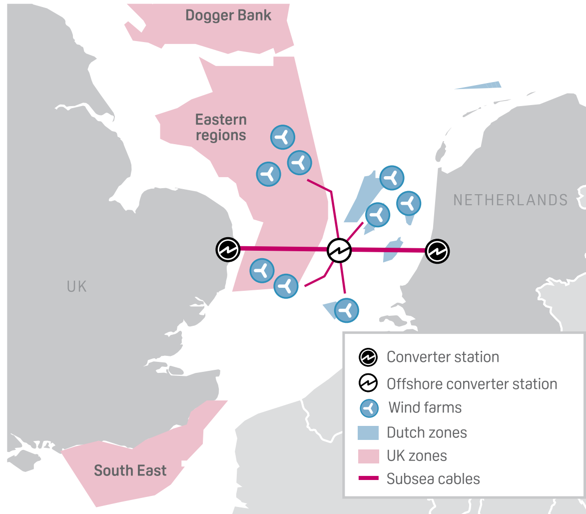
Eurobar aims to support Europe and its TSOs in the secure and efficient connection of offshore wind farms by striving for standardisation of interfaces and technology "offshore grid ready", reducing the environmental impact as well as interconnecting offshore wind clusters. These measures can be taken step-by-step and will be implemented when economically sound and technically needed.

WindConnector

TenneT

To be completed in **2029**

The multi-purpose interconnector (MPI) will simultaneously connect up to 4 GW of British and Dutch offshore wind between the British and Dutch electricity systems, providing an additional 2 GW of interconnection capacity between the countries. Therefore, the MPI will enable spare transmission capacity to be used to trade electricity between the countries, thereby increasing the potential utilisation of offshore infrastructure and thus mitigating the environmental impact on coastal communities.



(Source: S&P Global Platts)

INTERNAL REINFORCEMENTS

Internal reinforcements cover a wide range of projects such as new lines, switching stations and synchronous compensators which are required to ensure the security and quality of electricity supply while enabling the decarbonisation of national electricity systems via the integration of renewables.

Internal reinforcement projects often include the additional advantage of reusing existing corridors or infrastructures.

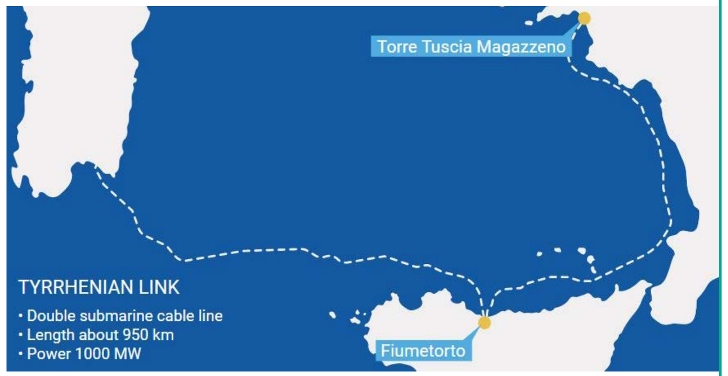
Tyrrhenian Link

Terna Driving Energy

First link to be completed by ***2026***

0,3-0,7 Mt CO_2eq/year in avoided emissions

The project consists of two submarine bipolar HVDC VSC links (1000 MW both) connecting Sardinia with Sicily and Sicily with the Italian mainland. The project allows a substantial integration of renewable energy into the Italian power system (+600 GWh/yr expected in 2030) as well as an important enhancement of the reliability of the power system and the possibility of decommissioning old power plants fed by oil/coal, currently operating, thus avoiding a substantial amount of pollutant emissions in atmosphere.



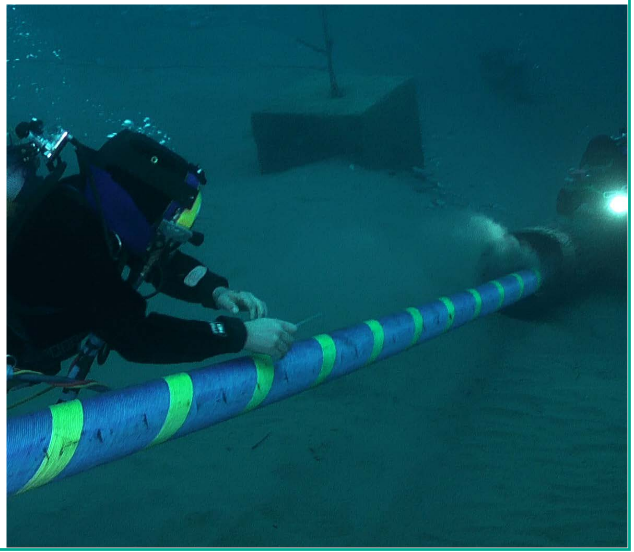
Reinforcement of the Spanish mainland & Balearic Islands link

RED ELÉCTRICA DE ESPAÑA

To be completed in ***2021-26***

0,9 Mt CO_2eq/year in avoided emissions

The reinforcement project includes a DC submarine link (2x200 MW capacity), 140 MW of batteries as fully integrated network components, 5 synchronous compensators and a new transformer. The project will allow the substitution of a large part of the diesel & gas power generation in the Islands by renewable (236 GWh/year) and efficient combined cycle thermal power, thus reducing CO_2 emissions.



SuedOstLink

elia group
Elia | 50Hertz | EGI
TenneT

To be completed in ***2025***

0,6 Mt CO_2eq/year in avoided emissions

The SuedOstLink is a 2GW 525kV HVDC transmission line. It is a joint project between TenneT and 50 Hertz.

The SuedOstLink has been categorised by the European Union as a project of common interest (PCI), indicating it is a key project for achieving EU decarbonisation goals.

The project is a crucial link to enable RES produced in the North of Germany to be transported to heavy industry located in the South of Germany.

Almaraz-Guillena corridor

RED ELÉCTRICA DE ESPAÑA

Completed in ***2014***

0,6 Mt CO_2eq/year in avoided emissions

The infrastructure links the central and southern areas of the Spanish peninsula by 327 km of electricity lines. It facilitates the evacuation of new renewable generation, continues the interconnection with Portugal and represents a significant improvement in the guarantee and quality of the electricity supply in the regions of Extremadura and Andalusia.

System operation and market design

The growing share of fluctuating RES in the electricity mix increases the flexibility and security of the system's supply needs in daily, weekly, seasonal and annual terms while simultaneously reducing system inertia, which has traditionally been provided by dispatchable generation power plants. Besides grid developments, managing the grid in a secure way requires the consistent integration of flexibility resources and changes to market mechanisms and regulations.

Market parties require clear long-term market signals to invest in cleaner generation power plants and flexible assets. Fostering cooperation between TSOs and the operators of the distribution grid will also be crucial, since most decentralised renewables and flexibility resources will be hosted by the latter. TSOs will support and accelerate this transition both in their own countries and across them, by facilitating the development of more integrated energy markets.

ACCELERATING THE INTEGRATION OF STORAGE AND DSR

TSOs actively support the integration of flexible resources into the system and associated changes to markets and regulations. Electrical storage systems and demand side response (DSR) are necessary for coping with the short-term flexibility requirements of the electrical system and (in particular) structural RES overgeneration during the central hours of the day and the steeper evening residual load ramp.

Equigy

TenneT, swissgrid, APG Austrian Power Grid, Terna Driving Energy

Ongoing

EQUIGY crowd balancing platform – www.equigy.com

Equigy plays a key role in the acceleration of the energy transition and the integration of the energy system. With the European crowd balancing platform, Equigy creates a trusted data exchange to enable aggregators to participate with smaller flexibility devices, such as home batteries and electric vehicles, in electricity balancing markets, turning consumers into prosumers. Owned by leading European transmission system operators, Equigy aims to set cross-industry standards throughout Europe, to support a future-proof, reliable and cost-effective power system that is independent of fossil fuel-based flexibility sources.

Consumer centricity

elia group – Elia | 50Hertz | EGI

Ongoing

The purpose of the Internet of Energy ecosystem is to allow players to explore, test and co-build new energy services through a consumer-centric approach. These services will allow consumers to be active and central players on the energy markets of the future and benefit from the technological investments they have made in solar panels, heat pumps, boilers or (car) batteries.

ENHANCED GRID OPERATION DRIVEN BY DIGITALISATION

The digital transformation enabled by the Internet of Things (IoT) is deeply improving TSO grid operation practices. Data-driven algorithms are progressively being integrated into automated control systems to maximise the availability of grid assets (e.g. in Dynamic Linear Rating solutions) and minimise RES curtailment (e.g. by optimally managing highly congested areas characterised by a presence of different renewables and storage resources).

Life Cycle Analysis of DLR service at RTE

Rte – Le réseau de transport d'électricité

To be completed in ***2021***

290-1500 t CO_2eq/year in avoided emissions

The objective of the study is to quantify the environmental impacts of the DLR service on two existing overhead lines. The results show GHG gains linked to substitution of thermal power station generation by RES generation for system adequacy. For the 2 lines, annual GHG emissions avoidance is estimated to be between 290 t CO_2e and 1500 t CO_2eq.

Dynamic Line Rating (DLR)

swissgrid

To be completed in ***2023***

1,000-2,000 t CO_2eq/year in avoided emissions

By expanding the transmission capacity, DLR promotes the integration of renewable generation. There is a synergy between DLR and wind energy; however DLR is also beneficial for any other stochastic renewable energy production. In real-time operations, DLR can be used to avoid redispatches which will reduce costs and energy losses but also any further investment in transmission network reinforcements.

SUPPORTING LONG-TERM INVESTMENT SIGNALS

Long-term investment signals are needed for an efficient and effective build-up of resources (RES and conventional generation, flexible demand, storage and other forms of flexibility) and secured capacity to guarantee security of supply.

Moreover, investment signals that reflect optimal locations are crucial for the efficient development of the power grid. Investment signals can be provided by the energy-only market, but price signals can be distorted for different reasons, hindering the generation of optimal investments. In this case, long-term investment signals can be provided through regulatory instruments such as support schemes for RES and capacity mechanisms.

In this regard, European electricity TSOs play a pivotal role in assessing challenges and proposing solutions for the efficient integration of resources into the markets and grids.

FOSTERING TSO – DSO COLLABORATION

Since a large part of non-programmable RES and flexible resources will be connected to the distribution grid, active collaboration between TSOs and distribution system operators (DSOs) will be required.

As mandated by the Clean Energy for all Europeans package, these two types of player have already established formal collaboration channels through their associations (ENTSO-E and the DSOs associations[11]).

Key areas of mutual exchange involve common practices for scenario building and grid planning, ensuring an improved visibility over distributed resources and the definition of common principles for the integration of flexibility resources into the grid.

BOOSTING MARKET INTEGRATION

Another fundamental step for increasing the efficiency of the electrical system and ensuring a transition to carbon neutrality at the least cost for society involves the integration of fragmented energy markets across European countries.

TSOs can play a pivotal role in creating an internal European energy market, facilitating the cross-zonal trading of energy and ancillary services and further increasing regional cooperation. Although market integration has been already implemented in several areas across Europe, as mandated by the Clean Energy for all Europeans package, there is still a need for harmonisation and the development of consistent common network codes.

This would minimise the curtailment of non-programmable renewables and ensure operational security and resource adequacy in Europe.

11. Now represented by the newly established EU DSO Entity.

Supporting electrification

The electrification of energy consumption involves the replacement of end use technologies supplied by fossil fuels with electrical ones (direct electrification) or with technologies supplied by energy carriers produced from low-carbon electricity (indirect electrification).

As part of their enabling role, TSOs fully support both forms of electrification outlined above, with the aim of decarbonising the whole energy system at the lowest cost for the society. However, while both types of electrification are needed to achieve carbon neutrality in the long-term, they also impact the electricity network. This simultaneously poses new challenges for TSOs whilst presenting them new opportunities for enhanced grid operation.

In this regard, TSOs regularly undertake modelling studies of the power system to verify the impacts of electrification on the electrical system in the short-, medium- and long-term. These studies are often used to inform national and European energy policy (for example, they are included in scenario reports and energy strategies).

DIRECT ELECTRIFICATION

Direct electrification involves the replacement of end use technologies which emit high amounts of carbon (and are typically less efficient) with electrical ones. In the long-term, the process will result in higher electricity consumption and modifications to the electricity demand profile. At the same time, the spread of decentralised electrical appliances, if appropriately managed, will provide TSOs with flexible resources to be used for real-time grid operation, thus helping to transform the electricity system into one which includes a high amount of variable RES. The end uses with the highest direct electrification potential are vehicles and heating systems. The latter can be carried out alongside energy efficiency measures to improve the thermal performance of buildings.

ELECTROMOBILITY

- *The EU is aiming for 30 million electric vehicles to be deployed by 2030, while up to 220 million are expected to be deployed by 2050 based on future energy scenarios.*
- *Such numbers will have a limited impact on the overall electricity demand, but could potentially create issues in peak management in case of simultaneous and uncontrolled charging.*
- *Time of use tariffs could be useful to mitigate the impact of electromobility on the grid. Smart charging could also provide TSOs with flexible resources to enhance grid operation. Charging infrastructure designed to be vehicle-to-grid (V2G) ready could provide system operators with additional flexibility opportunities.*

HEATING SYSTEMS

- *EU Energy scenarios for 2050 provide for up to 7 times the heat currently produced by electrical heat pumps, with significant geographical differences across Europe.*
- *The widespread adoption of electrical heating systems are likely to have a limited impact on the overall electricity demand, while potentially increasing system adequacy needs in countries with the highest technology switching ratios.*
- *If DSR-enabled, the electrical heating system could represent a source of flexibility for TSOs.*

INDIRECT ELECTRIFICATION

Indirect electrification involves the replacement of end use technologies that emit large amounts of carbon with alternatives supplied by gaseous and liquid fuels or heat produced from low-carbon electricity. Hydrogen technologies supplied by low-carbon hydrogen produced by Power-to-Gas (P2G) plants will prevail in future. With the aim of enabling the decarbonisation of "hard-to-abate" sectors, electricity TSOs will support the effective integration of P2G plants, which will also contribute to meeting the long-term flexibility requirements of the energy system.

POWER-TO-GAS

- *The EU hydrogen strategy provides for 40 GW of electrolysers to be installed by 2030 and estimates that low-carbon hydrogen will cover 13-14% of the energy consumption by 2050.*
- *Based on the specific configuration of electrolysers, their use will impact the electricity network. In cases where P2G plants are connected to the grid, TSOs will have to ensure an effective and secure integration of the additional RES required to supply them and manage the associated electricity flows. Depending on the system conditions, electrolysers could provide flexibility potentials for balancing and redispatching services.*
- *Electrolysers will also represent a flexibility resource, as they can be used to convert the seasonal or interannual excess of RES generation into green fuels, which can (in turn) be used in the directly in "hard-to-abate" sectors or converted back into electricity during periods when there is a shortage of RES generation. However, it will not be the silver-bullet on short and medium term due to high conversion losses and high technology costs.*
- *The location of large electrolysers is an important aspect that needs to be considered for the efficient development of infrastructure, guided by coordinated network development plans between electricity and gas TSOs. However, the optimal localisation of electrolysers depends on country-specific considerations.*
- *Transporting renewable power in the form of hydrogen over long distances could be an economically attractive option, in cases where there is a demand for hydrogen, there is already pipeline infrastructure in place or this could be developed as a result of coordinated network development plans.*
- *The development of an appropriate legal and regulatory framework and a market design that provides locational, when necessary, and operational incentives for electrolysers is also essential.*

REVEALING THE FULL DECARBONISATION POTENTIAL OF TSOs

To enable the electrification of consumption and the integration of a large amount of additional RES capacity into the system, TSOs will have to manage the resulting complexity by investing in network developments and innovative services to keep the system stable and secure.

The direct consequence of their enabling role is that their activities will grow in the coming years. As a result, their overall energy consumption could also grow. Building new transmission lines and grid assets (such as new transformers, synchronous condensers, etc.) and managing the higher flows resulting from the electrification of end uses and integration of intermittent RES will in fact inevitably lead to additional consumption for construction works and additional grid losses.

However, when observing this from a systemic point of view, the positive impact deriving from the implementation of tools enabling GHG emission reduction at system level will ultimately also contribute to the reduction of the TSO's carbon footprint. For instance, the additional grid losses that could result from the construction of a new line connecting an offshore wind farm to the onshore grid (and the associated GHG emissions) will be outweighed by the integration of the renewable energy generated by the wind farm into the system.

This example highlights the importance of assessing the decarbonisation potential of TSO activities by considering their impact on the energy system as a whole.

However, while actions taken by TSOs to reduce their carbon footprint are currently assessed according to standardised international protocols[12], the role of network operators as enablers of the energy transition (which holds a higher GHG emission reduction potential than the one that lies in the reduction of their carbon footprint), is not explicitly mentioned in GHG emission inventories. Moreover, this role is only partially recognised in cost-benefit analyses included in national and European grid development plans.

Revealing the full decarbonisation potential of TSOs, and thus their role in enabling the achievement of Europe's climate goals, requires the adoption of a systemic approach - one that would explicitly recognise TSOs as enablers of the energy transition. Their enabling activities need to be explicitly mentioned in GHG emission inventories under common assessment and monitoring frameworks, next to GHG emission sources associated with TSOs' carbon footprint.

With this in mind, the EU taxonomy regulation for sustainable activities published in July 2020 represents a good example of common criteria to assess the contribution of TSO activities to climate change mitigation and adaptation. This EU framework aims to direct investments towards sustainable activities. It recognises the enabling nature of TSO activities by using a systemic approach and assessing their overall impact on the emission factor of the whole European electricity system (see box on the next page for further information).

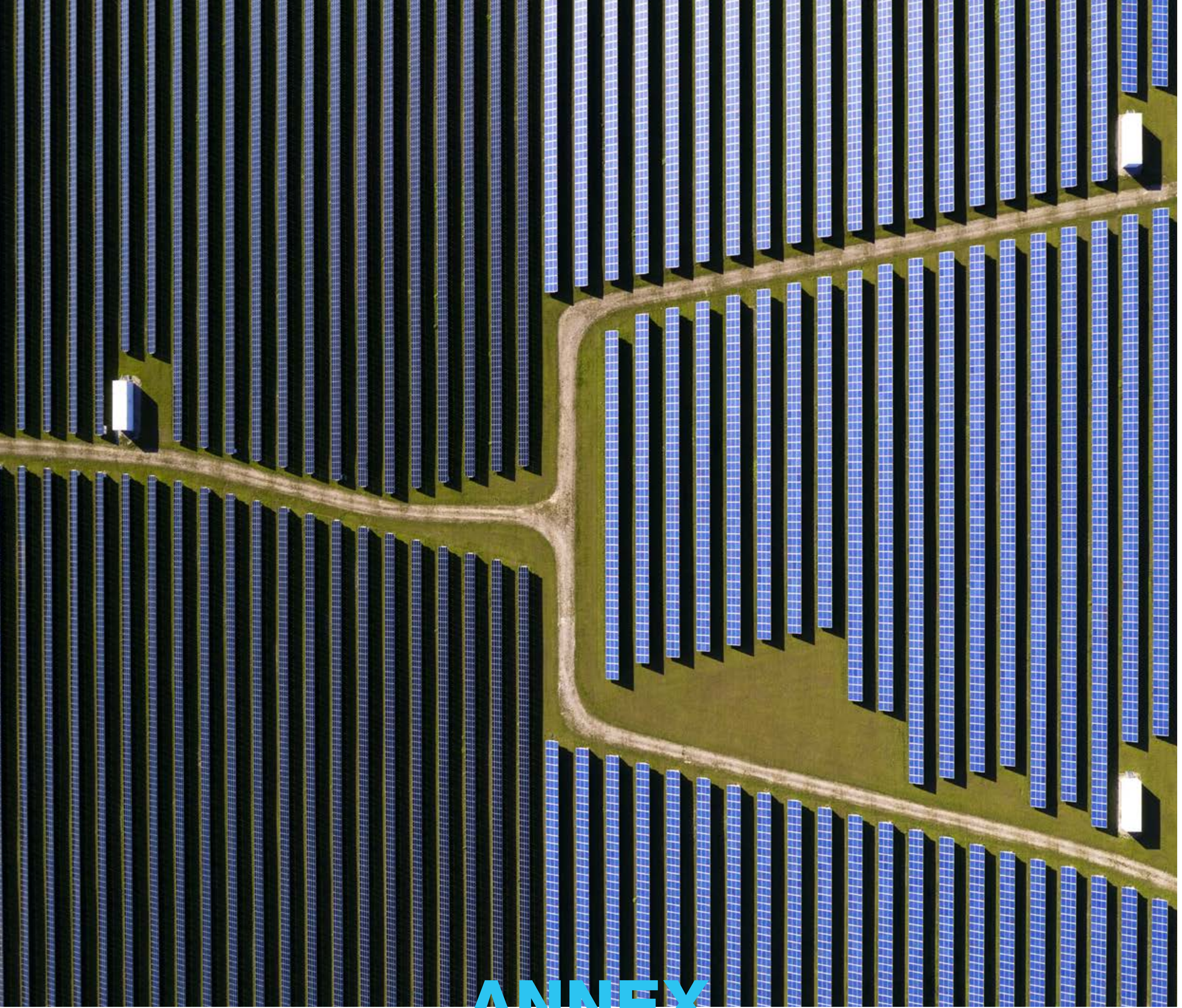
12. Such as the GHG protocol (https://ghgprotocol.org/)

THE EU TAXONOMY (REGULATORY 2020/852)

In order to meet the EU's climate and energy targets for 2030 and reach the objectives of the European Green Deal, investments should be directed towards sustainable projects and activities. This is why the action plan on financing sustainable growth called for the creation of a common classification system for sustainable economic activities, or an "EU taxonomy". With the objective of climate change mitigation in mind, the EU taxonomy defines technical screening criteria for assessing the contribution of TSO activities to the energy transition.
According to this taxonomy, each activity undertaken by TSOs makes a *substantial contribution to climate change mitigation* if:

- the transmission infrastructure or equipment is part of the interconnected European system;
- more than 67% of newly enabled generation capacity in the system is below the generation threshold value of 100 gCO_2e/kWh measured on a life cycle basis, over a rolling five-year period;
- the average system grid emissions factor is below the threshold value of 100 gCO_2e/kWh measured on a life cycle basis, over a rolling five-year period.

The following activities are considered as always eligible according to the EU taxonomy framework: the construction and operation or expansion of direct RES connections; the installation of Tier 2 transformers; the installation and operation of equipment or infrastructure aimed at integrating more renewable generation or increasing the controllability and observability of the network; interconnections between electricity systems, where at least one is considered compliant to taxonomy criteria.
Therefore, the vast majority of TSO activities fall within the aforementioned scope and are thus considered as activities that enable the energy transition.



ANNEX

GLOSSARY

Air-insulated Substation (AIS): AIS high voltage substation engineering uses air in a metal-clad system for insulation.

Coefficient of Performance (CoP): The CoP of a heat pump, refrigerator or air conditioning system is a ratio indicating the efficiency of such an asset: the useful heating or cooling provided for its user against the work (or energy) required to power it. Higher COPs equate to higher efficiency, lower energy (power) consumption and thus lower operating costs. The COP usually exceeds 1, especially in heat pumps, because of the contribution of ambient heat (source: Wikipedia).

Distribution System Operator (DSO): Regulated entity responsible for the transport of electrical power along the distribution network (e.g. between the high-voltage transmission system and the end consumer). They provide access to the distribution network users according to non-discriminatory and transparent rules.

ENTSO-E: the European Network of Transmission System Operators that represents 42 electricity transmission system operators (TSOs) from 35 countries across Europe. ENTSO-E was established and given legal mandates by the EU's Third Package for the Internal energy market in 2009, which aims to further liberalise the gas and electricity markets in the EU.

Gas Insulated Substation (GIS): GIS high-voltage substation engineering uses the gas sulfur hexafluoride (SF_6) or other gases for insulation.

Global Worming Potential (GWP): This is the heat absorbed by any greenhouse gas in the atmosphere, as a multiple of the heat that would be absorbed by the same mass of carbon dioxide (CO_2). GWP is 1 for CO_2. For other gases, it depends on the gas and the time frame (source: Wikipedia).

Greenhouse gas (GHG): A greenhouse gas is a gas that absorbs and emits radiant energy within the thermal infrared range, causing the greenhouse effect. The primary greenhouse gases in the Earth's atmosphere are water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3) (source: Wikipedia).

Greenhouse Gas emission protocol: The GHG Protocol establishes comprehensive global standardised frameworks to measure and manage greenhouse gas emissions from private and public sector operations, value chains and mitigation actions (https://ghgprotocol.org/).

Power-to-X (P2X): This refers to the conversion of electricity into other forms of energy (typically gas and liquid fuel and heat). Power-to-X conversion technologies allow for the decoupling of power from the electricity sector for use in other sectors (such as transport or chemicals). The X in the expression generally refers to one of the following: power-to-ammonia, power-to-chemicals, power-to-fuel, power-to-gas, power-to-hydrogen, power-to-liquid, power-to-methane, power-to-syngas, etc (source: Wikipedia).

Project of Common Interest (PCI): This is a category of projects that the European Commission has identified as a key priority for interconnecting the European Union's energy system infrastructure. These projects are eligible to receive public funds. The PCI list is reviewed every two years.

Renewable Energy Sources (RES): Renewable energy is useful energy that is collected from renewable resources, which are naturally replenished on a human timescale, including carbon-neutral sources like sunlight, wind, rain, tides, waves, and geothermal heat. This type of energy source stands in contrast to fossil fuels, which are being used far more quickly than they are being replenished.

Science-based target: Science-based targets provide companies with a clearly-defined path to reduce emissions in line with the Paris Agreement goals. More than 1,000 businesses around the world are already working with the Science Based Targets initiative (SBTi) (https://sciencebasedtargets.org/).

Sulphur hexafluoride (SF_6): This is an extremely potent and persistent greenhouse gas that is primarily utilised as an electrical insulator and arc suppressant. It is inorganic, colorless, odorless, non-flammable, and non-toxic (source: Wikipedia).

Ten Year Network Development Plan (TYNDP): One of the main publications of ENTSO-E, elaborated in coordination with ENTSOG, the association of the gas TSOs. It is the only existing pan-European network development plan, including transmission and storage projects. It is the basis for the selection of EU projects of common interest (PCIs) (https://tyndp.entsoe.eu/).

Transmission System Operator (TSO): Entity responsible for the bulk transmission of electrical power across the main high-voltage electric networks. The term is defined by the European Commission. The certification procedure for Transmission System Operators is listed in Article 10 of the Electricity and Gas Directives of 2009.

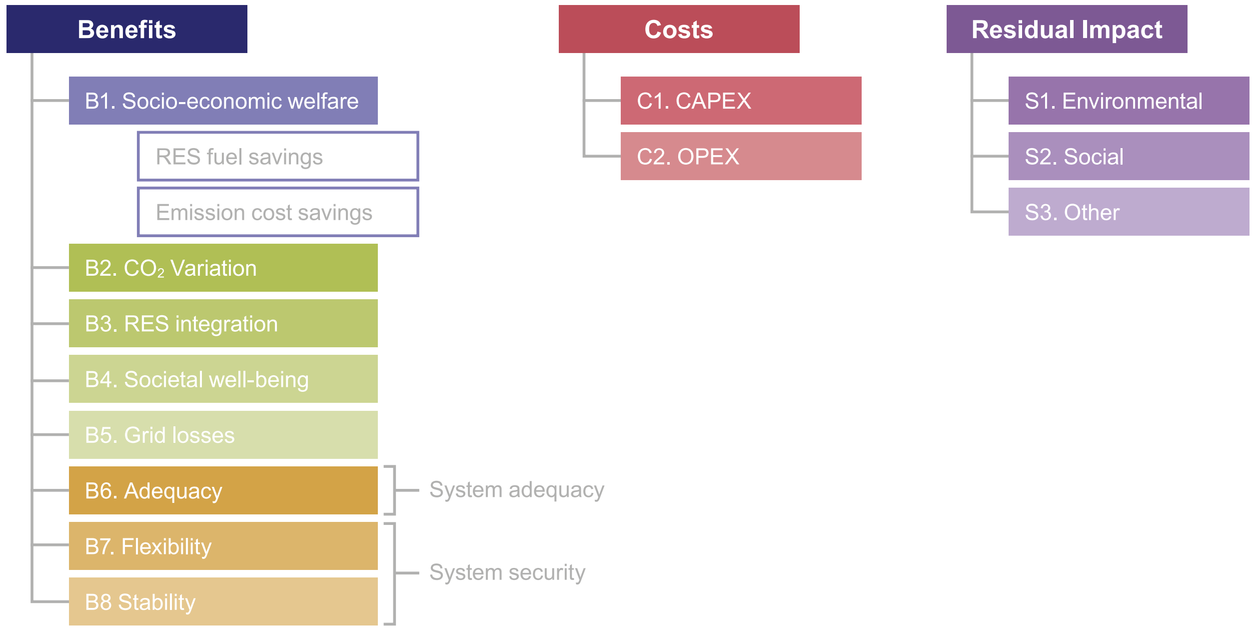
INTRODUCTION TO THE EUROPEAN COST-BENEFIT ANALYSIS

The European Cost Benefit Analysis (CBA) methodology provides a uniform basis for the assessment of transmission and storage projects included in ENTSO-E's Ten-Year Network Development Plan (TYNPD). The methodology complies with the requirements of EU Regulation (EU) 347/2013 and is also intended to be used by Member States as a reference for the realisation of their national development plans.

A robust assessment of transmission and storage projects, especially in a meshed system, requires the implementation of complex methodologies; costs and benefits associated with a project are evaluated using combined cost-benefit and multi-criteria approaches which result in both qualitative and quantitative indicators.

Some indicators - such as CO_2 variation (B2), RES integration (B3) and grid losses (B6) - are used to quantify a project's contribution to environmental and decarbonisation goals. Indicators are calculated by comparing the results of market and network simulations carried out both with and without the relevant project; they therefore represent how many CO_2 emissions, RES curtailments and grid losses have been avoided. More information about the CBA can be found on ENTSO-E's website.

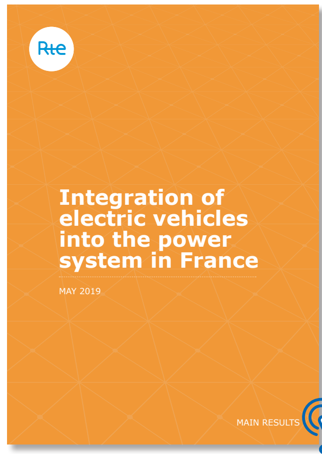
FIGURE 9 INDICATORS OF THE CBA METHODOLOGY



(Source: 2nd ENTSO-E Guideline for Cost Benefit Analysis of grid development projects, 2018)

DIRECT ELECTRIFICATION: FOCUS ON FRANCE

RTE's "Electromobility Study"

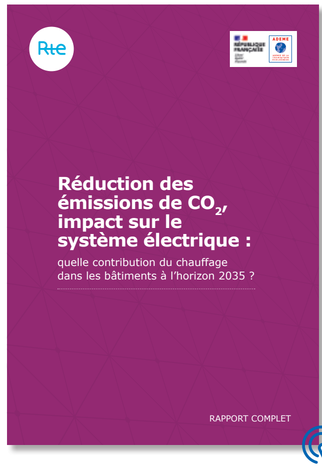


A significant expansion of electric mobility in the coming years, in line with the ambitions of public authorities (French Low Carbon Strategy), will not represent a major issue for security of supply and adequacy. Some of the vehicle recharging will have to be controlled, depending on how electric mobility is developed. Even under a 'limited growth' scenario (in terms of the number of vehicles which are rolled out and the characteristics of the recharging), controlling about half of all recharging events would be sufficient to guarantee compliance with the security of supply criterion. Bi-directional charging (V2G) represents an interesting economic opportunity for users and for the electrical system.

System services represent a market that can be very profitable for participating vehicles. However, according to the study, in France a few hundred thousand V2G-ready vehicles would be sufficient for providing all the system services which are required today.

Thanks to the electrification of transportation, France's carbon footprint could be reduced by at least 18 million tons CO_2eq per year by 2035. According to all future energy scenarios, current emissions in the transport sector will be reduced by between 20 million tons CO_2e and 35 million tons CO_2e per year in the run-up to 2035 (compared to a scenario without electromobility).

RTE and ADEME "Building heating study"



France's ambitious objectives related to building renovation and the development of renewable energy will not lead to an increase in electricity consumption for heating purposes and will not impact electrical peaks. In fact, all of the planned energy efficiency actions will compensate for the additional consumption created as a consequence of the rollout of new electric heating equipment.

The development of electrical solutions in buildings is, like the development of other decarbonised solutions, essential for decarbonising emissions linked to heating. These solutions must be undertaken in an efficient way and must be accompanied by measures to increase the performance of buildings. These ambitious objectives will allow emissions to be reduced by 28 million tons of CO_2eq per year by 2035 compared to 2018.

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