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ROBERT SCHUMAN CENTRE

The EU Green Deal (2022 ed.)

EDITORS
Leigh Hancher
Leonardo Meeus
Athir Nouicer
Valerie Reif

AUTHORS
Ronnie Belmans
Ilaria Conti
Albert Ferrari
Giulio Galdi
Leigh Hancher
James Kneebone
Leonardo Meeus
Athir Nouicer
Maria Olczak
Andris Piebalgs
Alberto Pototschnig
Valerie Reif
Daniele Stampatori
Tim Schittekatte

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Abstract

In this report we focus on the fundamentals of energy and climate policy as reformulated in the EU Green Deal. The 2022 edition includes updates following the publication of the Fit for 55 Package and the EU Hydrogen and Decarbonised Gas Markets Package. The reader is guided through the landscape of EU climate and energy policy. Starting with the big picture of the foundations of energy and climate policy, we then move to discussing in more detail European climate policy, security of supply and energy networks. We continue with energy wholesale and retail markets, and finish with a closer look at energy innovation. Each chapter is divided into several sections, aiming to give the reader a broad overview of the areas of climate and energy policy that are impacted by the EU Green Deal. The references at the end of each section serve as suggestions for further reading on each topic.

Keywords

EU Green Deal, Fit for 55 Package, EU Clean Energy Package, EU Hydrogen and Decarbonised Gas Markets Package, EU climate policy, security of supply, energy markets, energy innovation, energy, electricity, gas, policy pillars, EU institutions, EU treaties, legislation, subsidiarity, solidarity, EU organisations, EU agencies, climate agreements, EU ETS, carbon-border adjustment mechanisms, WTO, methane, renewable energy policy, energy efficiency policy, network planning, TYNDP, TEN-E, offshore, distribution, resource adequacy, capacity mechanisms, just energy transition, energy poverty, energy wholesale markets, retail markets, new deal, energy system integration, smart cities, electro mobility, energy technology, data exchange and interoperability, digital transformation, clean molecules, hydrogen

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List of Abbreviations

ACER	Agency for the Cooperation of Energy Regulators
AFID	Alternative Fuel Infrastructure Directive
AFIR	Alternative Fuel Infrastructure Regulation
ARCI	ACER Retail Competition Index
ATR	Auto-Thermal Reforming
ATSOI	Association of Transmission System Operators in Ireland
BAU	Business as Usual
BCM	Billion Cubic Metres
BRPs	Balance Responsible Parties
BSPs	Balancing Service Providers
CACM	GL Capacity Allocation and Congestion Management Guideline
CAP	Common Agricultural Policy
CAPEX	Capital Expenditure
CBA	Cost-Benefit Analysis
CBAM	Carbon Border Adjustment Mechanism
CCAC	Climate and Clean Air Coalition
CCfD	Carbon contracts for difference
CCHP	Combined Cooling, Heat and Power
CCUS	Carbon Capture, Use and Storage
CDM	Clean Development Mechanism
CEC	Citizen Energy Community
CEER	Council of European Energy Regulators
CEP	Clean Energy for all Europeans Package
CHP	Combined Heat and Power
CJEU	Court of Justice of the European Union
CM	Capacity Mechanism
CMA	Conference of the Parties Serving as the Meeting of the Parties to the Paris Agreement
CMP	Conference of the Parties Serving as the Meeting of the Parties to the Kyoto Protocol
COP	Coefficient Of Performance
COP	Conference Of the Parties
CPR	Construction Products Regulation
DC NC	Demand Connection Network Code
DR	Demand Response
DRI	Direct Reduced Iron
DoEAP	Digitalisation of Energy Action Plan
DSOs	Distribution System Operators
EAEC	European Atomic Energy Community
EB GL	Electricity Balancing Guideline
EC	European Commission
ECA	European Court of Auditors
ECB	European Central Bank
ECHA	European Chemicals Agency
ECRB	Energy Community Regulatory Board
EE	Energy Efficiency
EEA	European Environment Agency
EEC	European Economic Community
EED	Energy Efficiency Directive
EER	Energy Efficiency Ratio
EERA	European Energy Research Alliance
EGD	European Green Deal
EGDIP	European Green Deal Investment Plan
EIONET	European environment information and Observation network
EIP SCC	European Innovation Partnership on Smart Cities and Communities

EIPs	European Innovation Partnerships
ENNOH	European Network for Network Operators of Hydrogen
ENTSO-E	European Network for Transmission System Operators for Electricity
ENTSOG	European Network of Transmission System Operators for Gas
ENVI	Environment, Public Health and Food Safety
EP	European Parliament
EPBD	Energy Performance of Buildings Directive
EPCs	Energy Performance Certificates
EPREL	European Product Database for Energy Labelling
EPS	Emission Performance Standard
ER NC	Network Code on Electricity Emergency and Restoration
ERGEG	European Regulators' Group for Electricity and Gas
ESI	Energy System Integration
ESMA	European Securities and Markets Authority
ESO	Energy Saving Obligation
ETD	Energy Taxation Directive
ETF	Enhanced Transparency Framework
ETPs	European Technology Platforms
ETS	Emissions Trading System
ETSO	Association of European Transmission System Operators
EU	European Union
EVs	Electric Vehicles
FCA GL	Forward Capacity Allocation Guideline
FIT	Feed-In Tariff
FSR	Florence School of Regulation
GATT	General Agreement on Tariffs and Trade
GCs	Green Certificates
GHG	Greenhouse Gas
GIE	Gas Infrastructure Europe
GLE	Gas LNG Europe
GSE	Gas Storage Europe
GTE	Gas Transmission Europe
GWP	Global Warming Potential
H2020	Horizon 2020
HGMDPc	Hydrogen and Decarbonised Gas Market Package
HVDC NC	Requirements for Grid Connection of High Voltage Direct Current Systems and Direct Current-connected Power Park Modules Network Code
ICT	Information and Communication Technology
IEA	International Energy Agency
IMEO	International Methane Emissions Observatory
IPCC	Intergovernmental Panel on Climate Change
IPCEI	Important Projects of Common European Interest
IRENA	International Renewable Energy Agency
ITS	Intelligent Transport Systems
JAO	Joint Allocation Office
JI	Joint Implementation
KP	Kyoto Protocol
LCOE	Levelised Cost of Electricity
LDAR	Leak Detection and Repair
LNG	Liquified Natural Gas
LOH	Liquid Organic Hydrogen Carrier
LT-LEDS	Long-Term Low Greenhouse gas emission Development Strategies
MEPs	Members of the European Parliament
MFN	Most-Favoured-Nation
MMRs	Market Monitoring Reports

MRV	Measurement, Reporting and Verification
NC	Network Code
NCEPs	National Climate and Energy Plans
NDCs	Nationally Determined Contributions
NEMOs	Nominated Electricity Market Operators
NGEU	NextGenerationEU
NGOs	Non-Governmental Organisations
NORDEL	Organization of the Nordic Transmission System Operators
NPF	National Policy Framework
NRAs	National Regulatory Agencies
nZEBs	Nearly Zero Energy Buildings
OECD	Organisation for Economic Cooperation and Development
OGMP	Oil and Gas Methane Partnership
OPAL	Ostsee-Pipeline-Anbindungsleitung
OPEX	Operational Expenditure
OTC	Over-The-Counter
PPA	Power Purchase Agreement
PX	Power Exchange
R&I	Research and Innovation
RD&I	Research, Development & Innovation
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
REC	Renewable Energy Community
RED	Renewable Energy Directive
RES	Renewable Energy Sources
RfG NC	Network Code on Requirements for Grid Connection of Generators
RFNBOs	Renewable Fuels of Non-biological origin
RIs	Regional Initiatives
SAF	Sustainable Aviation Fuel
SBI	Subsidiary Body for Implementation
SBSTA	Subsidiary Body for Scientific and Technological Advice
SDAC	Single Day-Ahead Coupling
SDGs	Sustainable Development Goals
SDS	Sustainable Development Scenario
SECAP	Sustainable Energy and Climate Action Plan
SET	Strategic Energy Technology
SMR	Steam Methane Reforming
SO GL	Electricity Transmission System Operation Guideline
STEPS	Stated Policies Scenario
TCMs	Terms and Conditions or Methodologies
TEN-E	Trans-European Energy Networks
TENs	Trans-European Networks
TEN-T	Trans-European Transport Network
TEU	Treaty on European Union
TFEU	Treaty on the Functioning of the European Union
TPA	Third Party Access
TRIMs	Trade-Related Investment Measures
TSOs	Transmission System Operators
TYNDP	Ten-Year Network Development Plan
UCPTE	Union for the Coordination of Production and Transmission of Electricity
UCTE	Union for the Coordination of Transmission of Electricity
UKTSOA	United Kingdom Transmission System Operators Association
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VRE	Variable Renewable Energy
WTO	World Trade Organization

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Acknowledgements

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Like the Green Deal itself, this text is a work in progress. This 2022 edition includes updates following the publication of the Fit for 55 and the EU Hydrogen and Decarbonised Gas Markets packages. It is a collective work by the course team and many of our colleagues at the Florence School of Regulation. Some topics are explored to a greater extent than others and some key issues are described in more detail than others.

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The journey of the EU Green Deal has only just started, and its implementation will be a process taking place over the next 30 years. Therefore, this text will need to be continually updated. This 2022 edition considers updates to legislative proposals until mid-September 2022.

Disclaimer: The authors are responsible for any errors or omissions.

Introduction to this report

On 1 December 2019, the von der Leyen Commission took office. Ursula von der Leyen, President of the European Commission, defined a set of six political priorities for her Commission's 2019-2024 term (von der Leyen, 2019). The six priorities are:

- A European Green Deal, which aims to make Europe the first climate-neutral continent by becoming a modern resource-efficient economy;
- A Europe fit for the digital age, with a European digital strategy that will empower people with a new generation of technologies;
- An economy that works for the people, by creating a more attractive investment environment and growth that creates quality jobs, especially for young people and small businesses;
- A stronger Europe in the world, which means strengthening Europe's voice in the world by championing multilateralism and a rules-based global order;
- Promoting our European way of life by protecting the rule of law so as to stand up for justice and the EU's core values; and
- A push for European democracy, which means giving Europeans a bigger say and protecting European democracy from external interference such as disinformation and online hate messages.

On 11 December 2019, the European Commission presented the European Green Deal. It is a European Commission action that consists of numerous policy initiatives aiming to make Europe the first climate-neutral continent by 2050. At the same time, it aims to boost the economy, improve people's health and quality of life, and leave nobody behind in the process. The proposed measures are spread across eight policy areas. Some measures and areas relate to the energy and climate sectors while others go beyond EU energy policy and are important to combat climate change.

In this report, we focus on the measures related to energy and climate policy. The report contains five chapters. The choice of these five chapters is inspired by the well-known pillars of EU energy policy (see section 1.1), with inputs from the related EU Green Deal areas.

- In Chapter 1 we introduce the 'the big picture.' We start with an overview of the EU Green Deal and the Fit for 55 Package. We then move on to explaining the EU institutions and treaties, the subsidiarity and solidarity principles, EU agencies and organisations, and energy taxation.
- Chapter 2 focuses on EU climate policy. We cover international climate agreements, the EU ETS, carbon-border adjustment mechanisms and the World Trade Organization (WTO), decarbonisation instruments such as renewable energy and energy efficiency policies, and methane emissions.
- Chapter 3 covers EU security of supply policy. We discuss security of supply for oil, natural gas and electricity, and resource adequacy and capacity mechanisms. We also cover planning future networks and road transport and (electro) mobility infrastructure.
- Chapter 4 focuses on EU energy markets. We discuss electricity and gas wholesale and retail markets. We also look at a just energy transition and energy poverty.
- Finally, in Chapter 5 on EU energy innovation we spotlight smart city initiatives, energy technology, digital transformation, green gases and hydrogen.

The first edition of the EU Green Deal training course took place in late spring 2021, before the publication of the Fit for 55 Package. Following the publication of the Fit for 55 Package (Part I in July 2021, Part II in December 2021) and the *EU Hydrogen and Decarbonised* Gas Markets Package in December 2021, this report has been updated to reflect the changes that these packages bring to EU energy and climate policy.

At the time of writing, negotiations revising the proposals put forward by the European Commission are underway: this report collects updates until mid-September 2022. For the sake of simplicity, only the most substantial amendments proposed by the Parliament and the Council that have come to our attention were considered.

Note also that the core text refers to a context which precedes the beginning of the war in Ukraine and the consequent energy strategy adopted by the EU. However, the implications of the REPowerEU Plan on the Fit for 55 proposals are duly considered in this report.

1. The big picture

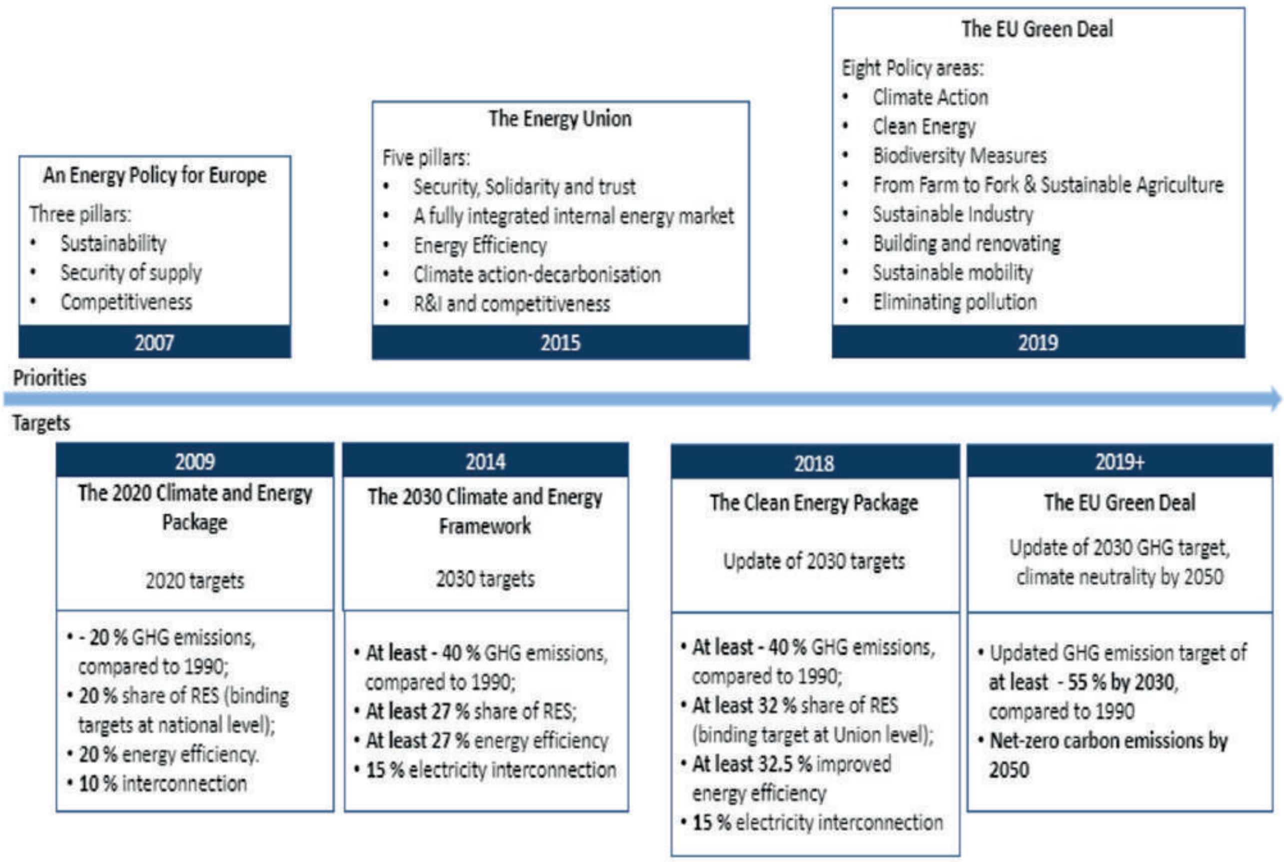
In this chapter we explore the 'big picture' of energy and climate policy in the EU in five sections. First, we present EU energy policy and the evolution of the relevant policy pillars, including a general introduction to the EU Green Deal. Second, we outline the main EU treaties, institutions and legislation, and take a closer look at the legislative packages that are relevant to energy policy, including the most recent Fit for 55 Package. Third, we introduce the concepts of subsidiarity and solidarity. Fourth, we introduce the main EU agencies and organisations. Fifth, we provide an introduction to the topic of energy taxation.

1.1 EU energy policy: from 3 pillars to 5 dimensions and 8 areas

Athir Nouicer and Valerie Reif

In this section, we investigate how EU energy policy has evolved over recent years. Figure 1 gives an overview of the elements of EU climate and energy policy that are described in this section. We start by describing the Energy Policy for Europe introduced in 2007. We then present the 2015 Energy Union Strategy. Finally, we introduce the Green Deal, which includes eight policy areas that are broader in scope.

Figure 1: The evolution of EU climate and energy policy with targets and priorities so far (September 2022).[1]



1 Note that the targets shown in the figure only include legally binding targets but not those at the proposal stage in the Fit for 55 Package (i.e., updated RES and EE targets). The energy efficiency target was proposed to be increased to 36 % (see also footnote 9). The share of RES target was initially proposed to be increased to 40%, but another proposal to increase it to 45 % was put forward by the European Commission in the context of REPowerEU (see also section 2.5).

An Energy Policy for Europe (2007) – the three policy pillars

In this subsection we first present the three pillars in the 2007 Energy Policy for Europe. Following this, we present the subsequent 2020 Climate & Energy Package and its targets.

The three pillars

Over the past seven decades, Europe's energy policy has been developed by means of several legislative measures based initially on the provisions in the European Treaties (see also section 1.2). It was only in 2007, however, that the European Union created a dedicated EU energy policy, which was referred to as 'An Energy Policy for Europe.' This was proposed by the European Commission (EC, 2007) and endorsed by the European Council (2007) later that year.

The policy was based on three pillars defined in an earlier Green Paper on a European Strategy for Sustainable, Competitive and Secure Energy (Commission of the European Communities, 2006). The Green Paper was developed following a summit of EU Heads of State and Government in 2005, which underlined the role of an integrated approach to climate change, energy and competitiveness objectives. The three equally important pillars,[2] which were later included in Article 194 of the TFEU (see section 1.3), are:

- Sustainable development,
- Security of supply, and
- Competitiveness.

First, sustainable development principles are among the drivers of EU climate policy. The EU is committed to tackling climate change by reducing greenhouse gas (GHG) emissions. This came in a context in which the energy sector was linked to 80% of all EU greenhouse gas emissions (Piebalgs et al., 2020) and the EU energy policies were not sustainable enough, as was highlighted in a Commission Green Paper (Commission of the European Communities, 2006). Sustainable development has been acknowledged as an overarching aim of the EU since its inclusion in the Treaty of Amsterdam in 1997. It has been prioritised at different public governance levels and is subject to increasing awareness in the private sector.

Second, security of supply is a concept that is often discussed at the national and European levels, especially in times of crisis (see section 3.1). According to the European Commission communication 'Energy Policy for Europe' (EC, 2007), increasing EU reliance on imported hydrocarbons,[3] together with uncertain ability and willingness of major producers to increase investments to meet future demand, represents an increased risk of supply failure. The communication stressed the need to establish solidarity among the Member States in the event of an energy crisis. In addition, at the beginning of the 21st century EU electricity demand was rising by about 1.5% a year, requiring essential investments in the following years (EC, 2007). This required predictability and effective energy markets promoting long-term investments. Three ways were highlighted in the 'Energy Policy for Europe' communication to promote energy security. First, diversification of gas supply, especially in Member States depending on one gas supplier. Second, improving the functioning of the EU's strategic oil stock mechanism. Third, electricity interconnections together with binding and enforceable reliability standards.

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2 Over time, one or more of these three pillars seem to acquire more prominence than the others in the policy debate. This tendency mostly depends on the specific political circumstances, such as an interruption in the supply of fossil fuels, a spike in energy prices or a strengthening of the environmentalist movements in the public opinion.

3 According to the European Commission (EC, 2007) communication, a business as usual (BAU) scenario would increase EU dependence on energy imports from 50% in 2007 to 65% of total EU energy consumption in 2030. In 2018, the EU dependence rate was equal to 58 % (Eurostat, 2021).

Third, the competitiveness pillar, with integrated energy markets as its most crucial element. Competitiveness was considered key to bring down costs for citizens and industry and to stimulate energy efficiency and investments, in particular in renewable energy. This would promote EU global leadership in these technologies with the aim of maintaining a positive trade balance for various industries while reaching sustainability and security of supply objectives. At that time, Member States were criticised for their "protectionist support for national market leaders" (EP, 2006), hindering competition.

In 2007, these pillars represented the three challenges in Europe's energy sector that the Internal Energy Market was expected to meet. To tackle these challenges, the starting points in the 'Energy Policy for Europe' communication were fighting climate change, limiting the EU's dependence on imported fuels and providing economic growth and jobs.

The 2020 Climate & Energy Package

The 'Energy Policy for Europe' communication led to adoption of the 2020 Climate & Energy Package, a set of laws passed to ensure that the EU met its climate and energy targets for the year 2020. The package set the so-called '20-20-20 targets':

- A 20% reduction in GHG emissions (compared to 1990 levels);
- At least a 20% share of renewables in the EU's energy consumption and at least a 10% share of renewables in the transport sector;
- A 20% energy consumption reduction target to improve energy efficiency (compared to what estimated in 2007).
- The targets were set by EU leaders in 2007 and enacted in legislation in 2009. More concretely, a set of four main laws and policies was developed to implement them:
- Renewable Energy Directive 2009/28/EC (RED I);
- Revised Directive on emissions trading 2009/29/EC (ETS Directive);
- Carbon Capture and Storage Directive 2009/31/EC;
- Effort Sharing Decision 406/2009/EC.

Piebalgs et al. (2020) state that the EU has been relatively successful in achieving the 2020 objectives, even though they came with relatively high costs, e.g. infrastructure investments and RES subsidy payments.

The Energy Union Strategy (2015) – five policy dimensions

In this subsection, we present the 2030 Energy and Climate Package. We then introduce the subsequent Energy Union Strategy. Finally, we discuss changes following the resulting Clean Energy Package.

The 2030 Climate and Energy Framework

In 2014, the European Commission announced a reform and transformation of Europe's energy policy. This came together with the European Council's endorsement of the 2030 Climate and Energy Framework (European Council, 2014), which set four key Union-level targets in the areas of GHG emissions, energy efficiency, renewable energy and electricity interconnection.

The 2030 Energy and Climate Framework further built on the 2020 Climate and Energy Package. This was a non-legislative political agreement that set targets for 2030:

- A reduction of at least 40% in economy-wide GHG emissions (from 1990 levels);
- An indicative target at the EU level of at least a 27% improvement in energy efficiency;
- A binding target at the EU level of at least 27% renewable energy consumption;
- Achieving the existing electricity interconnection target of 10% by 2020, with the objective of arriving at 15% by 2030.

It was important to ensure that all sectors would contribute to the achievement of the 40% GHG reduction target by both reducing emissions and increasing removals. Therefore, this target was implemented with the EU Emissions Trading System (see also section 2.2), the Effort Sharing Regulation, with Member State emission reduction targets, and the Land Use, Land Use Change and Forestry Regulation.

Five policy dimensions

The Energy Union strategy, '[A Framework for a Resilient Energy Union with a Forward-Looking Climate Change Policy]' adopted on 25 February 2015, was the proposed way forward. The strategy is based on five dimensions that are mutually reinforcing and in line with the preceding three pillars:

- Energy security, solidarity and trust;
- A fully integrated European energy market;
- Energy efficiency contributing to moderation of demand;
- Decarbonising the economy; and
- Research, innovation and competitiveness.

The first dimension (energy security, solidarity and trust) built on the security of supply pillar of the 2007 Energy Policy for Europe. This reflected the Commission's vision that the Member States should rely on each other to securely and reliably deliver energy to citizens, based on solidarity and trust. The Energy Union Strategy highlighted two key drivers of energy security, namely completion of the internal energy market and enhanced energy efficiency. These were included among the five dimensions of the strategy.

The second dimension (a fully integrated European energy market) built on the competitiveness pillar of the 2007 Energy Policy for Europe. The emphasis on this dimension reflects the need for a new political boost to complete the internal energy market, as was highlighted in the Energy Union Strategy. The strategy stated that "the current market design does not lead to sufficient investments, market concentration and weak competition remain an issue and the European energy landscape is still too fragmented."

The third dimension (energy efficiency contributing to moderation of demand) reflects the importance of energy efficiency, which was now included as a standalone dimension in the Energy Union strategy. It is a decarbonisation instrument, together with the promotion of renewable energy sources (RES) and the adoption of other mechanisms such as carbon pricing. Energy efficiency should be considered an energy source on its own represented by energy savings.

The fourth dimension (decarbonising the economy) built on the sustainable development pillar of the 2007 Energy Policy for Europe. This dimension has two subcategories: an ambitious climate policy and renewable leadership. This aimed to contribute to the achievement of the EU-wide binding targets for GHG emissions and renewables, in line with commitments in the Paris Agreement.

The fifth dimension was Research and Innovation (R&I), which were given more weight and put in a standalone dimension. This highlighted the fact that R&I were to be at the heart of the 2015 Energy Union strategy. According to the 2015 strategy, the European energy R&I approach should build on Horizon 2020[4] and focus on four core priorities: worldwide leadership on the next generation of renewable energy technologies; facilitating consumer participation in the energy transition; efficient energy systems; and more sustainable transport systems. It also considered the achievements of the European Strategic Energy Technology Plan (SET Plan; see section 5.2) addressing the challenges involved in the commercialisation of innovative low-carbon technologies.

From the Energy Union strategy to the Clean Energy Package

Following the 2030 Climate and Energy Framework (2014) and the Energy Union Strategy (2015), the Clean Energy Package (CEP) was the way forward to implement the various targets and dimensions in EU legislation. The CEP included four directives and four regulations:

- Energy Performance in Buildings Directive (EU) 2018/844;
- Renewable Energy Directive (EU) 2018/2001, commonly known as RED II;
- Energy Efficiency Directive (EU) 2018/2002;
- Governance of the Energy Union Regulation (EU) 2018/1999;
- Electricity Regulation (EU) 2019/943;
- Electricity Directive (EU) 2019/944;
- Risk Preparedness Regulation (EU) 2019/941;
- ACER Regulation (EU) 2019/942.

The CEP also updated the Union's 2030 targets for energy and climate (see Article 2(11) of the Governance Regulation):

- A Union-wide binding target of at least a 40% domestic reduction in economy-wide GHG emissions compared to 1990 levels;
- A binding target at the EU level of at least a 32% share of renewable energy consumed in the EU;
- An improved energy efficiency target at the EU level of at least 32.5% relative to a 2007 baseline scenario;
- A 15% electricity interconnection target.

The CEP Governance Regulation requires the Member States to develop and submit National Climate and Energy Plans (NECPs). These are ten-year plans that include national objectives for each of the five Energy Union dimensions together with corresponding national policies and measures to achieve them.

4 Horizon 2020, commonly referred to as H2020, is a financial instrument bringing together EU research and innovation funding under the same common strategic framework. It was established in 2013 in Regulation (EU) No 1291/2013. In January 2021, Horizon Europe replaced Horizon 2020. It covers the period 2021-2027.

In October 2021, the European Commission published its sixth report on the state of the Energy Union (European Commission, 2021b) following Article 35 of the Governance Regulation requirements. This was accompanied by a wide range of reports and annexes outlining the progress made in different fields of energy and climate policy. This monitoring is central to the functioning of the regulation. It aims to avoid gaps in reaching the EU targets for renewable energy and energy efficiency with warning signals and recommendations to Member States lagging behind.

The Green Deal (2019) – eight policy areas

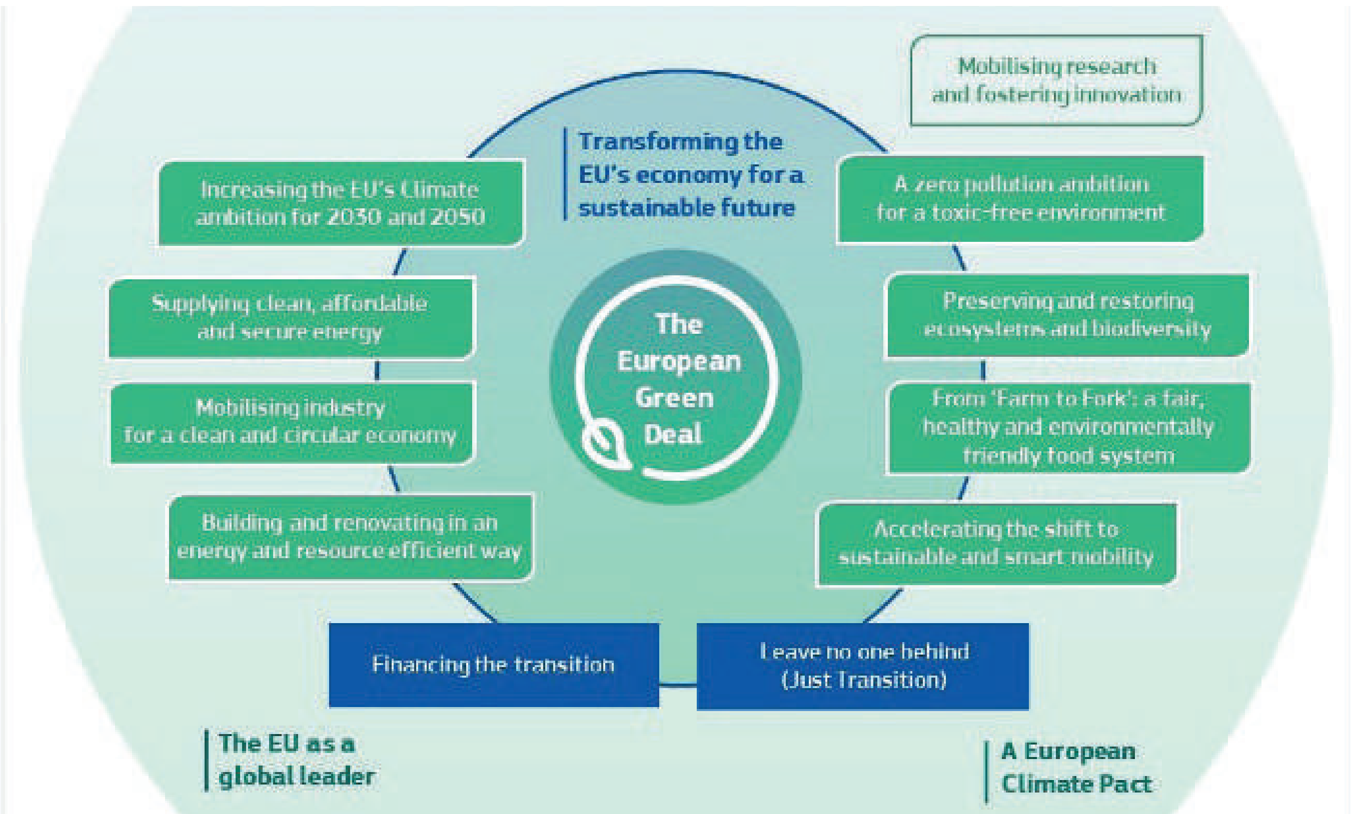
In December 2019, the European Commission presented the EU Green Deal. Compared to previous EU climate and energy packages and strategies, the Green Deal is broader in scope. It is the new growth strategy for Europe and a dedicated roadmap to make the EU economy sustainable and achieve climate neutrality by 2050.

This subsection describes the cornerstones of the Green Deal: first, the policy areas covered; second, its roadmap; third the European Climate Law; fourth, the Fit for 55 Package, including the Hydrogen and Decarbonised Gas Markets Package; and fifth, how to financing it.

The policy areas in the Green Deal

First outlined as a strategic priority in Commission President Ursula von der Leyen's political guidelines (von der Leyen, 2019), the European Green Deal was later detailed in Commission Communication COM(2019) 640 (EC, 2019). Eight policy areas are covered and they are accompanied by additional elements that aim to mainstream sustainability in all EU policies, as is shown in Figure 2.

Figure 2: The EU Green Deal (source: EC, 2019)



- **Climate action**: Making the EU climate-neutral by 2050 is at the heart of the Green Deal. Therefore, the Green Deal includes a climate initiative paving the way towards climate-neutrality. First, the European Climate Law enshrines in law the climate-neutrality objective. Second, the European Climate Pact is an EU-wide initiative to engage citizens, communities and organisations in climate action. Third, the 2030 Climate Target Plan 'Stepping up Europe's 2030 climate ambition' aims to cut GHG emissions by at least 55% by 2030. The revisions of the Climate Target Plan required are presented in the 'Fit for 55' Package.

- **Clean energy**: Decarbonising the EU energy system is critical to reach climate neutrality. This policy area is based on three fundamental principles: prioritising energy efficiency and renewable energies; a secure and affordable EU energy supply; and a fully integrated, interconnected and digitalised EU energy market.

- **Biodiversity measures:** The EU's ecosystem is fragile and needs to be protected. The EU biodiversity strategy for 2030 aims to put Europe's biodiversity on a path to recovery by 2030, targeting biodiversity loss drivers and bringing benefits for people, the climate and the planet.

- **From Farm to Fork/Sustainable agriculture**: European food systems account for nearly a third of global GHG emissions and consume large amounts of natural resources, which means there is a need to redesign them (EC, 2020a). The 'From Farm to Fork' strategy aims to ensure a healthier and more sustainable EU food system. Related to this is a reform of the Common Agricultural Policy (CAP) which specifies the future direction of the CAP, incorporates the Green Deal sustainable objectives and sets the path for the 'farm to fork' strategy.

- **Sustainable industry**: EU industry should be helped to evolve and make the most of domestic and global opportunities. The new EU industrial strategy, which is based on circular economy principles, aims to support the green transformation. A key aim should be to create more sustainable and environmentally friendly production cycles through development of new markets for climate-neutral products.

- **Building and renovating**: The European Commission recognises the need to develop a cleaner construction sector and to start a wave of building renovation to help people cut their energy bills and decrease their energy use. The Renovation Wave Strategy aims to improve the energy performance of buildings, leading to higher energy and resource efficiency. The Commission targets at least double renovation rates by 2030. Thirty-five million buildings could be renovated by then and up to 160,000 additional green jobs created (EC, 2020g).

- **Sustainable mobility**: The Green Deal includes measures to reduce transport emissions by promoting more sustainable means of transport. The Sustainable and Smart Mobility Strategy lays the foundations for the future EU transport system (EC, 2020h). The strategy aims to achieve a green and digital transformation and make the transport system more resilient. The targeted transport system is smart, competitive, safe, accessible and affordable.

- **Eliminating pollution:** The Green Deal includes a plan to protect Europe's citizens and ecosystems and prevent air, water and soil pollution. The Zero Pollution Action Plan includes measures to cut pollution rapidly and efficiently. It aims to reach no pollution from "all sources" and clean the air, water and soil by 2050.

The Green Deal roadmap

The publication of the European Green Deal Communication COM(2019)640 by the EC (2019) was only the beginning of the long journey towards 2050. In general, all EU actions and policies are now expected to contribute to the Green Deal objectives. In more detail, the annex of COM(2019)640 includes an indicative timetable for 47 key policies and measures to be implemented in the framework of the Green Deal. This initial roadmap is to be updated according to evolving needs and required policy responses.[5] So far, the main steps have been:

- Presentation of the EU Green Deal in December 2019;
- Presentation of the Green Deal Investment Plan and the Just Transition Mechanism in January 2020;
- Presentation of a proposal for a climate law in March 2020, followed by an amended proposal in September 2020 and entry into force of the final regulation in June 2021; and
- Presentation of the Fit for 55 Package in July and December 2021 (see also 1.2).
- Presentation of the proposal of a new EU framework to decarbonise gas markets, promote hydrogen and reduce methane emissions in December 2021.
- Presentation of the REPowerEU Plan in May 2022.[6]

The European Climate Law

In March 2020, the European Commission published a proposal for a European Climate Law (EC, 2020d). The aim was to complement the existing 2030 Climate and Energy Framework by setting the long-term direction of travel towards 2050 and turning the political Green Deal commitment to achieve climate neutrality by 2050 into a legally binding obligation.

Later that year and based on the 2030 Climate Target Plan (EC, 2020f), the European Commission published a proposal for the climate law. In addition to setting the long-term direction towards 2050, it introduced an intermediate target for 2030. The GHG reduction target for 2030 would be raised from at least 40% (as had been previously agreed under the 2030 Climate and Energy Framework) to at least 55% compared to 1990 (EC, 2020e). In April 2021, the Council and the Parliament reached agreement on the proposal. The regulation entered into force in July 2021. The European Climate Law (EC, 2021a):

- establishes a framework for achieving climate neutrality within the EU by 2050, i.e. a balance between EU-wide GHG emissions and their removal regulated in EU law;
- in addition to the binding objective of climate neutrality in the EU by 2050, includes the aim of achieving negative emissions in the EU thereafter;
- recognises the need to enhance the EU carbon sink;[7]
- provides a binding EU target of a net domestic reduction in GHG emissions by at least 55% (compared

5 On its website, the European Commission provides a timeline of Green Deal actions from its inception in December 2019 to the present, available at https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en (last accessed 01 March 2022).

6 Link to the key documents of REPowerEU: https://commission.europa.eu/publications/key-documents-repowereu_en.

7 A carbon sink is a reservoir that removes carbon dioxide from the atmosphere. The enhancement is to be achieved by means of a more ambitious Land Use, Land-Use Change and Forestry (LULUCF) Regulation, for which the Commission made a proposal as part of the Fit for 55 Package.

to 1990 levels) by 2030;

- allows the Commission to propose a climate target for 2040 within six months of the first global stocktake under the Paris Agreement;
- introduces rules (e.g., monitoring and reporting) to ensure continual progress towards the global adaptation goal in the Paris Agreement;

includes stronger provisions on adaption to climate change and a commitment to engage with sectors to prepare sector-specific roadmaps for climate-neutrality.

The regulation establishes an independent European Scientific Advisory Board on Climate Change composed of 15 senior scientific experts with broad expertise, which will provide independent scientific advice and issue reports on existing and proposed EU measures.

Member States are required to take further actions, such as setting up climate advisory bodies and establishing a multilevel climate and energy dialogue with different stakeholders. They must submit their 30-year strategies to the Commission by 1 January 2029, and every 10 years after that.

The European Commission is required to assess EU and national progress, including whether the measures at these levels are consistent and whether draft EU measures and legislation, including budgetary proposals, are consistent with the 2030, 2040 and 2050 targets.

The updated GHG emissions reduction target for 2030 resulted in a need to revise all relevant policy instruments. In 2021, the European Commission adopted a series of proposals as part of the so-called 'Fit for 55' Package. These are described in the following subsection (see also section 1.2).

The Fit for 55 Package

In July 2021, the European Commission published the first part of the Fit for 55 Package, which was followed by a second part including the Hydrogen and Decarbonised Gas Markets Package in December 2021. In alignment with the updated GHG emissions target for 2030, the Fit for 55 Package proposes an update of other 2030 climate targets:

- a 40% share of renewable energy sources (RES) in the EU's energy mix (an EU-level target complemented by indicative national targets)[8];
- a 36% energy efficiency target for final energy consumption.[9]

The package consists of several proposals. The following announced initiatives were adopted by the Commission and communicated on 14 July 2021:

- Revision of the EU Emissions Trading System (COM(2021) 551 final) – see section 2.2;
- A Carbon Border Adjustment Mechanism (COM(2021) 564 final) – see section 2.3;
- Review of the Effort Sharing Regulation (COM(2021) 555 final);

8 As is described in footnote 1 and section 2.5, the European Commission proposed in the context of REPowerEU to increase the RES target to 45%. See the link in footnote 6 for more information.

9 As is described in more detail in section 2.6, the Fit for 55 Package introduces a new EU energy efficiency target, which must collectively ensure a further reduction in energy consumption of at least 9% by 2030, compared to projections made in the EU 2020 reference scenario (EC, 2021e). This new method of calculating EU energy efficiency translates into increased targets for reducing EU primary (-39%) and final (-36%) energy consumption by 2030.

- Revision of the Energy Tax Directive (COM(2021) 563 final) – see section 1.5;
- Amendment of the Renewable Energy Directive to implement the ambition of the new 2030 climate target (COM(2021) 557 final) – see section 2.5;
- Amendment of the Energy Efficiency Directive to implement the ambition of the new 2030 climate target (COM(2021) 558) – see section 2.6;
- Revision of the Regulation on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry (LULUCF) (COM(2021) 554 final);
- Revision of the Directive on deployment of alternative fuel infrastructure (COM(2021) 559 final) – see section 3.4;
- Revision of the Regulation setting CO2 emission performance standards for new passenger cars and for new light commercial vehicles (COM(2021) 556 final) – see section 3.4.

In addition to these initiatives, proposals for a new Social Climate Fund (COM(2021) 568 final) (see section 4.4) and an EU Forest Strategy (COM(2021) 572 final) are considered as part of the Fit for 55 files.

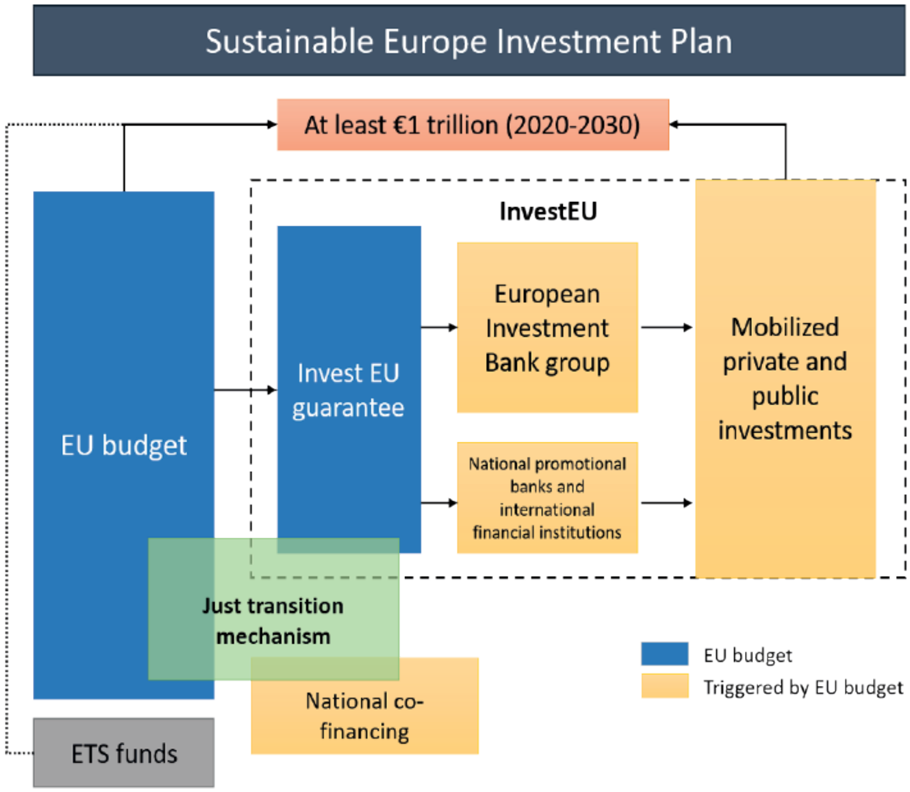
The following initiatives were adopted and communicated on 15 December 2021:

- A proposal for a regulation on methane emission reduction in the energy sector (COM(2021) 805 final) – see section 2.4;
- Revision of the Energy Performance of Buildings Directive (COM(2021) 802) – see section 2.6;
- Revision of the Third Energy Package for gas (Directive 2009/73/EU and Regulation 715/2009/EU) to regulate competitive decarbonised gas markets (COM (2021) 803 and COM(2021) 804, respectively) – see sections 4.2, 5.4 and 5.5)

Financing the Green Deal

To achieve the Green Deal ambition, significant investments will need to be made and sustained over time. In January 2020, the European Commission published a communication that detailed the investment pillar of the European Green Deal, the European Green Deal Investment Plan (EGDIP), also referred to as the Sustainable Europe Investment Plan (EC, 2020c). The EGDIP builds on contributions from the EU budget and national budgets to EU projects, and public and private investments mobilised by InvestEU and ETS funds, as is shown in Figure 3.

Figure 3: Conceptual overview of the mechanisms to finance the European Green Deal (modified from EC, 2020c)



The Commission has pledged to mobilise at least one trillion euros in sustainable investments over the period 2020-2030 to reach the updated 2030 climate and energy targets.

A significant contribution to the EGDIP comes from the EU budget. Thirty per cent of the EU's multiannual budget (2021-2028) and of the EU's unique NextGenerationEU (NGEU) instrument to recover from the COVID-19 pandemic has been allocated for green investments. Member States must use at least 37% of the financing they receive under the Recovery and Resilience Facility (which is part of the NGEU) for investments and reforms that support climate objectives. On the part of the EU, the Commission intends to raise 30% of the funds under NGEU through issuance of green bonds. It is expected that this high contribution from the EU long-term budget to the EDGIP will stimulate additional national co-financing of climate and environment projects.

A smaller contribution to the EGDIP comes from the Innovation and Modernisation Funds, which are financed by a part of the revenue stemming from auctioning carbon allowances under the EU ETS.

The Just Transition Mechanism is designed to provide those most affected by the green economy transition with financial support and technical assistance.[10] It has three main sources of financing (EC, 2020b):

- A Just Transition Fund, used primarily to provide grants;
- A dedicated just transition scheme under InvestEU, which will crowd in private investments;
- A public sector loan facility with the European Investment Bank backed by the EU budget to leverage public financing and mobilise additional investments in the regions concerned.

10 The Just Transition Mechanism is more than funding. It includes a governance framework and a Just Transition Platform, which is described in more detail in section 4.4.

The InvestEU programme is intended to provide the EU with crucial long-term funding by leveraging substantial private and public funds. Noteworthy is the inclusion of an EU budget guarantee that allows the European Investment Bank Group and other implementing partners such as national promotional banks and international financial institutions to invest in more and higher-risk projects. As is stated in the InvestEU Regulation (EU) 2021/523 (EP and Council, 2021), actions under the InvestEU programme are expected to contribute at least 30% of the overall financial envelope of the InvestEU Programme to climate objectives.

In addition, sustainable finance measures are foreseen to contribute to the European Green Deal by boosting and channelling private sector investment in green and sustainable projects. These measures include the Taxonomy Regulation (EU) 2020/852, which creates a common classification system for sustainable economic activities.[11] In essence, the Taxonomy Regulation requires that "'green funding' will have to finance predominantly, if not exclusively, the commercial activities that are 'taxonomy compliant'" (Piebalgs and Jones, 2021), which will have an influence on the attractiveness of energy investments in the future. Jones et al. (2021) state that "it is fair to expect that non-taxonomy aligned activities will become progressively more difficult, and more expensive to finance."[12]

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11 More information about the EU taxonomy of sustainable activities and the most recent developments are provided by the European Commission at https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en (last accessed 8 December 2022).

12 For more information on the EU Taxonomy, watch the recording of the FSR debate on Sustainable Finance and the EU taxonomy in June 2021, available at https://fsr.eui.eu/the-implications-of-sustainable-finance-and-taxonomy-for-the-energy-industry/ (last accessed 3 March 2022).

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1.2 EU treaties, institutions and legislation

Athir Nouicer

In this section, we first focus on the different treaties governing the operation of the EU. Second, we present the main EU institutions that are involved in the development of EU legislation. Finally, we introduce the main legislation relevant to the energy sector in the EU, from the First Energy Package to the Fit for 55 and the Hydrogen and Decarbonised Gas Markets packages.

EU treaties

The EU is based on the rule of law. This means that actions taken by the EU are founded on the treaties (European Union, 2020a). The EU treaties are a group of international treaties between the EU Member States. They are binding agreements between these states and have been approved voluntarily and democratically by them. The EU treaties are primary legislation that set the EU's objectives and the rules for the EU institutions.

There are eight main EU treaties. Four of them are founding treaties and two are considered core functional treaties, as is shown in Table 1. The founding treaties were amended when new countries joined the EU in 1973 (Denmark, Ireland, United Kingdom), 1981 (Greece), 1986 (Spain, Portugal), 1995 (Austria, Finland, Sweden), 2004 (Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia), 2007 (Bulgaria, Romania) and 2013 (Croatia).

Table 1: Overview of the main EU treaties (European Union, 2020a)

Treaties - in chronological order	Entry into force	Founding treaty	Core Functional Treaty
Treaty establishing the European Coal and Steel Community	23 July 1952	X	
Treaty establishing the European Atomic Energy Community	1 January 1958	X	
Treaty establishing the European Economic Community – Rome Treaty (EEC), then becoming the Treaty on the Functioning of the European Union (TFEU)	1 January 1958	X	X
Merger Treaty – Brussels Treaty	1 July 1967		
Single European Act	1 July 1987		
Treaty on European Union (TEU) – Maastricht Treaty	1 November 1993		X
Treaty of Amsterdam	1 May 1999		
Treaty of Nice	1 February 2003		
Treaty of Lisbon	1 December 2009		
Energy Community Treaty	1 July 2006		

Treaty establishing the European Coal and Steel Community (ECSC)

The Treaty establishing the European Coal and Steel Community (ECSC) was signed on 18 April 1951 and entered into force on 23 July 1952. It brought together six countries (Belgium, Germany, France, Italy, Luxembourg and the Netherlands) to create a common market and organise free movement for coal and steel. It reduced distrust and tensions following the second world war (WWII) and transformed coal and steel into materials for peace. The Treaty, which had been valid for 50 years, expired in 2002. It represented the first step towards European integration and was the origin of the EU institutions.

Treaties of Rome: EEC and EURATOM treaties

The European Economic Community (EEC) and the European Atomic Energy Community (Euratom) treaties were signed on 25 March 1957 and entered into force on 1 January 1958. The treaties extended European integration to include general economic cooperation. The EEC treaty, which brought together the same six countries, created a common market based on free movement of goods, persons, services and capital. The EEC Treaty has been amended multiple times and is today called the Treaty on the Functioning of the European Union (TFEU). A solidarity clause was added in 2004, which provides the EU and its Member States with the option to act jointly and provide assistance to other Member States in emergency situations and disasters.

The Euratom Treaty was initially created to coordinate the Member States' research programmes for the peaceful use of nuclear energy. The Treaty established the European Atomic Energy Community (EAEC or Euratom), which is an international organisation that coordinates these research programmes, helps to pool knowledge, infrastructure and funding, and implements a centralised monitoring system to ensure the security of nuclear energy supply.

Merger Treaty – Brussels Treaty

The Merger Treaty, also known as the Brussels Treaty, was signed in the eponymous city on 8 April 1965 and entered into force on 1 July 1967. The Treaty streamlined the European institutions. It established a single Commission of the European Communities and a single Council to serve the three European Communities (EEC, Euratom, ECSC). The Treaty was a significant stepping stone toward the modern EU. It was repealed by the Treaty of Amsterdam, which was signed in 1997.

Single European Act

The Single European Act was signed on 17 February 1986 in Luxembourg and on 28 February 1986 in The Hague. It entered into force on 1 July 1987. The Treaty aimed to reform the institutions for the membership of Portugal and Spain and to accelerate decision-making in preparation for the single market. The Single European Act set qualified majority voting in the Council in several areas, making it harder for a single EU country to veto proposed legislation. It also strengthened the role of the European Parliament, giving it legislative power.

The Single European Act was the first treaty to include a dedicated chapter on environmental policy. It amended the EEC Treaty by adding environmental policy (Title VII). The Single European Act stipulated that environmental protection was to be integrated in the Community's other policies. It also set out a number of environmental policy objectives and the means to achieve them. Following this, the inclusion of environmental policy in subsequent EU treaties increased, becoming a main pillar in EU policies.

The Maastricht Treaty – Treaty on European Union

The Maastricht Treaty, also known as the Treaty on European Union (TEU), was signed in Maastricht on 7 February 1992. It entered into force on 1 November 1993 and represented a new step in European integration, creating an "ever-closer union among the peoples of Europe." It is considered the founding treaty of the European Union. It prepared the ground for the European Monetary Union and established the European Central Bank (ECB) and the European System of Central Banks. Cooperation between the Member States was increased in several new areas. The Maastricht Treaty introduced the concept of European citizenship and citizens were allowed to reside in and move freely across the EU. The Treaty established a common foreign and security policy and developed new forms of close cooperation on justice and home affairs. In addition, criteria that countries have to meet in order to join the euro, such as inflation and public debt levels, were defined.

The Treaty of Maastricht established the principle of subsidiarity in EU law and the two other principles of conferral and proportionality. These are considered to be essential in European decision-making. Related to energy, Article 3 of the treaty includes "measures in the spheres of energy, civil protection and tourism" among the activities of the Community. The Treaty also extended the activities of the EU to the development of trans-European networks (TENs) in the areas of transport, telecommunications and energy infrastructure.

Treaty of Amsterdam

The Treaty of Amsterdam was signed on 2 October 1997 and entered into force on 1 May 1999. The Treaty was established to reform the EU institutions preceding the addition of future members. It amended, renumbered and consolidated the TEU and EEC treaties. It brought more transparent decision-making. It also extended and made more effective the ordinary legislative procedure, the so-called co-decision procedure.

Sustainable development has been recognised as an overarching aim of the EU since its inclusion in the Treaty of Amsterdam in 1997.

Treaty of Nice

The Treaty of Nice was signed on 26 February 2001 and entered into force on 1 February 2003. It aimed to reform the institutions to cope with new challenges involved by the enlargement to 25 Member States. The Treaty imposed new measures for changing the composition of the European Commission. It also redefined the voting system in the Council. The legislative and supervisory powers of the Parliament were increased. In addition, qualified-majority voting in the Council was extended to more areas – but with the notable exception of fiscal matters.

Treaty of Lisbon

The Treaty of Lisbon was signed on 13 December 2007 and entered into force on 1 December 2009. It had the purpose of making the EU more democratic and efficient. It also reinforced the EU's commitment to combat climate change and promoted sustainable development and renewable energy sources.

The Treaty of Lisbon enhanced the European Parliament's law-making powers, amending the previous Treaties to put it on an equal footing with the Council. The European Parliament therefore became a fully recognised co-legislator with enhanced budgetary powers. The Treaty also clarified the division of powers between the EU and the Member States.

The Lisbon Treaty amended the TEU and the EEC, which was later renamed the Treaty on the Functioning of the European Union (TFEU). It included a new part on energy, which was added to the TFEU as Article 194 (Article 176A in the Lisbon Treaty). The treaty introduced a new legal basis for the EU in the matter of energy policies based on the principle of solidarity and promoting the objective of an integrated and efficient energy market. Article 194 of the TFEU states:

> "1. In the context of the establishment and functioning of the internal market and with regard for the need to preserve and improve the environment, Union policy on energy shall aim, in a spirit of solidarity between Member States, to:
>
> (a) ensure the functioning of the energy market;
>
> (b) ensure security of energy supply in the Union;
>
> (c) promote energy efficiency and energy saving and the development of new and renewable forms of energy; and
>
> (d) promote the interconnection of energy networks.
>
> 2. Without prejudice to the application of other provisions of the Treaties, the European Parliament and the Council, acting in accordance with the ordinary legislative procedure, shall establish the measures necessary to achieve the objectives in paragraph 1. Such measures shall be adopted after consultation of the Economic and Social Committee and the Committee of the Regions.[13]
>
> Such measures shall not affect a Member State's right to determine the conditions for exploiting its energy resources, its choice between different energy sources and the general structure of its energy supply, without prejudice to Article 192(2)(c).
>
> By way of derogation from paragraph 2, the Council, acting in accordance with a special legislative procedure, shall unanimously and after consulting the European Parliament, establish the measures referred to therein when they are primarily of a fiscal nature."

Energy Community Treaty

The Energy Community Treaty was signed on 25 October 2005 in Athens and it entered into force on 1 July 2006 for a ten-year term. It aimed to bring together the EU and its neighbours. According to the treaty, the Energy Community is composed of the EU on the one hand and "*the Republic of Albania, the Republics of Bulgaria, Bosnia and Herzegovina, the Republic of Croatia, the former Yugoslav Republic of Macedonia, the Republic of Montenegro, Romania, the Republic of Serbia and the United Nations Interim Administration Mission in Kosovo (pursuant to United Nations Security Council Resolution 1244)*" on the other hand. It established the contracting parties as an Energy Community, which is an international organisation serving the purposes of the treaty.

The treaty aimed, among other things, to create a legal and market framework that is stable and attractive for investors in order to guarantee security of energy supply. It also aimed to extend the EU regulatory rules and principles to its neighbours for energy trade purposes. In addition, the Treaty sought to improve energy efficiency and develop renewable energy sources.

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13 The European Committee of the Regions (CoR) was established in 1994 following the Treaty of Maastricht. It is composed of representatives of regional and local bodies, and acts in advisory capacity and assists the European Parliament, the Council and the European Commission on certain topics that affect local or regional interests. It must be consulted in areas like energy and climate change, environment, or trans-European networks, can be consulted on any other matter that the institutions consider appropriate and may also draw up opinions on its own initiative.

The Energy Community has its own established institutions following the treaty. The Ministerial Council provides general policy guidelines following the treaty's objectives. A Permanent High-Level Group prepares the work of the Ministerial Council. The Energy Community Regulatory Board (ECRB) advises the other institutions on regulatory and technical rules. The ECRB working groups are composed of representatives of all interested parties and provide advice to the Energy Community. Finally, the Secretariat based in Vienna provides the other institutions with administrative support.

The treaty was extended for a new ten-year period until 2026 by unanimous decision of the Ministerial Council on 24 October 2013. On 17 December 2020, the Energy Community Ministerial Council met to discuss a future amendment to enhance market integration and energy transition within the Energy Community. The Council also discussed the application of the Green Deal in the region, and the Commission presented a Communication on the Economic and Investment Plan for the Western Balkans (European Commission, 2020b).

The EU institutions

According to Article 13 of the Treaty on European Union (TEU) the EU institutional framework has seven main institutions. These are the European Parliament, the European Council, the Council of the European Union (simply called 'the Council'), the European Commission, the Court of Justice of the European Union, the Court of Auditors and the European Central Bank. In this subsection, we introduce this unique institutional setting and the roles of the institutions in the EU.

The European Commission

The European Commission (EC), which is based in Brussels, was established in 1958. However, it was only named the 'European Commission' in 2009 following the Lisbon Treaty.[14] It is the Union's executive body and represents the interests of the Union as a whole. The EC is headed by a team, called the 'College' of Commissioners, one from each of the 27 EU countries. The President of the EC assigns responsibility to the College for specific policy areas.

The EC has a monopoly on legislative initiatives. It also implements the decisions of the European Parliament and the Council. It manages EU policies and allocates EU funding. In addition, the EC enforces EU law together with the Court of Justice. Furthermore, the EC represents the EU internationally, for instance in trade policy, and negotiates international agreements for the EU (European Union, 2020b).

The European Parliament

The European Parliament (EP) is based in Brussels, Luxemburg and Strasbourg and represents the EU's citizens. It is the only institution directly elected by citizens in all the Member States. It was created in 1952 as the Common Assembly of the European Coal and Steel Community. Then, following the establishment of the EEC and Euratom, the ECSC Common Assembly was expanded to cover the three communities and met for the first time on 19 March 1958. On 30 March 1962 the Assembly adopted a resolution changing its name to the European Parliament. The first direct elections were held in 1979. The Parliament is part of the EU legislative process, and some laws have to go through the EU Parliament and the Council of the EU before they are adopted. There are 705 seats in the Parliament and the same number of Mem-

14 The European Commission was preceded by the High Authority of the European Coal and Steel Community, established in 1951. In 1958, the EEC and EURATOM treaties established two additional commissions: one for the EEC and one for the Euratom. The three Commissions co-existed until the Merger Treaty established the Commission of the European Communities on 1 July 1967. In 2009 the Treaty of Lisbon officially renamed The Commission of the European Communities the European Commission.

bers of the European Parliament (MEPs). Direct elections of the MEPs take place every five years in the Member States.

The European Parliament has three main roles: legislative, supervisory and budgetary (European Union, 2019). The legislative role entails passing laws together with the Council of the EU based on European Commission proposals. The EP also reviews the work of the European Commission and can ask for legislative proposals. In addition, the Parliament decides on international agreements and EU enlargements. The supervisory role of the Parliament involves democratic scrutiny of all the EU institutions. It also elects the EC President and approves the other members of the Commission, who are nominated by the Council of the European Union. The Parliament has the right to vote on a motion of censure obliging the EC to resign. It can also question the EC and the Council. The budgetary role of the Parliament encompasses establishing the EU budget together with the Council. It also approves the long-term EU budget.

The Council of the European Union

The Council of the EU, or the Council, is based in Brussels and was founded in 1958 (as the Council of the European Economic Community). It is composed of government ministers from each Member State in relevant policy areas. The member states share the Presidency of the Council on a 6-month rotating basis. It is not to be confused with the European Council or with the Council of Europe, which is not an EU body.

The Council's role is to negotiate and adopt EU laws together with the European Parliament based on European Commission proposals. The Council also coordinates the policies of Member States. It has a role in developing the EU's foreign and security policy based on European Council guidelines. In addition, the Council concludes agreements between the EU and other countries and international organisations. Moreover, jointly with the European Parliament it adopts the annual EU budget (European Union, 2020c).

The European Council

The European Council is based in Brussels and is composed of the heads of state or government of the EU countries, the European Council President and the European Commission President. It was created in 1974 as an informal forum for discussion among heads of state. Under the 1992 Treaty of Maastricht, the European Council obtained formal status and a role. In 2009 following the Lisbon Treaty, the European Council became one of the seven EU institutions (European Union, 2020d).

The role of the European Council is to define the general political direction of the EU and its priorities, as is set out in Article 15 of the Treaty on European Union (TEU). It has no legislative power, unlike the Council of the European Union.

For instance, in 2014 the European Council agreed on the 2030 climate and energy policy framework for the European Union after it was proposed in an EC communication of 22 January of the same year. The 2030 framework was a political agreement setting EU targets for renewables, energy efficiency and greenhouse gas emissions. It did not entail legislative resolutions.

The other EU institutions

According to Article 13 of the TEU, next to the four institutions presented above three other EU institutions complete the EU institutional framework. The Court of Justice of the European Union (CJEU) and the European Court of Auditors (ECA) are two institutions that play vital roles. The CJEU ensures correct interpretation of EU law and that it is applied in the same way across the Member States. It also ensures that the Member States and the EU institutions comply with EU law. The ECA's role is to check the correct collection and use of EU funds and to help improve EU financial management. The seventh institution is the European Central Bank (ECB). Its role is to manage the euro, maintain stable prices and conduct EU economic and monetary policy.

EU legislation related to energy

In this subsection we introduce the various legislative packages in the EU relating to electricity and gas. The 'packages' include sets of Directives and Regulations that are secondary legislation, or law derived from the principles in the EU Treaties.

Table 2: Overview of the different types of secondary law

Type of secondary law	Description
Listed in Article 288 TFEU	
Regulations	A Regulation is a binding legislative act. It is to be applied wholly in every EU Member State. One example is Regulation (EU) 2019/943 that introduces a new European entity for distribution system operators (EU DSO Entity).
Directives	A Directive is a legislative act that sets out common principles for national regulatory frameworks or for the achievement of common goals. Examples are the regulatory framework for individual and collective self-consumption, and citizen energy communities in Directive (EU) 2019/944, and targets, such as the 32% RES target in Directive (EU) 2018/2001, which the Member States must achieve. Member States need to transpose Directives into national laws and as such are given a certain amount of freedom regarding detailed implementation.
Decisions	Decisions are binding on the Member States to which they are addressed. An example is Decision No 1254/96/EC laying down a series of guidelines for trans-European energy networks. It was among the first steps in EU involvement in transmission infrastructure development. Another example is Decision 406/2009/EC, commonly known as the Effort Sharing Decision.
Opinions	Opinions are not binding and allow institutions to make a statement without an underlying obligation. Examples are the European Commission opinions on national implementation plans for market reforms to be made by all Member States with identified adequacy concerns (European Commission, 2020c).
Recommendations	Recommendations suggest lines of actions that are not binding and do not have any legal consequences. An example is the Commission Recommendation of 3.4.2019 on cybersecurity in the energy sector.
Not listed in Article 288 TFEU	
Atypical acts: Communications, resolutions, white papers and green papers	Atypical acts are adopted by EU institutions. They are called this way because they do not fall within the TFEU categorisation. They may relate to EU internal organisations, or they can have a more general scope or be focused on specific topics. An example of these is the Green Paper – A European Strategy for Sustainable, Competitive and Secure Energy (Commission of the European Communities, 2006).

The First Energy Package

The First Energy Package contained two Directives: the first Electricity Directive 96/92/EC adopted in 1996 and the first Gas Directive 98/30/EC adopted in 1998. The package laid down provisions on the liberalisation of the internal markets for electricity and gas. Management and accounting unbundling of national transmission system operators (TSOs) were required. Member States had to transpose the Directives into national law by 1998 for electricity and 2000 for gas.

The Second Energy Package

The Second Energy Package was adopted in 2003 and contained two Directives and one Regulation: the second Electricity Directive 2003/54/EC, the second Gas Directive 2003/55/EC and Regulation (EC) No 1228/2003 on conditions for accessing the network of cross border exchanges of electricity.[15] The package continued the liberalisation of the internal markets for electricity and gas, enabling, for instance, industrial and domestic consumers to freely choose their gas and electricity suppliers. Legal unbundling of TSOs was required. Importantly, the Second Package also required Member States to create national regulatory agencies (NRAs) that are independent of the industry and government. The directives in the Second Energy Package were to be transposed at the national level by 2004, with some provisions only entering into force in 2007.

The Third Energy Package

The Third Energy Package was adopted in 2009 and contained two Directives and three Regulations. The two directives were Electricity Directive 2009/72/EC and Gas Directive 2009/73/EC. The regulations were Regulation (EC) No 713/2009 establishing an Agency for the Cooperation of Energy Regulators, Regulation (EC) No 714/2009 on conditions for access to the network of cross-border exchanges in electricity and Regulation (EC) No 715/2009 on conditions for access to the natural gas transmission networks. The package had the aim of further liberalising and integrating the internal energy markets. For example, it included provisions requiring further unbundling of network operators and the establishment of ACER (see section 1.4). The Third Package also strengthened the independence of NRAs. Importantly, the European Networks for Transmission System Operators for electricity and gas (ENTSO-E and ENTSO-G) were also created to enhance cross-border cooperation. The package set additional rules for opening and improving competition in retail markets. Finally, the package triggered the creation of electricity and gas network codes and the detailed rules governing these markets today (see sections 4.1 and 4.2). The codes and guidelines were adopted as delegated legislation. The Member States had to transpose the package by March 2011.

The Clean Energy Package

The Clean Energy for all Europeans Package, referred to in short as the Clean Energy Package (CEP), is a set of eight legislative acts on the energy performance of buildings, renewable energy, energy efficiency, governance and electricity market design. The European Commission published its initial proposal for the package in November 2016. This is why it was also nicknamed the Winter Package at that time. The package was completed with the publication of its final texts in the Official Journal of the European Union in June 2019 after a trialogue between the European Commission, the Council and the Parliament.

15 Regulation (EC) No 1775/2005 on conditions for access to the natural gas transmission networks is often considered part of the Second Energy Package too.

The CEP is the fourth package of its kind. Unlike the previous energy packages, it did not include specific legislation on the gas sector, which instead fell under the scope of the Hydrogen and Gas Market Decarbonisation Package published in December 2021. The CEP further built on the energy policy framework set in the Third Energy Package and paved the way for a gradual transition away from fossil fuels towards a carbon-neutral economy. The CEP also updated the EU climate targets for 2030 (see section 1.1).

The Fit for 55 Package and the Hydrogen and Decarbonised Gas Markets Package

The Green Deal climate neutrality objective for 2050 was written into law by means of the European Climate Law Regulation (EU) 2021/1119. To reach this target, the Climate Law, which entered into force on 29 July 2021, set the intermediate objective of reducing net GHG emissions by at least 55% compared to 1990 levels by 2030.

To put the 55% emission reduction objective on track and align EU policies with the updated targets in the Green Deal and the Climate Law, in July 2021 the Commission published the Fit for 55 Package, which contains a number of legislative proposals for measures to reach the 2030 targets, covering areas such as climate, energy, land use, transport and taxation. It was complemented in December 2021 with a second release of legislative proposals. Among them was the Hydrogen and Decarbonised Gas Markets Package, which aims to review and revise the gas-related legislation in the Third Energy Package (see section 4.2).

REPowerEU

In response to the hardships and global and European energy market disruptions caused by Russia's invasion of Ukraine, the European Commission presented the REPowerEU Plan in May 2022 (European Commission, 2022). The key objective is to rapidly reduce Europe's dependence on Russian fossil fuels and accelerate the green transition by means of three main streams of action: saving energy, producing clean energy, and diversifying Europe's energy supplies. REPowerEU aims to accelerate the roll-out of solar, wind and heat pumps to reduce gas consumption. It includes plans to reskill and upskill the workforce, measures to simplify and shorten permitting for renewable energy projects, and stresses the importance of supporting the infrastructure in the switch to electrification and hydrogen. The Commission will advance implementation of the Innovation Fund to support this switch. Although not a dedicated energy package, REPowerEU has put on the table a set of short-term and medium-term measures that are likely to be interacting with the areas of the Green Deal presented in this report.[16]

16 See the website of the European Commission on REPowerEU: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en.

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1.3 Solidarity and subsidiarity

Valerie Reif and Andris Piebalgs

In this section, we first give an overview of how competences are distributed between the EU and the Member States. We then explain the principles of subsidiarity and solidarity. Finally, we look at how these principles materialise in European energy policy.

The distribution of competences between the EU and the Member States

The Treaty on European Union (TEU) governs how competences are distributed between the EU and the Member States.[17] Article 5(1) of the TEU states that "*the limits of Union competences are governed by the principle of conferral. The use of Union competences is governed by the principles of subsidiarity and proportionality*" (OJEU, 2016). More concretely, the principle of conferral means that the EU can only act within the limits of the competences that have been conferred on it by the Member States in the EU Treaties. In turn, competences that are not conferred on the Union in the Treaties remain with the Member States.

The Treaty of Lisbon (signed in 2007 and in force since 2009) clarified the division of competences between the EU and the Member States. The competences that are conferred on the Union are defined in Articles 2-6 of the Treaty on the Functioning of the European Union (TFEU) and can be categorised in four types.[18]

- *Exclusive competence* (Article 3 TFEU): only the EU can act in these areas and adopt legally binding acts, e.g. customs union and monetary policy for the countries that use the euro.
- *Shared competence* between the EU and Member States (Article 4 TFEU): Member States can only act if the EU has chosen not to, e.g. internal market, trans-European networks, consumer protection, energy and environment. According to Declaration No. 18 annexed to the Treaty of Lisbon, Member States may ask the European Commission to repeal an adopted legislative act in one of the shared areas to ensure better compliance with the principles of subsidiarity and proportionality.
- *Supporting competence*: The EU can support, coordinate or supplement Member State actions without suspending their competence in these areas (Article 6 TFEU), e.g. protection and improvement of human health, industry, culture and tourism.
- *Special competence*: The EU sets up arrangements like broad guidelines within which EU countries must coordinate policy (Article 5 TFEU), e.g. economic policy.

The subsidiarity principle

The principle of subsidiarity as laid down in Article 5(3) of the TEU is fundamental in the functioning of the EU and European decision-making as it determines when the EU is competent to legislate. It applies to all EU institutions in areas in which competence is shared between the Union and the Member States.

Subsidiarity means that decisions (in areas in which the EU does not have exclusive competence) are to be taken at the level that is the closest possible to the citizen, i.e. local, regional or national. The principle also seeks to safeguard the ability of Member States to take decisions and actions, and authorise inter-

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17 More information on the EU Treaties and EU institutions mentioned in this section is provided in section 1.2.

18 See also the website of the European Commission, available at https://ec.europa.eu/info/about-european-commission/what-european-commission-does/law/areas-eu-action_en (accessed 15 March 2022).

ventions by the EU in case action at the Member State level is not sufficient to achieve the objectives of a proposed action. In other words, the EU should only become active when it is more effective (for reasons of scale or effects of the proposed action) than action at the national, regional or local level, and constant checks should be carried out to verify that EU action is justified in the light of the possibilities available at these levels.

Subsidiarity was first introduced in the TEU in 1992 alongside the principles of conferral and proportionality. The proportionality principle requires that any action by the EU should not go beyond what is necessary to achieve the objectives of the Treaties (Article 5(4) TEU). The Treaty of Amsterdam (signed in 1997) extended the subsidiarity principle by requiring that all legislative proposals be assessed for their impact on subsidiarity. The Treaty of Lisbon (signed in 2007) further strengthened the subsidiarity principle by introducing several mechanisms to monitor its application.

Two protocols annexed to the Treaty of Lisbon are important in terms of national parliamentary scrutiny:

- Protocol No. 1 on the role of national Parliaments requires closer communication with national parliaments during the legislative process and encourages their involvement in EU activities. It requires EU documents and proposals to be forwarded promptly to the national parliaments so they can examine them before the Council makes a decision.
- Protocol No. 2 on the application of the principles of subsidiarity and proportionality provides for greater consultation with the local and regional levels when drafting legislative proposals. It requires the European Commission to take into account the regional and local dimensions of all draft legislative acts and to make detailed statements on how the principle of subsidiarity is respected. Under an ex ante 'early warning' mechanism national, parliaments can object to a proposal on the grounds that it breaches the principle. Subject to a voting procedure laid down in Protocol No. 2, the proposal is reviewed ('yellow card') and may be maintained, amended or withdrawn by the European Commission. In the case that the European Commission decides to maintain its proposal, the matter is referred to the Parliament and the Council, which may approve or reject it ('orange card').[19]

After the adoption of a legislative act, there is also the option to initiate an ex post review of compliance with the principle of subsidiarity by means of a legal action before the Court of Justice of the EU. Member States may request the annulment of a legislative act on the ground of a breach of the principle of subsidiarity. The Committee of the Regions[20] may also bring such actions before the Court in areas where the TFEU provides for it to be consulted.

The origin of the solidarity principle

The foundation of the European Union as we know it today was based on two core principles: peace and solidarity. The founding principle of solidarity was included in the Schuman Declaration of 9 May 1950, in which the French foreign minister Robert Schuman proposed the creation of a European Coal and Steel Community: "Europe will not be made all at once, or according to a single plan. It will be built through concrete achievements which first create a de facto solidarity."[21]

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19 Until October 2021, the 'yellow card' procedure had been triggered three times, while the 'orange card' procedure had never been used. For more information see for example <https://www.europarl.europa.eu/factsheets/en/sheet/7/the-principle-of-subsidiarity> (accessed 15 March 2022).

20 See footnote 10 in section 1.2 on the EU treaties and institutions.

21 The full text of the Schuman Declaration is available at https://europa.eu/european-union/about-eu/symbols/europe-day/schuman-declaration_en (accessed 15 March 2022).

De facto solidarity in energy was at the heart of the European project from the very beginning. Jacques Delors, former president of the European Commission (1985-1994), described it as follows: "Back in 1951, six European countries decided to pool their interests in two key areas of the economy in order to create a Community designed to replace conflict with cooperation and animosity with prosperity. Energy was one of those areas and solidarity was one of its founding principles" (Andoura, 2013).

The European Union was later founded on the basis of core values that are common to the Member States, one of which is solidarity, as is laid out in Article 2 of the TEU signed in 1992: "The Union is founded on the values of respect for human dignity, freedom, democracy, equality, the rule of law and respect for human rights, including the rights of persons belonging to minorities. These values are common to the Member States in a society in which pluralism, non-discrimination, tolerance, justice, solidarity and equality between women and men prevail" (OJEU, 2016).

Solidarity and subsidiarity in European energy policy

Energy had long been an area driven by national independence and sovereignty, with Member States unable to develop a common energy policy. This is reflected in the European Treaties and the fact that Member States are free in their choice of energy sources and the overall structure of their energy supply. The resulting diversity is mirrored in the different energy mixes in Member States.[22]

Only in 2005 at an informal summit at Hampton Court did the Heads of State and Government lay the foundations for a common and ambitious European energy policy. This was a response to growing concerns about climate change, increased energy prices, a growing dependence on foreign supplies of fossil fuels and problems with supplier and transit countries. In 2007, the European Council agreed on an energy and climate package, which brought about the famous 20-20-20 targets. For the first time, solidarity among Member States was a clear priority, both as a prerequisite for increased security of supply of oil, gas and electricity and in terms of achieving the 2020 climate targets binding at the national level. Indeed, when establishing the national objectives to reach the 2020 targets, the EU took account of the different starting points and overall conditions in the Member States.

At the same time, an ongoing conflict between Russia and Ukraine over the price of gas heavily affected several EU countries and highlighted the vulnerability of certain Member States, mainly in Central and Eastern Europe, and the overall lack of solidarity in the European energy system. Eventually, this crisis marked a turning point in European energy policy and led to the inclusion of an energy solidarity clause in the Treaty of Lisbon, which was signed in 2007.

Energy solidarity in the Treaty of Lisbon

As mentioned above, Article 4 of the TFEU states that energy is a shared competence between the EU and its Member States. Moreover, according to Article 194 of the TFEU the EU shall strive to achieve the main aims of energy policy "in a spirit of solidarity between Member States." However, each Member State maintains its right to "determine the conditions for exploiting its energy resources, its choice between different energy sources and the general structure of its energy supply." Article 122 is also of importance as it states that "Without prejudice to any other procedures provided for in the Treaties, the Council, on a proposal from the Commission, may decide, in a spirit of solidarity between Member States, upon the measures appropriate to the economic situation, in particular if severe difficulties arise in the supply of certain products, notably in the area of energy."

22 The latest available statistics on the energy mixes of EU countries can be found in the statistical pocketbook of the EC (2021a).

The Treaty did not provide a clear definition of the principle of solidarity and neither did it include a framework or guidelines for its implementation in the development of the new European energy policy. For these reasons, there has been ongoing debate on the application of the solidarity principle and the related legal obligations of Member States and the European institutions.

Nevertheless, the principle of solidarity has proven to be of high political importance in the light of crises and shortages of supply of both electricity and gas. European institutions have increasingly been mentioning energy solidarity in their strategies and communications. It is also referred to in secondary legislation such as the Effort Sharing Regulation (EU) 2018/842 for non-ETS sectors, the proposal for its review under the Fit for 55 Package (EC, 2021d) and the proposal for a recast of the Energy Efficiency Directive (EC, 2021e)[23] The OPAL case described in Box 1 brought new momentum to discussion on the solidarity principle but also left many questions open when it comes to its application.

Subsidiarity and solidarity in the context of the Energy Union

In 2015, the Paris Agreement was signed and the European Commission proposed a new energy strategy for the EU, namely the 'Energy Union.' As was described in section 1.1, one of the five dimensions of the Energy Union is 'security, solidarity and trust,' namely diversifying Europe's sources of energy and ensuring energy security through solidarity and cooperation among EU countries. Taking into account both the objectives of the Energy Union and the Paris Agreement, the European 2030 climate targets were proposed by the European Commission and subsequently adopted in 2018. An important distinction between the 2020 and 2030 targets is that the former were binding at the Member State level while the latter are binding only at the EU level.

Binding targets at the EU level have both advantages and disadvantages. On the one hand, this approach gives Member States more freedom to set their individual climate and energy targets and choose their energy mixes according to what they consider most cost-effective for them. On the other hand, it has the difficulty of ensuring Member State commitments to adopt adequate individual policies to collectively achieve the 2030 climate and energy goals at the EU level (Piebalgs et al., 2020).

To help the EU reach its 2030 climate targets, Regulation (EU) 2018/1999 on Governance of the Energy Union and Climate Action ('Governance Regulation') was established as part of the Clean Energy Package. It sets common rules for planning, reporting and monitoring and also ensures that EU planning and reporting are synchronised with the ambition cycles in the Paris Agreement. According to recital 73, the objectives of the Governance Regulation cannot be sufficiently achieved by the Member States alone, which is why the EU may adopt measures in accordance with the subsidiarity principle.

The Member States are mandated to develop integrated national energy and climate plans (NECPs) based on a common template.[24] They are also to provide annual and biennial progress reports. The EC assesses the draft NECPs and may issue country-specific recommendations to a Member State, for example where policy developments in the Member State show inconsistencies with the overarching objectives of the Energy Union (Art. 30) or insufficient progress is made towards meeting its objectives, targets and contributions or its reference point for renewable energy, or in implementing the policies and measures set out in its NECP (Art. 32). Although the recommendations are not legally binding, Member States should

23 Recital 2 of the Regulation (EU) 2018/842 states that "all Member States should participate in this effort, balancing considerations of fairness and solidarity."

24For a brief overview of the National Energy and Climate Plans, see for example an FSR blog post available at https://fsr.eui.eu/national-energy-and-climate-plans-necps/ (accessed on 30 March 2021).

explain insufficient outcomes and cover the gaps, thereby taking "*due account of the recommendation in a spirit of solidarity between Member States and the Union and between Member States*" (Art. 34).

Box 1: The OPAL case

The OPAL case is a long dispute between Poland and the European Commission over the exemption of the OPAL gas pipeline from provisions in the Gas Market Directive 2009/73/EC.[25] The OPAL (Ostsee-Pipeline-Anbindungsleitung) pipeline is one of the onshore extensions of the Nord Stream 1 pipeline, which carries Russian gas from the Baltic Sea to the German grid (Figure 4).

In 2009, the German NRA initially granted the OPAL pipeline derogations from provisions on regulated third-party access and tariff regulation laid down in Directive 2003/55/EC. The same year, the European Commission reviewed this decision and provided for a cap on cross-border capacity reservation, which effectively meant that Gazprom was able to operate the OPAL pipeline only up to 50% of its capacity after it was put into service in 2011. In 2016, and given the intention of the German NRA to modify certain provisions in the exemption, the Commission updated its decision and essentially granted a lift of the capacity cap.

Figure 4: Nord Stream 1 and OPAL gas pipelines (source: Wikipedia)

Poland appealed to the General Court of the EU for annulment of the 2016 Commission decision. The country claimed that the decision violated the principles of energy security and energy solidarity in that it undermined the interests of certain EU countries. Poland also claimed the decision brought a risk of significant reductions in the utilisation of other supply routes competing with the OPAL pipeline. In 2019, the General Court ruled that the Commission had breached the TFEU, and more concretely the principle of energy solidarity, when issuing the OPAL decision and pointed out that the principle of energy solidarity is a cornerstone of the European integration process. In 2020, Germany filed a plea against the General Court's 2019 ruling, while Poland, Lithuania and Latvia called to uphold it.

The dispute over the OPAL exemption decision focuses on the application of the solidarity principle. For the first time, a principle typically used in general terms in EU legislation was interpreted as having concrete legal significance. The decision gave rise to an extensive legal debate, including on the question of

25 Case T-883/16 Republic of Poland v. European Commission. A comprehensive summary is provided in press release No 129/21 from the General Court of the European Union (GCEU, 2021).

how to take Member States' interests into account in important regulatory decisions by EU institutions.[26]

In its final ruling on the OPAL case on 15 July 2021, the Court of Justice dismissed the appeal brought by Germany and ruled on the nature and scope of the principle of energy solidarity. It stated that the principle can indeed produce binding legal effects and that the legality of energy policy-related actions by the EU institutions must be assessed in the light of the principle. The court also stated that the principle not only applies to situations involving terrorist attacks or disasters but to any action falling within the EU's energy policy.

Despite open questions on its exact applicability, upholding the principle of solidarity as a legal tool could have far-reaching consequences for the governance of energy and climate action, including under the Green Deal.[27] It may no longer be possible for EU countries to develop energy infrastructure while ignoring the vital interests of other countries. The OPAL case could also provide a basis for the European institutions, Member States and other parties to bring legal challenges against Member States which violate the principle of solidarity.

It is important to mention that the Governance Regulation does not provide any detail on the (punitive) measures that may be available to European authorities if recommendations are not implemented and/or progress at the national level remains insufficient. Vandendriessche et al. (2017) raise the question of whether this 'soft governance' approach, which depends much on Member States' goodwill, will be effective enough to reach the climate targets and whether there will be a need for stronger governance.

As part of the Energy Union Package, Regulation (EU) 2017/1938 governing the security of natural gas supply was adopted (EC, 2017). It aims to safeguard an uninterrupted supply of gas and lays down the framework for EU emergency preparedness and resilience to gas disruption. In addition to provisions aimed at enhancing regional cooperation and improving transparency, the regulation also includes a solidarity mechanism, which can be activated as a last resort in extreme gas crisis situations. EU countries must help each other to always guarantee gas supply to the most vulnerable consumers, even in severe gas supply situations, with fair compensation from the country receiving solidarity (see also sections 1.3 and 3.1).

Subsidiarity and solidarity in the Green Deal

The solidarity principle is taken up in the European Climate Law (EC, 2021b). The European authorities and the Member States are to consider "fairness and solidarity across and within Member States, in light of their economic capability" in their pursuit of the climate-neutrality objective, for example when proposing Union 2040 climate targets, issuing an EC recommendation in the case of insufficient progress at the national level and implementing such a recommendation at national level.

As part of the Fit for 55 Package, a proposal for a recast of the Gas Regulation (EC, 2021) sets out solidarity obligations building on the Security of Gas Regulation (EU) 2017/1938 and extending its scope to cover new renewable and low-carbon gases. Member States are encouraged to set up bilateral solidarity arrangements. The regulation's Annex contains the procedure, in the form of mandatory templates, for implementing a solidarity measure if no such technical, legal or financial arrangements exist between the requesting and providing Member States.

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26 See, for example, Iakovenko's (2021) analysis of the OPAL case and other EU case law on the solidarity principle.

27 For a more detailed discussion, see, for example, a recording of the Vienna Forum on European Energy Law on 16 November 2020 on 'The Solidarity Principle and the Just Transition in Energy: Poetry or Law?' available at <https://fsr.eui.eu/event/the-vienna-forum-on-european-energy-law-webinar-1/> (accessed 23 March 2021).

Solidarity is also mentioned in the context of the proposed Social Climate Fund, which aims to provide Member States with dedicated funding to support the European citizens most affected by or at risk of energy or mobility poverty (EC, 2021e). The fund should promote fairness and solidarity between and within Member States and build on and complement existing solidarity mechanisms (see also section 4.4).

An open issue is how the principle of solidarity will be incorporated in the Just Transition Mechanism. The mechanism is one of the central tools to facilitate the transition to a carbon neutral EU by 2050 as it shall provide financial support to the regions most affected by the socio-economic impact of the transition. However, some Member States expected to receive significant funding from the schemes under the Just Transition Mechanism, such as Poland, signalled that they have plans to continue to invest in coal, for example.[28] It is yet to be seen how this and similar issues will be addressed, also considering the latest geopolitical developments.

Recent developments[29]

In May 2022, the Commission published its detailed REPowerEU plan together with a number of other communications (EC, 2022a).[30] Next to energy savings, clean energy production and diversification of energy supply, the plan stresses the importance of building new energy infrastructure. This includes the implementation of "*many long pending projects, with a particular focus on cross-border connections to build an integrated energy market that secures supply in a spirit of solidarity*." In light of the winter to come, the Commission also called on Member States to conclude the outstanding bilateral solidarity arrangements between neighbouring countries, which should serve as last resort in the event of an extreme gas shortage to ensure supply to households, district heating systems and basic social facilities in the affected country.

In June 2022, new gas storage rules were adopted under Regulation (EU) 2022/1032 (EC, 2022b). [31]The objective is to ensure that storage capacities in the EU would not remain unused and that storages could be shared across the Union, in a spirit of solidarity. The Regulation requires the EU Member States to fill storage facilities to 80% of capacity by November 2022 – and to 90% in the years thereafter. Not all Member States have underground gas storage facilities on their territory, however. And while increased security of supply would benefit all Member States, the storage obligations would impose financial burdens on the relevant actors in those Member States that have relevant underground gas storage facilities. Thus, to share the burden, recital 21 states that "[in order to] *share the burden of ensuring that underground gas storage facilities in the Union are sufficiently filled to safeguard the security of gas supply, in a spirit of solidarity, Member States without underground gas storage facilities should use underground gas storage facilities in other Member States*." More concretely, Member States without underground gas storage facilities should ensure that market participants within such Member States have in place arrangements in Member States that have such facilities that provide for the use, by 1 November, of storage volumes corresponding to at least 15% of their average annual gas consumption over the preceding five years. However, in "*the event that a Member State has no interconnection with other Member States or if a Member State's limited cross-border transmission capacity or other technical reasons make it impossible to use underground gas storage facilities in other Member States, that obligation should be reduced accordingly.*" There would also be an option to develop alternative burden sharing mechanisms with Member States with

28 Poland has plans to phase out coal-fired power generation and shut down coal mines by 2049.

29 See also section 3.1

30 See footnote 6.

31 A recording of an online debate by the Florence School of Regulation on the "regulatory framework for gas storage" is available at https://fsr.eui.eu/event/a-regulatory-framework-for-gas-storage/ (last accessed 11 April 2022).

storage facilities. However, these solidarity measures by Member States without storage facilities may also have a financial impact on the relevant market actors in these countries. Recital 22 states that "*Member States without underground gas storage facilities should therefore be allowed to provide financial incentives or compensation to market participants for the shortfall in revenues or for the costs of obligations imposed on them which cannot be covered by revenue. If such measures are financed through a levy, that levy should not be applied to cross-border interconnection points*."

In July 2022, the European Commission published the gas demand reduction plan 'Save gas for a safe winter' with the aim to reduce gas use in Europe by 15% between 1 August 2022 and 31 March 2023 (EC, 2022c). In this context, the European Commission also proposed a Council Regulation based on Article 122 of the TFEU (see above) that includes the possibility for the Commission to declare, after consulting Member States, a 'Union Alert' on security of supply imposing a mandatory gas demand reduction on all Member States. The Council reached a political agreement only one week later, and the Council Regulation was published in the Official Journal on 8 August 2022 (Council, 2022).

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1.4 EU agencies and organisations

Athir Nouicer

The aim of European authorities to realise the transition from fragmented national energy systems to well-functioning European energy markets has increased the need for cooperation across borders among the Member States, national regulatory authorities (NRAs), national companies such as transmission system operators (TSOs) and, more recently, distribution system operators (DSOs) and hydrogen network operators. Energy policy is no longer an exclusive competence of national governments. The four EU legislative packages that have been adopted so far have mandated the creation of several EU bodies and organisations: ACER, the European Union Agency for the Cooperation of Energy Regulators; ENTSO-E, the European Network of Transmission System Operators for Electricity; ENTSO-G, the Euopean Network of Transmission System Operators for Gas; and the EU DSO Entity – the European association for electricity DSOs. The Hydrogen and Decarbonised Gas Market Package of December 2021 extends the scope of the EU DSO entity to natural gas DSOs and create a new European Network of Network Operators for Hydrogen (ENNOH).

To facilitate interaction among stakeholders involved in completing the EU internal energy market, the European Commission has introduced the concept of stakeholder interactions through informal forums. Four forums exist today, which are named after the cities in which they take place: the Florence Forum, the Madrid Forum, the Copenhagen Infrastructure Forum and the Dublin Forum (also 'Citizens' Energy Forum'). Other forums like the Amsterdam Forum on renewable energy and energy efficiency and the Berlin Forum initially on fossil fuels are no longer taking place. These forums finish with formal minutes providing relevant inputs for legislation. They typically take place once or twice a year and are structured around timely issues related to energy regulation.

In what follows, we present the main EU agencies relating to the electricity and gas sectors, followed by the relevant EU forums. Finally, we introduce two other EU organisations relating to the environment and chemicals that are relevant in the Green Deal context.

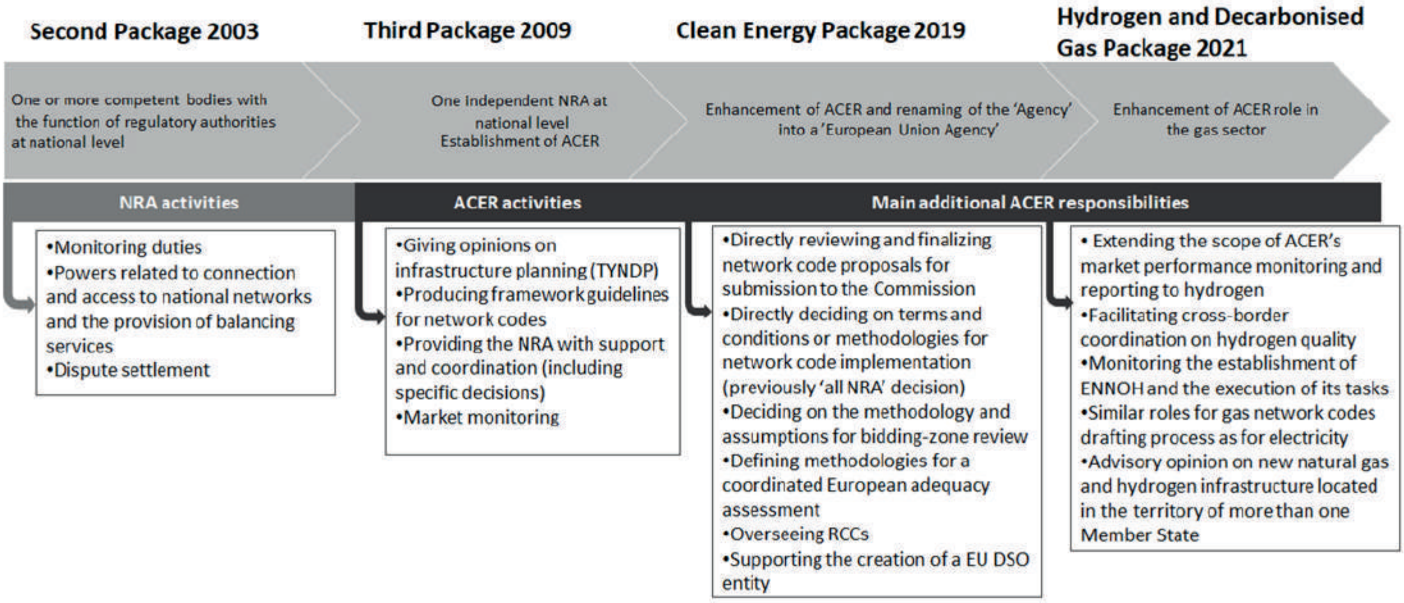
The European Union Agency for the Cooperation of Energy Regulators (ACER)

The liberalisation of energy markets created a need to establish 'watchdogs' independent from industry and national governments to ensure non-discriminatory and effective access to transmission and distribution networks for electricity and gas. Such watchdogs were first created at the national level (national regulatory agencies, NRAs) and a European agency (ACER) followed years later. Figure 5 shows the evolution of NRAs and ACER through the relevant EU Energy Packages.

At the national level, the Second Energy Package required Member States to designate one or more competent bodies independent from the energy industry to function as regulatory authorities. The Third Energy Package adopted in 2009 increased the independence of these authorities from national governments and put an obligation on Member States to have a single NRA entrusted with pursuing the regulatory objectives provided in the Package.

At the European level, the Third Package included Regulation (EC) No 713/2009 (also known as the 'ACER Regulation'), which established an Agency for the Cooperation of Energy Regulators (ACER). ACER was the successor to the European Regulators' Group for Electricity and Gas (ERGEG), an advisory body established to assist the European Commission in consolidating a single EU market for electricity and gas. ACER was created to assist and complement the work of NRAs regarding issues with cross-border relevance.

Figure 5: The development of regulatory authorities at the national and European levels and a selection of their tasks, adapted from Meeus (2020).



The Clean Energy Package enhanced the tasks of ACER with Regulation (EU) 2019/942, which substantially amended Regulation (EC) No 713/2009. Regulation (EU) 2019/942 also renamed the 'Agency' as a 'European Union Agency.' Among ACER's tasks is participation in processes to develop, adopt and implement European network codes for electricity (see section 4.1) and gas (see section 4.2). Furthermore, ACER is empowered to give European institutions advice on energy-related issues. It is also competent to oversee ENTSO-E, ENTSOG, the EU DSO entity and ENNOH, which was established in the Hydrogen and Decarbonised Gas Market Package.

The Council of European Energy Regulators (CEER)

CEER, the Council of European Energy Regulators, was established in 2000 for cooperation among the European NRAs. It is the NRAs' 'own' association and is directly funded by them. The Council proposes its own work programme and gets feedback on it through public consultations (Nies, 2020). Its role is different from and complimentary to that of ACER. Like ACER, it seeks to facilitate the efficient functioning of the EU internal energy market, but while ACER focuses on what legislation is required and issues regulatory decisions, CEER has a role supporting stakeholders by providing position papers and views on energy regulation. It works in cooperation with ACER in areas like producing Market Monitoring Reports (MMRs).[32] Additionally, CEER participates in European forums representing the NRAs' views, such as the Florence, Copenhagen, Dublin and Madrid Forums, which will be introduced later in this section.

The European Network of Transmission System Operators for Electricity (ENTSO-E)

In the European electricity system, TSOs are the national companies that operate the networks through which electricity is transported. Transmission networks are natural monopolies and are subject to regulation. Although their scope is national, TSOs have a pivotal role in the process of integrating national electricity markets into a single EU market for electricity. TSOs facilitate cross-border electricity exchanges and

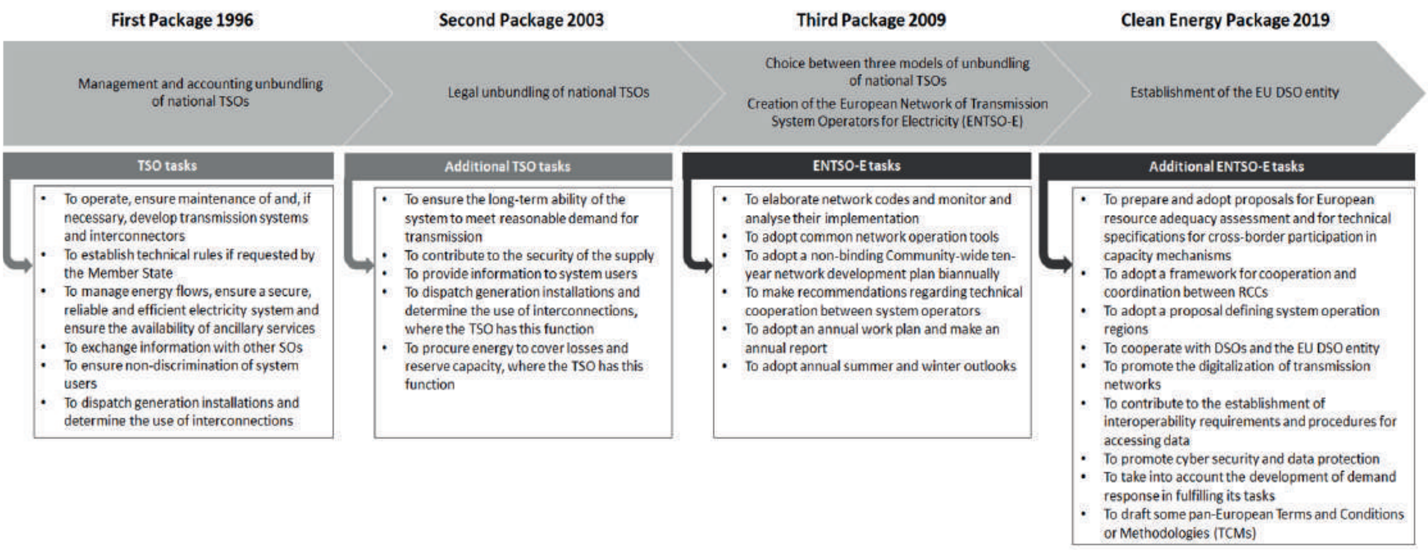
32 ACER-CEER MMRs consist of three volumes: an Electricity Wholesale Market volume, a Gas Wholesale Market volume and an Energy Retail and Consumer Protection volume. They are published every year and focus on developments since the previous edition (CEER, 2020).

ensure the safe operation and reliability of the increasingly complex electricity network at all times. Figure 6 shows the development of TSOs' roles and governance in Europe.

European TSOs have been cooperating across geographical borders since the 1950s. In 1951, the Union for the Coordination of Production and Transmission of Electricity (UCPTE) was founded by TSOs from eight western European countries. UCPTE was later extended to include more TSOs from more European countries. Its role was to contribute to the development of economic activity through more effective use of energy resources, which was enabled by the interconnection of electricity networks. In 1999, the organisation changed its name to UCTE, dropping the 'P' for production. This shift of focus to the transmission grid was a result of the unbundling and restructuring of the electricity sector that followed the liberalisation of electricity markets.

The UCTE was later involved in founding the Association of European Transmission System Operators (ETSO) together with associations from other parts of Europe such as ATSOI (for Ireland), NORDEL (for Northern Europe) and the UKTSOA (for the United Kingdom). The UCTE focused on technical rules while ETSO developed economic and legal procedures to complete international electricity transits and trade. On 29 June 2001, ETSO became an international association with a direct membership of 32 independent TSO companies operational in the then 15 Member States of the European Union plus Norway and Switzerland. Following the Third Energy Package, ETSO was wound up and all its operational tasks were transferred to ENTSO-E in 2009.

Figure 6: The development of electricity TSOs at the national and European levels and a selection of their tasks, adapted from Meeus (2020)



The creation of ENTSO-E enabled more effective cooperation among TSOs to address the shortcomings and limitations shown in TSO voluntary initiatives. The Third Package tasked the ENTSOs with EU-level functions such as contributing to the development of EU-wide network rules, developing a ten-year network development plan (TYNDP) and carrying out seasonal resource adequacy assessments. The Clean Energy Package transferred additional tasks to ENTSO-E, such as preparation of the EU resource adequacy assessment and cooperation with DSOs and the EU DSO entity.

The European Network of Transmission System Operators for Gas (ENTSOG)

Similarly to electricity systems, gas systems have gas TSOs. Nevertheless, unlike electricity, gas is transported via pipelines and via liquified natural gas (LNG) cargoes and ships if compressed and made liquid and then regasified in LNG terminals. Gas TSOs are therefore the companies that operate and own the gas transmission infrastructure such as the pipelines and LNG terminals.

The gas network infrastructure is considered a natural monopoly, like most network industries, due to high sunk costs and the inefficient duplicability of networks. This applies to gas and electricity transmission and distribution activities. The co-existence of regulated and competitive activities in an industry that meets essential needs requires supervision by regulation (European Commission, 2013).

With the liberalisation of the EU gas market, the number of system connections among network users has significantly grown, i.e. more gas shippers have started delivering gas to consumers across the continent. Gas TSOs have had to manage an increasingly complex system and face new challenges in network investment planning and capacity calculations.

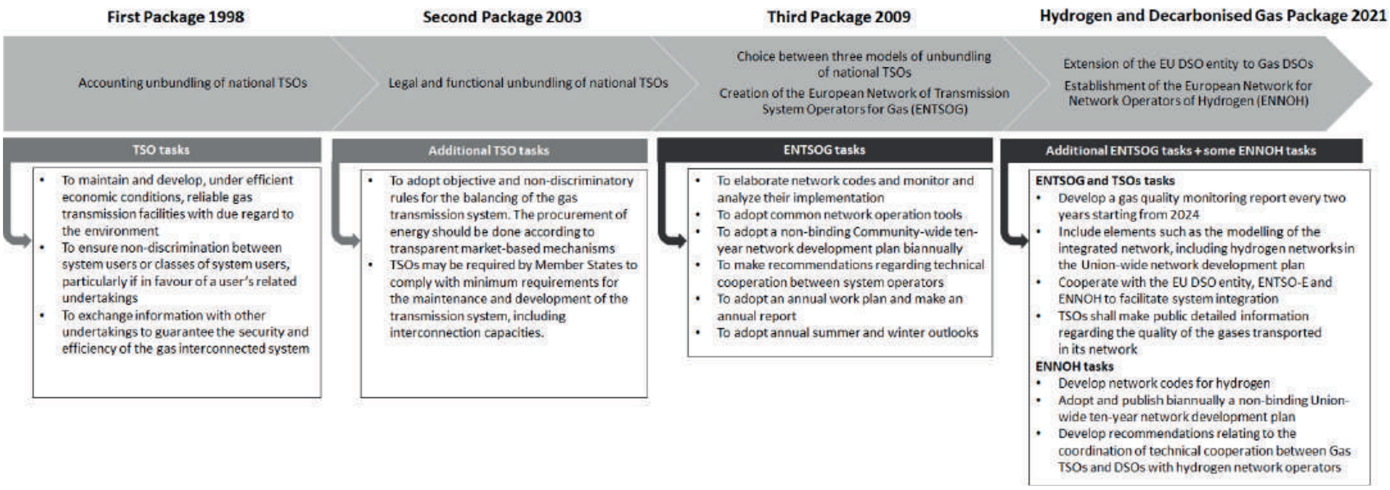
The requirement for accounting unbundling of wholesalers and suppliers in the first Gas Directive (98/30/EC) increased the need to create an independent body speaking for gas TSOs. The Directive, which had to be transposed at the national level by August 2000, aimed to create a competitive natural gas market with transparent non-discriminatory third-party network access.

Following the first Madrid forum in 1999, which was a consequence of the first Gas Directive, the European Commission requested further independent input on network issues from the gas TSOs. Therefore, Eurogas, the European gas industry association representing companies and associations engaged in the gas supply chain, decided to set up the Gas Network Interoperability Working Group. This group set the path towards the establishment of the Gas Transmission Europe (GTE) organisation in 2001. In 2005, Gas Storage Europe (GSE) and Gas LNG Europe (GLE) were grouped under the umbrella of Gas Infrastructure Europe (GIE) (GIE, 2012). In view of the Third Energy Package, GTE+ was established in 2007 as a GTE initiative with the aim of preparing the establishment of the ENTSOG. In December 2009, GTE+ was transferred into ENTSOG as required by Third Energy Package, splitting therefore from GIE.

The main function of ENTSOG is to facilitate the cooperation of national gas TSOs across Europe and particularly on cross-border gas trading activities, as is shown in Figure 7. The aim is to ensure the development of a pan-European transmission system the support the achieve of EU energy policy goals.

The Clean Energy Package focused mainly on electricity regulation. It was not particularly relevant to ENTSOG except for some general regulatory provisions included in the ACER Regulation (EU) 2019/942. Then in 2021, the Hydrogen and Decarbonised Gas Market Package proposals brought ENTSOG additional tasks such as developing a gas quality monitoring report and cooperating with the EU DSO entity and ENNOH.

Figure 7: The development of gas TSOs at the national and European levels and a selection of their tasks, own illustration



European Network for Network Operators of Hydrogen (ENNOH)

A key provision in the Hydrogen and Decarbonised Gas Markets Package proposals was the establishment of a new entity, the European Network of Network Operators for Hydrogen (ENNOH). This new organisation will ensure optimal development and management of the EU dedicated hydrogen infrastructure, including cross-border coordination. Among the tasks of ENNOH will be drafting network codes in areas relevant to hydrogen and developing non-binding ten-year network development plans (TYNDPs) for hydrogen. ENNOH will also cooperate with ENTSO-E and ENTSOG.

Hydrogen network operators will submit draft statutes, lists of members and draft rules of procedure for the ENNOH to the European Commission and ACER by 1 September 2024. Following this and after consulting relevant stakeholders, ACER will provide the Commission with its opinion. In turn, the Commission will deliver its opinion. A positive opinion will mean that hydrogen network operators are to adopt and publish ENNOH's statutes, list of members and rules of procedure.

Until the establishment of ENNOH, the European Commission will establish a temporary platform that involves ACER and all relevant stakeholders, e.g. ENTSOG, ENTSO-E and the EU DSO entity. The aim of the platform is to promote work on issues relevant to the development of the hydrogen network and markets. During this transition period, ENTSOG will also be in charge of developing gas and hydrogen TYNDPs in coordination with all the market participants, including those related to hydrogen.

The EU DSO entity

Electricity DSOs have traditionally organised themselves at the EU level through four associations: EURELECTRIC, GEODE, EDSO for smart grids and CEDEC. For gas DSOs, GD4S represents natural gas DSOs in seven EU Member States, while Eurogas has some gas DSOs among its members together with other companies and associations operating in the wholesale and retail sectors. GEODE and CEDEC have both electricity and gas DSOs among their members.

The Clean Energy Package contains for the first time a provision establishing a new EU structure for electricity DSOs, reflecting the pivotal role of DSOs in the energy transition. The entity aims to strengthen inter-DSO cooperation on the management of networks and enhancing technical dialogues with other stakeholders, e.g. TSOs, on technical issues. Membership of the entity was first opened to all electricity

DSOs that wished to participate following the CEP provisions. In 2021, the Hydrogen and Decarbonised Gas Market Package proposals extended the membership of the entity to gas DSOs.

The DSO entity is an expert entity working for general European interests. It aims to promote the operation and planning of distribution networks in coordination with TSOs. Among its tasks in the electricity sector are facilitating the integration of distributed energy resources (DERs) and other embedded resources such as energy storage. The entity should also contribute to digitalising distribution systems, including deploying smart grids and smart metering systems. In addition, the entity participates in developing network codes in coordination with ENTSO-E when relevant to distribution grids. In 2021, the Hydrogen and Decarbonised Gas Market Package proposal extended the membership of the EU DSO entity to gas DSOs with the aim of increasing the efficiency of distribution networks and enhancing cooperation with TSOs and ENTSOG. The proposal for a Gas Regulation (EU) 2021/804 updated the principal rules and procedures for the EU DSO entity established in the electricity Regulation (EU) 2019/942 such as on the composition of the Strategic Advisory Group. The EU DSO entity will submit an updated statute, a list of registered members, draft updated rules of procedure and draft updated financing rules within a year of entry into force of the Gas Regulation.

The EU DSO entity will undertake most of the activities listed in Regulation (EU) 2019/942 Article 55 regarding gas distribution networks. The inclusion of gas DSOs provides the entity with additional tasks. Among these are participating in the development of network codes that are relevant to the operation and planning of gas distribution grids and contributing to mitigating methane leakage emissions from the natural gas system.

European Forums

Following the First Energy Package, the European Commission saw a need for increased interaction with stakeholders and institutional coordination to overcome omissions in legislation and possible regulatory gaps (Vasconcelos, 2005). The Commission decided to convene two regulatory forums following the First Energy Package, creating so-called regulation by cooperation (Eberlein, 2005). Indeed, with the European Union being a new venue for regulating energy markets, there was a need to develop further platforms to facilitate negotiation processes. In 1998, the first forum, called the 'European Electricity Regulation Forum,' was set up in Florence, Italy. This was followed by the European Gas Regulatory Forum in Madrid a year later. Further regulatory and energy system development led to the establishment of the London/Dublin and Copenhagen Forums. The forums include participation by the European Commission, Member State governments, Members of the European Parliament, representatives of NRAs, TSOs, DSOs, industry and consumer organisations, and other stakeholders which provide informal input and possible solutions to internal market issues.

The Florence Forum

In 1998, the European Electricity Regulation Forum, commonly referred to as the Florence Forum, was set up on the initiative of the European Commission to discuss the creation of an internal electricity market. Since its establishment, the Forum has met once or twice a year to discuss issues such as wholesale market integration, cross-border electricity trade and electricity market design to accommodate the integration of renewable energy sources (RES). The Florence Forum led to popularisation of electricity regulation by cooperation. It also led to the establishment of important 'by-products' such as the CEER and ERGEG (the predecessor of ACER) mini-fora and regional initiatives (Trinh and Meeus, 2009).

The Madrid Forum

The European Gas Regulatory Forum, commonly referred to as the Madrid Forum, was set up in 1999 following the adoption of the first Gas Directive (98/30/EC) to cover issues like market integration, competition, congestion management and interoperability and interconnection of networks. The forum has since met once or twice a year, providing input and viable solutions to gas market issues. This led to the establishment of institutions such as Gas Transmission Europe (GTE), representing gas TSOs (Herweg, 2016).

The Dublin Forum (previously called the London forum)

The first Citizens' Energy ('Dublin') Forum was held in 2008 in London on an initiative of the European Commission. It seeks to strengthen the role of consumer representative bodies in influencing decision-making on issues related to the functioning of the retail market. Its establishment followed the successful experiences of the Florence and Madrid forums. Due to Brexit, the forum was moved from London to Dublin in 2018. With liberalisation of wholesale and especially retail markets and in particular following the adoption of the Clean Energy Package, consumers have been put at the centre of the energy transition and are adopting a key role in the changing energy markets. The forum aims to structure the debate and explore consumers' perspectives on a competitive retail energy market.

The Copenhagen Forum

The first Energy Infrastructure ('Copenhagen') Forum was held in 2015 in Copenhagen under the chairmanship of the European Commission. The forum was set up to discuss challenges relating to electricity and gas infrastructure development and EU energy policy. The idea of creating the Copenhagen Forum was part of the Energy Union strategy. The forum aims to discuss progress on major infrastructure projects with the Member States, regional cooperation groups and EU institutions (European Commission, 2015). The forum also hosted the launch of the Copenhagen School of Energy Infrastructure, which has been operational since 2017.

Regional Initiatives

In 2006 and at the request of the European Commission, ERGEG launched Regional Initiatives (RIs) to group market participants in a voluntary bottom-up process. These initiatives complement EU top-down measures on the integration of the Internal Energy Market. The Commission encouraged these initiatives as they act as platforms and pilot projects to test and implement solutions to EU cross-border issues. Seven electricity regions and three gas regions were created (European Commission, 2010). The RIs were conceived as building blocks of the internal energy market. In 2011, ACER took over the responsibilities of the RIs. Electricity RIs ceased to operate in 2015, while Gas RIs continued, especially in southern and south-south-eastern regions, focusing on implementation of network codes and completion of the internal gas market. The implementation of electricity network codes and guidelines continued to be monitored through other channels such as the Electricity Market Stakeholders Committee (ACER, 2016).

Other Relevant EU agencies

In this part we present two EU agencies that are relevant to the Green Deal roadmap: the European Environment Agency and the European Chemicals Agency. Both were established by EU legislation.

The European Environment Agency (EEA)

The European Environment Agency (EEA) is an agency of the European Union located in Copenhagen. It was formed in 1993 following Council Regulation (EEC) No. 1210/90[33] of 7 May 1990 and started its activities in 1994. The same regulation also set up the European environment information and observation network (EIONET) (EEA, 2021).

The EEA has 32 member countries: the 27 EU Member States and five non-EU member countries. There are also six cooperating countries whose cooperation activities are integrated in EIONET. The Agency also engages in international cooperation with other bodies such as the Organisation for Economic Cooperation and Development (OECD) and United Nations agencies, following Art. 15(2) of Regulation 401/2009.

The EEA's mandate is to assist the EU, its members and cooperating countries in their decision-making regarding environmental policies and coordinate the EIONET network, which is responsible for collecting and assessing high-quality environmental data.

In the CEP, Article 42 of Regulation (EU) 2018/1999 introduces the role of the EEA in assisting the Commission in the governance of the Energy Union, with regard to decarbonisation and energy efficiency objectives. The Agency is to compile the information reported by the Member States regarding policies, measures and projections and perform quality checks on the information submitted.

Within the Green Deal, the EU Climate Law (Regulation (EU) 2021/1119) requires reinforcement of the Commission's and the EEA's human resources through a legislative financial statement. The EEA is to assist the Commission in preparing the national and Union five-yearly assessments of progress towards climate neutrality.

The European Chemicals Agency (ECHA)

The European Chemicals Agency (ECHA) is a European Union agency located in Helsinki. It started its activities on 1 June 2007 following Regulation (EC) No 1907/2006 on Registration, Evaluation, Authorisation and Restriction of Chemicals, commonly known as The REACH regulation.

The Agency's Management Board is composed of 27 members from the EU Member States, six representatives of the Commission, of which three represent interested parties and are without voting rights, and two independent representatives of the European Parliament.

The Agency's mission is to provide the Member States and the EU institutions with scientific and technical advice relating to chemicals that fall within its area of activity following the REACH Regulation provisions. More specifically, it has the objectives of ensuring human health and environment protection, avoiding animal testing methods, guaranteeing the free circulation of substances on the internal market while enhancing competitiveness and innovation. REACH applies to manufacturing, putting on the market and using chemical elements or substances, with some exceptions.

The European Commission (2020) chemicals strategy for sustainability in the Green Deal aims to better protect human health and boost innovation in sustainable chemicals. The strategy consolidates and simplifies the EU regulatory framework, including the REACH regulation and Regulation (EC) No 1272/2008 on the classification, labelling and packaging (CLP) of hazardous substances, assessing how to best include legislative reforms.

33 Council Regulation (EEC) No 1210/90 was later amended by EEC Regulation 933/1999 and EC Regulation 401/2009.

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1.5 Energy taxation

Daniele Stampatori and Valerie Reif

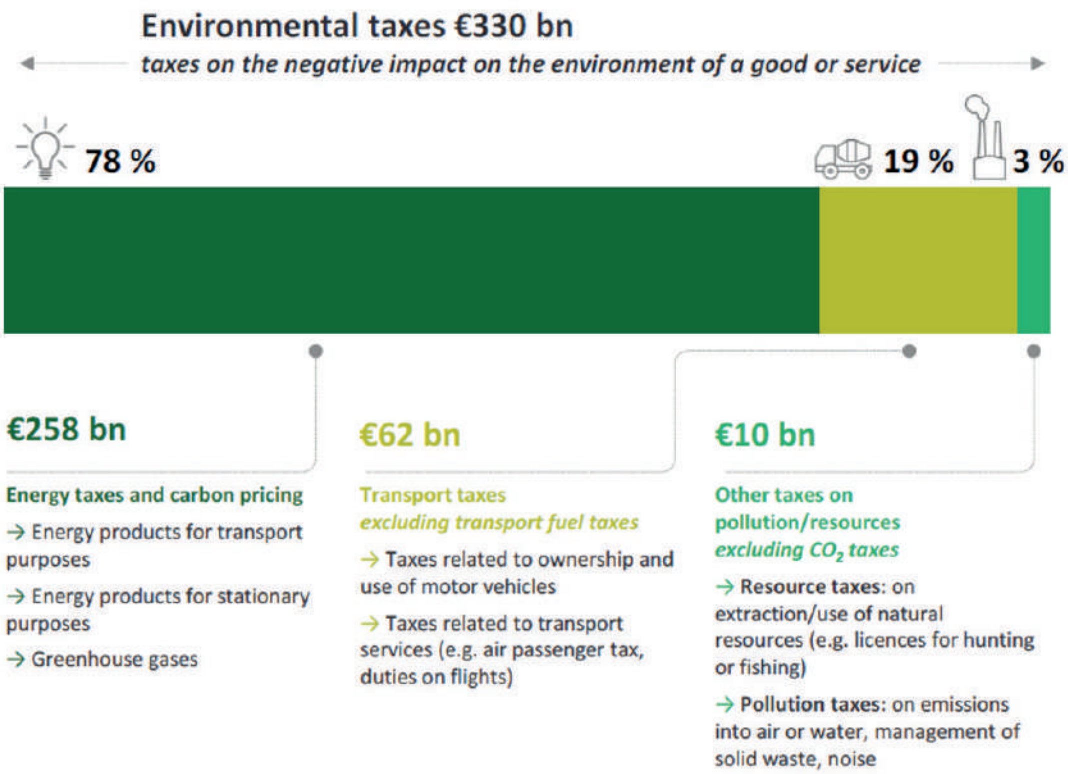
This section introduces energy taxation and related discussions in the context of the Fit for 55 Package. We first explain what energy taxation is and how it impacts energy prices for EU households and industry. We then explain how energy taxation can contribute to achieving the Green Deal objectives. Finally, we give an overview of the current and proposed EU legislative framework for energy taxation.

What is energy taxation?

Energy taxation is a tool that governments can use not only to raise revenue but also to support climate objectives. It can ensure that the price signals of different energy products reflect their impact on the environment and can incentivise business and consumers to make greener energy choices.

Energy taxes are part of the wider category of environmental taxes, which serve the purpose of internalising negative external environmental costs. According to the OECD Glossary of Statistical Terms,[34] an environmental tax is a "tax whose tax base is a physical unit (or a proxy of it) that has a proven negative impact on the environment." Four subsets of environmental taxes can be distinguished: transport taxes, pollution taxes, resource taxes and energy taxes. In the EU27, energy taxes account for more than three quarters of total environmental taxes (Figure 8).

Figure 8: EU27 energy taxes as part of total environmental taxes, based on data from 2019 (source: ECA, 2022)



34 Available at https://stats.oecd.org/glossary/ (accessed 15 March 2022).

According to Eurostat (2013), energy taxes include taxes on energy production and on energy products used for both transport and stationary purposes. The most important energy products for transport purposes are petrol and diesel. Others are natural gas, kerosene and fuel oil. Energy products for stationary use include fuel oils, natural gas, coal, electricity, coke and biofuels. Taxes on biofuels and on any other form of energy from renewable sources and taxes on stocks of energy products are also included. Note that CO2 taxes are also included among energy taxes rather than pollution taxes. Moreover, revenue from auctioning emissions permits (such as under the EU ETS) are treated as tax receipts in national accounts and should therefore be included in this category.

Energy taxes and carbon pricing can take different forms (ECA, 2022):

- specific taxes on fuel use (primarily excise taxes[35]), typically a tax rate per physical unit (litre or kilogram) or unit of energy (kilowatt hour or gigajoule);
- explicit carbon taxes typically set a tax rate for energy use based on carbon content;
- emission allowances traded in emission trading systems.

In the field of indirect taxation, the EU has competence to coordinate, harmonise and approximate VAT and excise duties, as these can affect the single market (ECA, 2022). Note that all tax decisions taken at the European level are subject to the unanimity rule. This means that all Member States must agree on any measure adopted in the taxation field. In 2019, the EC published a communication (EC 2019b) on more efficient and democratic decision-making on EU energy and climate policy, in which it asked the European Parliament and Council to reflect on the benefits of moving from the current unanimity system to qualified majority voting. At the time of writing, the reform is ongoing and is part of a broader review involving all EU tax policies, not just energy.

In line with EU competencies, the EU Energy Taxation Directive (ETD) (see below) focuses on excise duties. It sets out rules and minimum excise duty rates for taxation of energy products, electricity used as motor fuel and heating fuel to harmonise national legislation and avoid distortions in the internal market.

What is the impact of taxation of energy prices on EU households and industry?

Taxes account for a significant share of the final prices consumers pay for energy in the EU and can have a strong impact on consumption and investment patterns, the type of energy consumed and its use.

Taxes vary across types of consumers (industry, households), energy products (electricity, gas) and Member States. To illustrate the differences, this is an excerpt from a factsheet on energy taxation produced by the EC (2019c) based on a report on energy prices and costs that is published every two years:[36]

> “For households, [taxes] represent on average 40% of the electricity price, 25% of the gas price and 31% of the heating oil price in 2017. Industry, for competitiveness reasons, is usually taxed less than households: the average industrial consumer pays 13% of the gas price in taxes (and large consumers only 6%), and between 34-38% in taxes on electricity. The importance of taxes on prices also varies significantly across Member States, e.g. taxes on households range from 7% to 70% of the price for electricity and from 10% to nearly 60% for gas.

35 According to the European Commission, excise duties are indirect taxes on the sale or use of specific products, such as energy (and also alcohol and tobacco), the revenue from which go entirely to the country where they are paid. In energy, EU excise duty rules cover all energy products used for heating and transport, as well as electricity.

36 See https://energy.ec.europa.eu/data-and-analysis/energy-prices-and-costs-europe_en (accessed 17 March 2022).

> Taxes on motor fuels account for 60% for gasoline and 55% for diesel, with a variation range across Member States of 50-66% for gasoline and 45-60% for diesel.
>
> Tax rates vary considerably between households and industry, as important tax reductions or exemptions are applied by Member States for various users or uses of these products."

Voulis et al. (2019) explain that there is a stream of literature on energy taxes specifically and environmental taxes in general that addresses the question of how to set such tax rates correctly, including what should be taxed and by how much. The authors also refer to Pigouvian Theory (Pigou, 1920), which classically addresses the choice of tax base and level, and states that energy taxes (as a type of excise duty) should equal the marginal cost of the damage energy products cause and should be levied directly on the source of emission.

Accordingly, there is an ongoing debate among both academics and practitioners on how to implement an environmental tax in a cost-effective way in terms of the kind of taxation (e.g., on energy or carbon emissions) and the taxable base (e.g., a kWh consumed or the input to produce it) (see, e.g., Feindt et al., 2021; Teixidó et al., 2017). This is relevant in the context of revision of the ETD, which suggests a change (and expansion) of the taxable base for excise duties, as is described further below.

How can energy taxation help to achieve the Green Deal objectives?

As part of the Green Deal, the European Commission aims to align European energy taxation with climate objectives. Taxation can help to achieve these goals by encouraging a switch to cleaner energy and more sustainable industry. By increasing the final prices of energy products, energy taxes can induce citizens and businesses to:

- consume less energy, incentivising energy savings and energy efficiency;
- switch to cleaner technologies, if, for example, energy taxation is differentiated according to the carbon intensity of fuels.

The European Court of Auditors (ECA, 2022) lists examples of the effect of taxation on energy efficiency and therefore its key role in reaching the EU's climate objectives. In its report it makes three points in this context. First, energy taxation measures that go beyond the EU minimum rate were the second-biggest driver of energy savings (16% of the total energy savings reported) in progress towards national energy efficiency targets for 2020. Second, in their National Energy and Climate Plans (NECPs), four Member States quantified the impact of planned energy taxation measures, estimating a range between 4% and 32% of total expected energy savings. And third, the OECD evidenced a negative correlation between taxation and the energy intensity of GDP; it concluded that countries with higher energy taxes tend to have less energy-intensive economies. In the same document, the ECA reports having carried out a similar assessment for EU Member States and having found a similar correlation.

What is the current legal framework for energy taxation in the EU?

This subsection provides an overview of the evolution of European legislation concerning energy taxation until today. It also highlights the main shortcomings of the current legislation that make an update under the Fit for 55 Package necessary.

Pre-2003

Before 2003 the so-called Mineral Oils Directives (Council, 1992a/b) were the only European laws regulating minimum taxation levels for energy products, although they had very limited application. In fact, they only covered oil used for transport and heating and gas for heating. During the 1990s there were proposals to introduce common CO2/energy taxes in the EU and to restructure the Community framework for the taxation of energy products, but both were blocked because of lack of agreement. It was not until March 2003 that a proposal for energy taxation resulted in an effective Directive setting out minimum levels of taxation for energy products in Member States.

The first Energy Taxation Directive (2003)

The Energy Taxation Directive (ETD; Council, 2003) answered the need for a clear framework for energy taxation among Member States, removed market distortions due to tax competition and supported other EU policies (e.g., environment, labour, transport). The ETD had four main objectives:

- to reduce distortions caused by divergent national frameworks;
- to remove competitive distortions between mineral oils and other fuels used in the transport, heating and electricity sectors;
- to support the competitiveness of EU businesses;
- to promote the use of renewables (e.g., biofuels).

The ETD lays down a common EU framework for taxing motor fuels, heating fuels and electricity. This includes minimum excise duty rates that Member States must apply to energy products used as motor or heating fuel and some options for exemptions for the use of energy products and electricity.

Moreover, the directive sets minimum rates for commercial and industrial purposes (such as agriculture, stationary motors and machinery used in construction and public works), includes special provisions on commercial diesel and also defines which uses of energy products and electricity it does not apply to.

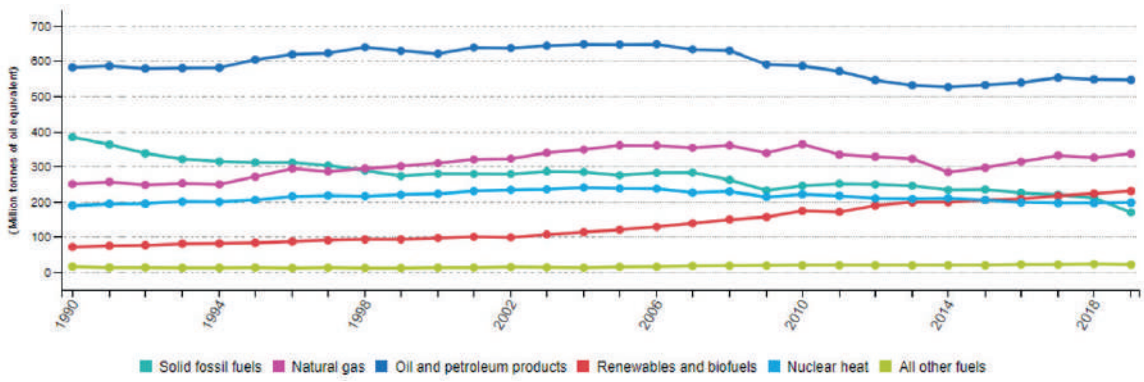
Note that EU legislation only sets harmonised minimum rates, while Member States are free to apply excise duty rates above these minima according to their national needs. Indeed, most Member States tax most energy products and, in some cases electricity, considerably above the ETD minimum rates, as is shown in the following subsection.

Developments in the energy sector since the first ETD

In the period 2003-2019, energy markets and technologies in the EU underwent significant developments (EC 2019a):

- The share of renewable energy in the EU's energy mix tripled, reaching 18%;
- The share of renewable electricity increased from 13% to 31% (see Figure 9);
- Consumption of biofuels increased 10-fold. The share of biofuels in transport grew from virtually zero to almost 5%.
- Several new products including hydrogen and synthetic gases entered the market.

Figure 9: Gross available energy in the EU in the period 1990-2019 (data source: Eurostat 2019)

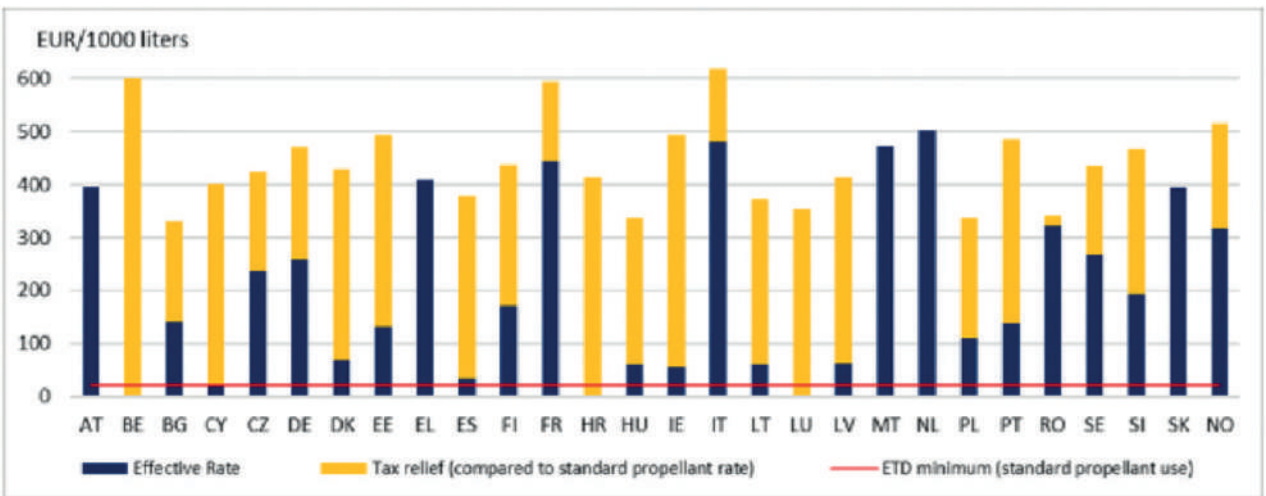


However, the energy tax framework has not kept up with these changes as it has not changed since the ETD entered into force in 2003. It is considered outdated for several reasons, which are listed in a proposal for a recast of the ETD (EC, 2021a).

First, the existing ETD is not in line with EU climate and energy objectives as it does not adequately promote greenhouse gas emissions reductions, energy efficiency or take-up of electricity and alternative fuels. The existing framework does not guarantee consistent treatment of energy sources based on the polluter-pay principle, i.e. on externalities such as pollutants and GHG emissions arising from their use. On the contrary, fuel taxation according to the first ETD is based on volume and not according to energy content, and penalises renewable fuels over fossil ones (in particular gas oil, i.e. diesel) due to their lower energy density.

Second, the existing ETD de facto favours fossil fuel use. Highly divergent national rates are applied in combination with a wide range of tax exemptions and reductions. The wide range of exemptions and reductions are forms of fossil fuel incentives which are not in line with the objectives of the Green Deal. An example is the taxation of gas oil in the agriculture sector (Figure 10). On the one hand, it shows the highly divergent situation across Member States in terms of effective rates compared to the ETD minimum. On the other hand, it shows that in some countries the rate is effectively zero due to tax exceptions, refunds and rebates.

Figure 10: Effective rates for gas oil use in agriculture in 2019/20 (own illustration, data source: EC 2021d)



Third, the ETD is no longer contributing to the proper functioning of the internal market as the minimum tax rates have lost their converging effect on national tax rates. The minimum tax levels are low as they have not been updated since 2003. In addition, they have become more and more misaligned with current market energy prices and have therefore not been sufficient to promote diversification of energy sources and investment in energy efficiency (EC, 2019b). Although national rates are often significantly higher than the minimum rates (see also Figure 10), the differences are large and the rates do not produce the convergence effect among countries that had originally been intended.

Last, legal uncertainties have been created by some aspects of the ETD that lack clarity, relevance and coherence. These include, among others, the definition of taxable products, uses that are beyond the scope of the directive, and interpretation of the exemption related to motor fuels used in air and waterborne navigation.

What does the proposed revision of the ETD entail?

The proposal to recast the ETD (EC, 2021a) embedded in the Fit for 55 Package[37] aims to address the shortcomings of the 2003 ETD by:

- fostering the transition toward clean fuels, incentivising electricity and (advanced) renewable fuels over fossil fuels;
- resolving the harmful effects of energy tax competition;
- overcoming outdated exemptions and incentives for the use of fossil fuels;
- ensuring revenue for Member States from environmental taxes rather than taxes on labour.

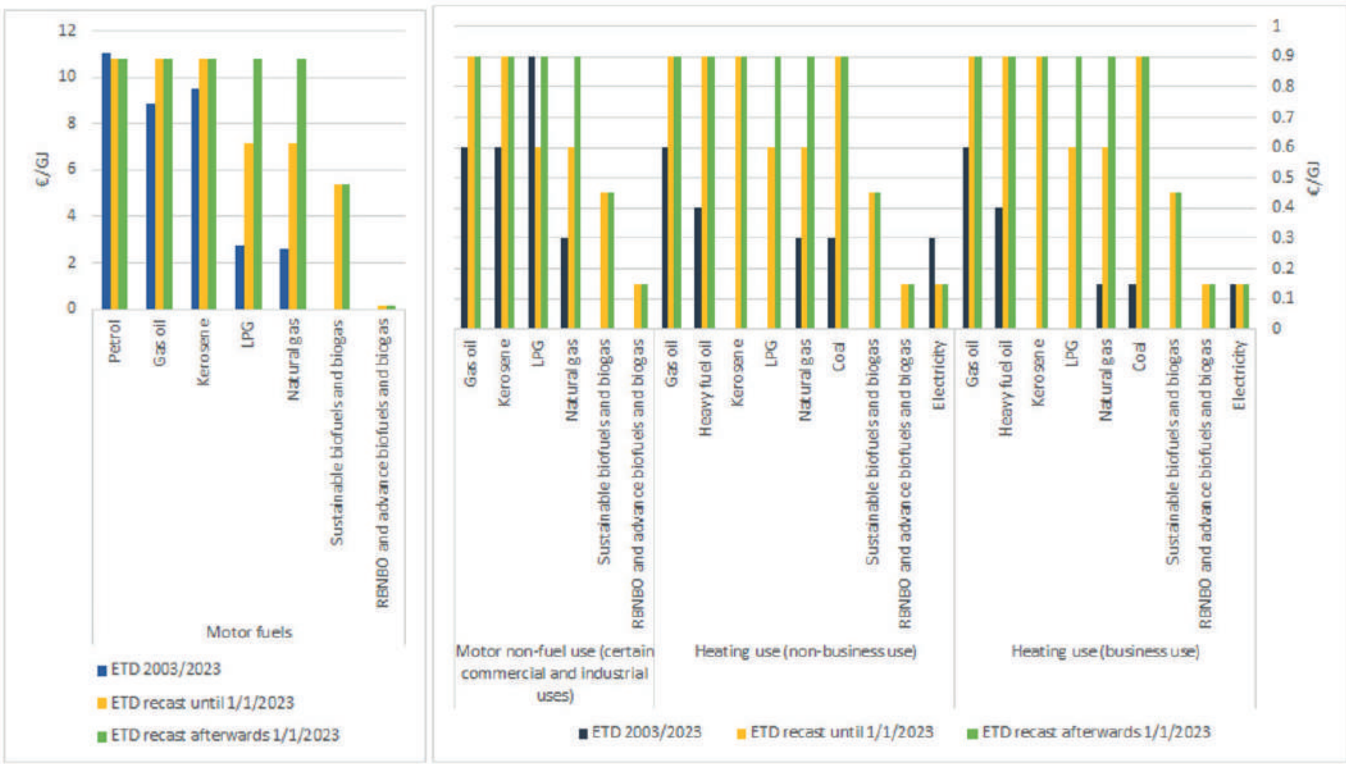
In order to achieve these objectives, the ETD proposal foresees updating the energy taxation framework. First, the proposal puts forward a new structure of minimum tax rates based on the energy content and environmental performance of fuels and electricity, rather than on volume (as is currently mostly the case). Hence, minimum rates will be expressed in €/GJ. At the same time the new system ensures that, within the same category (i.e., motor fuels, motor non-fuel use, heating in the new proposal), the most polluting fuels are taxed the highest.

Second, energy products and uses that had previously escaped the EU's energy taxation framework will be included, enlarging the taxable base. At the same time, a number of national exemptions and rate reductions will be removed; kerosene used for aviation and heavy oil used in the maritime industry will no longer be fully exempted from energy taxation for intra-EU voyages. In general, there will be an upward adjustment of minimum tax rates. The increase in minimum values for certain fuels will be implemented with an intermediate step in 2023 (see Figure 11).

Third, in order to foster its use, electricity is always among the least taxed energy sources. In fact, tax rates have been set according to the energy content and environmental performance of different fuels and electricity. In this way, the new system will ensure that the most polluting fuels are taxed the highest. Figure 11 shows that, excluding fuels that are not listed in the ETD, the highest percentage increases will be applied to coal (83%), heavy fuel oil (55%), natural gas and LPG for transport applications (around 63%). Only petrol used as motor fuel will benefit from a slight decrease in the minimum rate (of about 2%). In absolute terms, electricity and renewable fuels of non-biological origin (RFNBO, such as hydrogen) are the most favoured in terms of minimum tax rates.

37 For a recent discussion on revision of the Energy Taxation Directive, see the recording of the FSR online debate in March 2022, available at https://fsr.eui.eu/event/the-revision-of-the-energy-taxation-directive/ (accessed 17 March 2022).

Figure 11: Evolution of minimum levels of taxation for some energy products (own illustration, data source: EC 2021b)



The proposal maintains the possibility for Member States to apply tax rates higher than the minimum values set in the document. Indeed, more ambitious taxation is recommended. Moreover, in order to remove intersectoral distortion, the proposal eliminates distinctions between commercial and non-commercial diesel and between business and non-business use for heating fuels and electricity. In Figure 11 above these distinctions are only maintained according to the ETD for graphical coherence (but the values indicated in the ETD recast are the same). In order to ensure smooth implementation of the Directive, the tax exemptions for fuel used by cargo-only flights are maintained while the minimum levels of taxation for some fuels, namely motor fuels used for intra-EU non-business and non-pleasure flights, sustainable alternative fuels and electricity, and intra-EU waterborne navigation, will be introduced after a transition period of ten years.

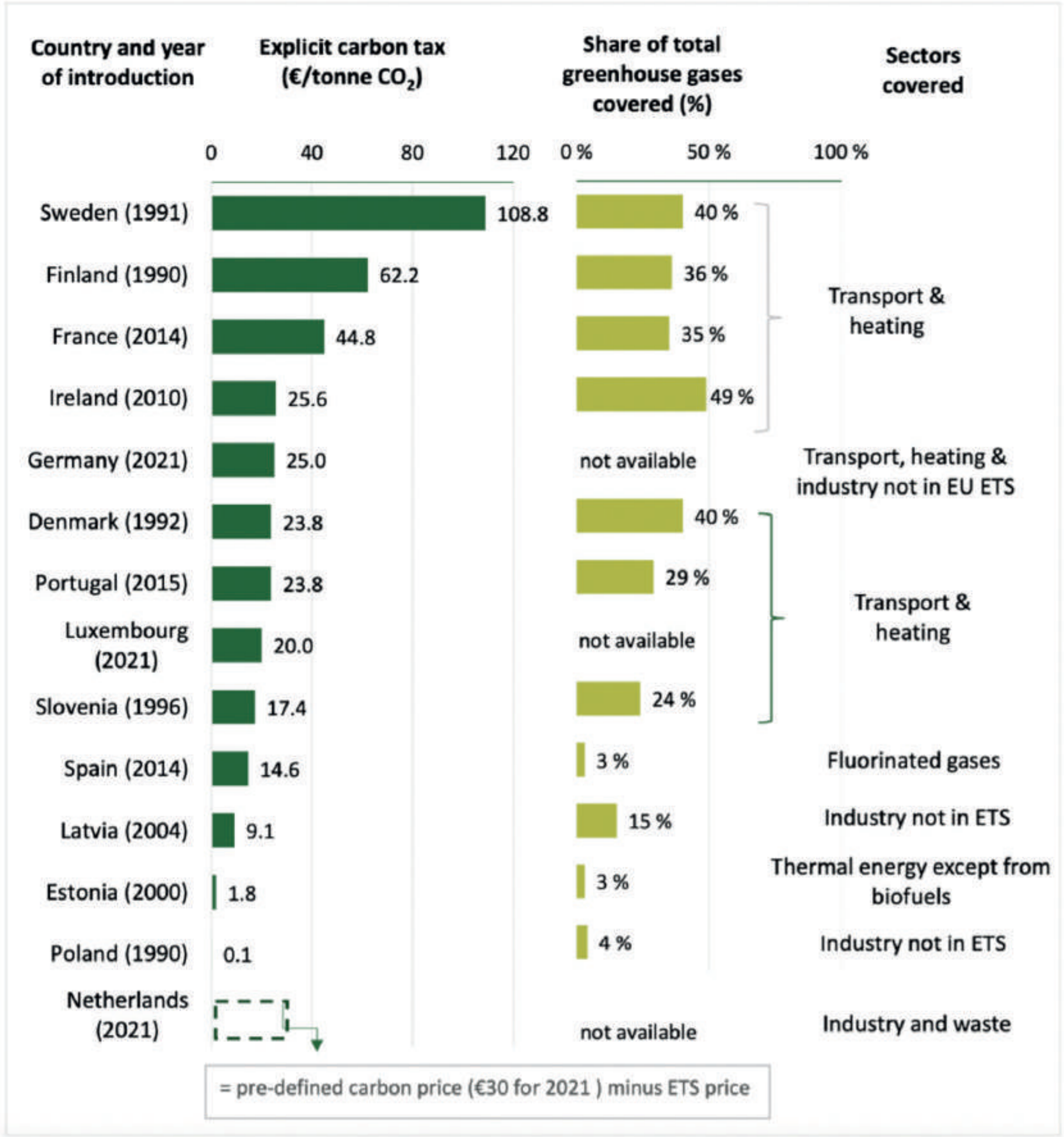
What complementarities are there with other forms of environmental taxation?

According to the EC (2021e), energy taxation and the Emission Trading System (ETS) are instruments that could continue to co-exist (the ETS was established in 2005) on the basis of their complementarity. In fact, while the ETD puts a tax on output fuels/energy content, the ETS limits GHG emissions by putting a price on these emissions (in a limited number of sectors). While the same energy product or economic sector can be subject to both mechanisms at the same time, the European Commission guarantees that as long as a particular sector or energy use is taxed under the ETD for fuel consumption and charged under the ETS for CO2 emissions, no overlap or double taxation will occur.

In this context, the proposed introduction of a specific ETS for the road transport and building sectors will be complementary to the proposed revision of the ETD. Emissions trading will tackle CO2 emissions while the ETD will ensure that fuel taxation incentivises an efficient use of energy and the consumption of more sustainable energy products, while not including a specific CO2 tax component.

Nowadays, only a limited number of Member States have implemented an explicit carbon tax, which does not usually involve sectors already covered by the existing EU ETS (Figure 12). A recent OECD (2021) publication estimates a carbon price equal to €120 per tonne in order to meet the carbon neutrality target by 2050, a value rather higher than those in Figure 12 below.[38]

Figure 12: Explicit carbon taxes in the EU (data source: ECA 2022)



Finally, note that a flat carbon tax on electricity which does not distinguish between the carbon content of different generation mixes could jeopardise the switch towards low-carbon technologies. However, such differentiation may only be temporary since in the long-term revenue from excise duty and carbon tax on fossil fuels may eventually disappear, leaving electricity as the main source of energy tax revenue.

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2. EU climate policy

In this chapter, we give an overview of EU climate policy in five sections. First, we outline different international climate agreements and explain how climate negotiations work and how they influence the EU's climate and energy policy. Second, we present the EU emission trading system. Third, we introduce the carbon border adjustment mechanism and how it is related to the World Trade Organization. Fourth, we provide an introduction to methane emissions. Fifth and sixth, we describe two decarbonization instruments, namely renewable energy policy and energy efficiency policy.

2.1 International climate agreements

Maria Olczak

What is the UNFCCC?

The United Nations Framework Convention on Climate Change (UNFCCC) is the foundation of international efforts to address climate change (United Nations, 1992). It paved the way for both the Kyoto Protocol and the Paris Agreement. Adopted at the Rio Earth Summit on 9 May 1992, the Convention entered into force on 21 March 1994. Currently, there are 197 parties – 196 countries and one regional economic integration organisation (the European Union) – to the Convention.[39]

With the adoption of the UNFCCC, governments around the world recognised for the first time that the climate system is changing as a result of human activity. Therefore, the ultimate objective of the Convention, highlighted in Article 2, is to achieve "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (United Nations, 1992).

The UNFCCC covers major greenhouse gases (GHGs)[40] and recognises that developed countries should lead the way because of their responsibility for most past emissions. This group of countries is also known as Annex I countries and encompasses the Organisation for Economic Co-operation and Development (OECD) member countries, including countries transitioning to a market economy (the so-called economies in transition) in Central and Eastern Europe. The parties not mentioned in Annex I are sometimes referred to as non-Annex I countries.

How do climate negotiations work?

The parties meet regularly to take stock of progress in fulfilling their obligations under the Convention and to discuss further efforts to address climate change. There are three governing bodies, which play major roles in the process of negotiation:[41]

- Conference of the Parties (COP) to the Convention;

39 See https://unfccc.int/process-and-meetings/the-convention/status-of-ratification/status-of-ratification-of-the-convention (accessed 04/02/2022).

40 Seven GHGs in total: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and nitrogen trifluoride (NF_3). NF_3 was added to this list later based on the Doha Amendment and the change applies from the beginning of the Kyoto Protocol 2nd commitment period

41 See https://unfccc.int/process-and-meetings/bodies/the-big-picture/what-are-governing-process-management-subsidiary-constituted-and-concluded-bodies (accessed 04/02/2022).

- Conference of the Parties Serving as the Meeting of the Parties to the Kyoto Protocol (CMP);
- Conference of the Parties Serving as the Meeting of the Parties to the Paris Agreement (CMA);

Decisions are confirmed at a plenary meeting under unanimity rule. Before the final text of a decision reaches this stage, it is negotiated in several lower-level technical groups (Wojtal, 2018). The governing bodies are supported by the Bureau and two permanent bodies: the Subsidiary Body for Scientific and Technological Advice (SBSTA)[42] and the Subsidiary Body for Implementation (SBI).[43]

Who negotiates? Negotiating groups and main actors

Due to the complexity of negotiations, the negotiating positions are usually agreed on behalf of a group of countries (Wojtal, 2018). Even though the Paris Agreement departs from the bygone division between developed (Annex I) and developing (non-Annex I) countries as both of these groupings have diversified (Brunnée and Streck, 2013; Hurrell and Sengupta, 2013), the main negotiating groups, created in the early ’90s, remain largely unchanged.

There are five United Nations regional groups and ten key negotiating groups operating in various arrangements (see Table 3). However, there are also individual countries which play leading roles in negotiations because of their economic and diplomatic influence: the US, China, India, South Africa, Brazil, Russia, Japan, Norway, Korea, Mexico, Canada, Japan, Switzerland and the EU MSs (mainly Germany and France) (Wojtal, 2018).

Table 3: UN Regional Groups and negotiating groups. Source: Wojtal, 2018.

<table>
<tr><td colspan="6">UN REGIONAL GROUPS</td></tr>
<tr><td colspan="2">African Group</td><td>Eastern European Group (EEG)</td><td>Western European and Others Group (WEOG)</td><td>Asia-Pacific Group</td><td>Latin American & Caribbean Group (GRULAC)</td></tr>
<tr><td colspan="6">NEGOTIATING GROUPS</td></tr>
<tr><td rowspan="3">Developing</td><td>G77&China 134</td><td>Least Developed Countries (LDCs)</td><td>Alliance of Small Island States (AOSIS)</td><td>Arab Group</td><td>Like-Minded Developing Countries (LMDCs)</td></tr>
<tr><td rowspan="2">Small Island Developing States (SIDS)</td><td rowspan="2">Independent Alliance of Latin America and the Caribbean (AILAC)</td><td>Bolivarian Alliance for the Peoples of our America (ALBA)</td><td rowspan="2">Organisation of Petroleum Exporting Countries (OPEC)</td><td rowspan="2">Brazil-South Africa-China-India (BASIC)</td></tr>
<tr><td>Coalition of Rainforest Nations</td></tr>
<tr><td>Developed & mixed</td><td>Umbrella Group (UG)</td><td>Environmental Integrity Group (EiG)</td><td colspan="3">European Union (EU)</td></tr>
</table>

42 See https://unfccc.int/process/bodies/subsidiary-bodies/sbsta (accessed 04/02/2022).

43 See https://unfccc.int/process/bodies/subsidiary-bodies/sbi (accessed 04/02/2022).

The UNFCCC Secretariat ensures the continuity of and support for climate negotiations at both the organisational and technical expertise levels. The secretariat is located in Bonn (Germany) and led by the Executive Secretary. Since 2016 this position has been held by a former Minister of Foreign Affairs of Mexico – Patricia Espinosa.[44]

What is the Kyoto Protocol?

The UNFCCC put in place a general framework, but only in 1997 did the parties agree on a Protocol to the Convention specifying concrete reduction targets: the Kyoto Protocol (KP). Based on the Kyoto Protocol, the Annex I countries committed to cut their greenhouse gas emissions by an average of about 5% compared with 1990 levels over the period 2008-2012 (United Nations, 1997).

However, the Protocol only officially entered into force on 16 February 2005 after it had been ratified by the Russian Federation. The US did not ratify the Kyoto Protocol after the election of George W. Bush as President. The US non-participation in the KP weakened its impact, in both political and economic terms (Pickering et al., 2017). Moreover, in 2011 Canada withdrew from the Protocol, while three other countries – Japan, New Zealand and the Russian Federation – did not participate in the KP's second commitment period. Currently, there are 192 Parties to the Kyoto Protocol.[45]

Since 2005, discussions have focused on the multilateral response to climate change post-2012, i.e. following the end of the Protocol's first commitment period (Wojtal, 2018). At that time, it was expected that a new climate agreement would be adopted by December 2009. However, the fiasco of negotiations at COP15 fuelled by disagreement between the US and China over the roles of developed and developing countries in addressing climate change (Christoff, 2010) led the parties to extend the Kyoto Protocol for another commitment period.

On 8 December 2012, the Parties adopted the Doha Amendment to the Kyoto Protocol (United Nations, 2012), which extended the Protocol for a second commitment period (2013-2020). During this period, the remaining parties committed to reduce GHG emissions by at least 18% below 1990 levels. The amendment entered into force on 31 December 2020.[46]

What is the legacy of the Kyoto Protocol?

Despite the limited participation and lengthy negotiation process, the Kyoto Protocol brought about some significant changes (Nature, 2012). These include:

- adoption of national GHG emission reduction targets;
- development of national GHG inventories and reporting and verification mechanisms;
- creation of flexible market mechanisms: a Clean Development Mechanism (CDM), Joint Implementation (JI) and International Emissions Trading;
- following the creation of International Emissions Trading, development of regional cap-and-trade systems, such as the EU ETS (see also section 2.2).

44 See https://unfccc.int/about-us/about-the-secretariat (accessed 04/02/2022).

45 See < https://unfccc.int/kyoto_protocol> (accessed 04/02/2022).

46 See < https://unfccc.int/process/the-kyoto-protocol/the-doha-amendment> (accessed 04/02/2022).

What is the Paris Agreement?

What had not worked in 2009 turned out to be possible six years later, when the parties agreed on a new legally binding international treaty on climate change. The Paris Agreement was adopted on 12 December 2015 and entered into force on 4 November 2016 (United Nations, 2015). Currently, there are 193 parties to the Paris Agreement.[47]

The 2015 climate treaty introduces a different emission reduction mechanism to that under the Kyoto Protocol. Instead of setting domestic reduction targets, it sets a so-called 'temperature goal,' to limit the increase in the average global temperature to well below 2, preferably 1.5, degrees Celsius above pre-industrial levels.[48] Moving beyond that level increases the risks resulting from climate change, such as droughts, floods, extreme weather events, etc. (IPCC, 2018).

To achieve this temperature goal, countries need to peak global GHG emissions as soon as possible and reach climate neutrality by 2050.[49] Article 2 of the Paris Agreement specifies two other goals – to increase adaptation to negative impacts of climate change and to make financial flows (both private and public) "consistent with a pathway towards low greenhouse gas emissions and climate-resilient development." In other words, the Paris Agreement objectives cover three areas: mitigation, adaptation and finance.

What are the Nationally Determined Contributions?

To achieve its three objectives, the Paris Agreement introduced a 5-year ambition cycle. By 2020 the parties were expected to submit their climate action plans, the so-called nationally determined contributions (NDCs).[50] The NDCs can include GHG reduction targets and other actions to reach the Paris Agreement objectives such as renewable energy targets, building resilience to adapt to the impacts of climate change and financial flows, and also different forms of support for developing countries, including capacity-building, financial and technical support.

Every new or updated NDC is expected to be more ambitious than the previous one to ensure that countries work continually to achieve the Paris Agreement objectives (Figure 13). Moreover, the climate agreement invited the parties to communicate by 2020 their long-term low greenhouse gas emission development strategies (LT-LEDS), which would provide a long-term perspective on the NDCs. However, in contrast to NDCs, these long-term strategies are not mandatory. So far, 50 parties have submitted them.[51]

47 See < https://unfccc.int/process/the-paris-agreement/status-of-ratification> (accessed 04/02/2022).

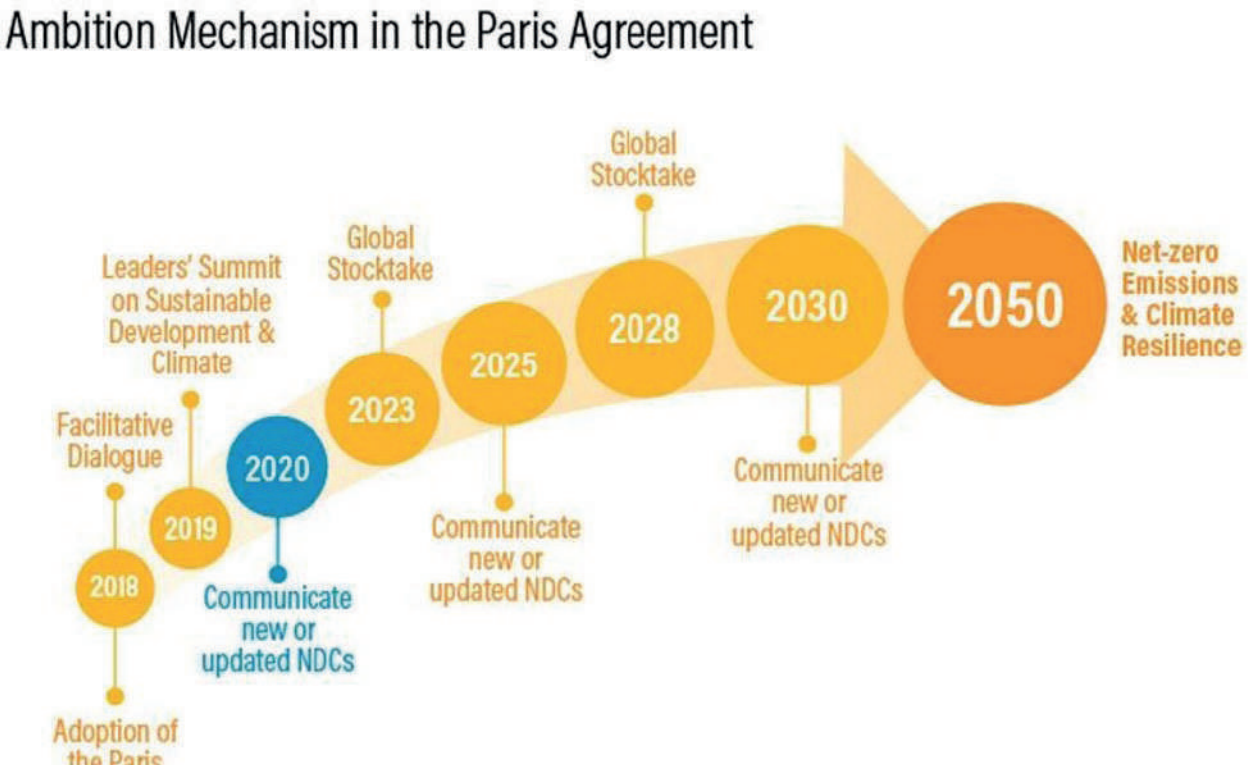
48 Art 2: "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels." Pre-industrial refers to any period of time before the start of large-scale industrial activity around 1750. For instance, the IPCC Special Report on Global Warming of 1.5ºC uses the reference period 1850-1900 to approximate pre-industrial global mean surface temperature. See < https://www.ipcc.ch/sr15/chapter/spm/> (accessed 04/02/2022).

49 ee < https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement> (accessed 04/02/2022).

50 See the interim NDC registry at https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx (accessed 04/02/2022). According to Climate Tracker, so far 130 parties have submitted new NDC targets (129 countries plus the EU27) covering almost 72% of global GHG emissions See https://climateactiontracker.org/climate-target-update-tracker/ (accessed 04/02/2022).

51 See https://unfccc.int/process/the-paris-agreement/long-term-strategies (accessed 04/02/2022).

Figure 13: Ambition Mechanism in the Paris Agreement. Source: WRI, 2017



How to ensure compliance with the climate objectives?

The Paris Agreement does not specify any sticks or penalties for countries that do not fulfil their commitments. However, it contains a mechanism to track progress in terms of climate change mitigation, adaptation and financial flows. Under the Enhanced Transparency Framework (ETF) the parties will report on actions taken and their progress towards meeting the Paris Agreement objectives. This information will serve as a basis for a global stocktake, which will evaluate collective progress and lead to a set of recommendations to set more progressive climate plans in the next 5-year cycle.[52]

How does action on climate link with the Sustainable Development Goals?

The Paris Agreement is linked to other UN-led initiatives such as the 2030 Agenda for Sustainable Development. There are synergies between the efforts to halt global warming and to achieve the Sustainable Development Goals, as climate change disproportionately affects the poorest and most vulnerable nations. The 2030 Agenda was adopted by the UN General Assembly in 2015 with 17 Sustainable Development Goals and 169 targets, including SDG13 on climate action. SDG13 is to "Take urgent action to combat climate change and its impacts by regulating emissions and promoting developments in renewable energy."[53]

52 See < https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement > (accessed 04/02/2022).

53 See < https://unfccc.int/topics/action-on-climate-and-sdgs/action-on-climate-and-sdgs > (accessed 04/02/2022).

How do global negotiations influence EU climate and energy policy?

The international climate negotiations have had a significant impact on both EU and national climate and energy policies. Although the EEA estimated that the EU was responsible for roughly 8% of global GHG emissions in 2018, it has traditionally been one of the most active and progressive parties to climate conventions (Wojtal, 2018).

Moreover, multilateral climate negotiations are one of the for a in which the EU is able to speak with one voice on behalf of all 27 Member States, which, nonetheless, often have different views on the pace and depth of the clean energy transition. This requires a great deal of internal coordination, e.g. during meetings of the Working Party on International Environment Issues in the Council, as EU external policy on climate change is a mixed competence shared between the Member States and the EU (Oberthür and Kelly, 2008). We should also remember that credibility at the negotiation table depends largely on the effectiveness of domestic action and legislation. The ambitious EU climate agenda helps the EU to lead by example and to provide greater certainty for Member States and investors regarding long-term EU policies (Wojtal, 2018).

Table 4: E U climate change commitments and legislation. Own elaboration based on EU Commission, 2020; Wojtal, 2018; Oberthür and Kelly, 2008.

EU COMMITMENTS AND LEGISLATION	
UNFCCC establishment	- Both the EU and the MSs are parties to the UNFCCC - The EU-15 and other industrialised countries (the so-called Annex II parties) agreed to provide financial and technological assistance to developing countries - Council Decision of 24 June 1993 for a monitoring mechanism of Community CO2 and other greenhouse gas emissions - The proposal by the European Commission for a combined European CO2/energy tax was rejected by the MSs - 1st and 2nd European Climate Change Programmes (2000, 2005) - EU ETS established (Emissions Trading Directive (2003/87/EC)), ETS phase 1 (2005-2007)
Kyoto Protocol 1st commitment period (2008-2012)	- The EU-15 agreed to reduce GHG emissions jointly (as the 'EU bubble') by 8% compared to 1990 levels - EU ETS phase 2 (2008-2012) - Other relevant legislation: Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources; Directive 2003/30/EC on the promotion of biofuels in transport; Directive 2004/101/EC on the linking of the EU ETS with the project mechanisms under the Kyoto Protocol

Kyoto Protocol 2nd commitment period (2013-2020)	- The EU-28 to reduce GHGs by 20% compared to 1990 levels by 2020 - 2020 climate and energy package (3x20% targets) - EU ETS phase 3 (2013-2020) and Effort Sharing Decision (covering non-ETS sectors)
Paris Agreement	- EU-28 (EU-27 since 1 January 2021) to reduce GHGs by at least 40% compared to 1990 levels by 2030 - 2030 climate and energy framework (40% GHG reduction target, 32% RES, 32.5% energy efficiency) - EU ETS phase 4 (2021-2030) and Effort Sharing Regulation (non-ETS sectors) - Land use, land use change and forestry (LULUCF) Regulation Regulation on the Governance of the Energy Union and Climate Action
Long-Term Strategies	- EU objective to reach climate neutrality by 2050 (European Green Deal) including: - European Climate Law to make the 2050 climate neutrality objective legally binding; - European Climate Pact to engage citizens and all parts of society in climate action; - 2030 Climate Target Plan to further reduce net greenhouse gas emissions by at least 55% by 2030 (Fit for 55 Package); - EU Strategy on Climate Adaptation to make Europe a climate-resilient society by 2050.

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2.2 The EU Emission Trading System (EU ETS)

Giulio Galdi and Albert Ferrari

The EU Emission Trading System (ETS) is the cornerstone of Europe's climate policy and covers about 40% of the EU's greenhouse gas (GHG) emissions and about 5% of global emissions. The cap-and-trade scheme follows the 'polluters-pay-principle' that firms covered by the ETS must purchase an emission allowance for each tonne of CO2-eq they inject into the atmosphere. In this respect, the EU ETS is a carbon pricing mechanism similar to a carbon tax. Two main features distinguish an ETS from a carbon tax. First, a carbon tax fixes the price for polluting but the amount of CO2-eq abated by the measure is uncertain. By contrast, the EU ETS sets an emissions cap imposing an upper bound to emissions but the price of allowances is determined by buyers' bids (it currently hovers around €80).[54] Second, it incentivises firms to perform better and invest in decarbonising their activities. In fact, a firm that invests in decarbonising its activities will emit less and therefore need to buy a lower number of allowances. When installations receive some allowances for free based on sectoral benchmarks, or when they own too many allowances, they can even sell their surplus to more carbon-intensive firms.

The EU ETS has been in operation since 2005 and was the first international emissions trading scheme. It was the largest one until the Chinese ETS became operational in mid-2021. Indeed, many more ETSs currently exist and are being developed around the world in both developed and developing countries (Galdi et al., 2020; ICAP, 2022), enhancing ETS linkage possibilities.[55]

A revision of the EU ETS is currently under discussion in the European Parliament and the Council following proposals made by the European Commission in the EU 'Fit for 55' Package released on 14 July 2021 (European Commission, 2021a, 2021b and 2021c; European Parliament Research Service, 2022). Originally, the Package aimed to align existing policies with the EU Climate Law (Regulation (EU) 2021/1119) objective of reducing GHG emissions by 55% compared with 1990 levels by 2030, and with the EU's commitment to reach net-zero carbon emissions by 2050. Modifications have been introduced after the first proposal. Following the REPowerEU initiative, the Commission presented an amendment to the EU ETS Directive which increases the Recovery and Resilience Facility financial envelope with €20 billion in grants from the sale of EU ETS allowances currently held in the Market Stability Reserve. Moreover, the final text adopted by the EU Parliament increases the target on GHG emission reduction to 63% by 2030. (European Parliament, 2022). Four trilogues have already taken place.

The overall cap in the EU ETS decreases at a yearly rate[56] (European Parliament and the Council, 2018). Between 2011 and 2020, the applicable rate, the so-called Linear Reduction Factor (LRF),[57] of 1.74% was applied as part of Phase III of the EU ETS. The currently applicable LRF has been raised to 2.2% above the 2010 baseline and was initially expected to be valid for Phase IV of the ETS (2021-2030).

Relative to its launch in 2005, in 2020 the sectors covered by the EU ETS achieved and exceeded the targeted 21% reduction in regulated emissions. Compared to 2005, in 2020 there was a 41% emission reduction in sectors covered by the EU ETS (European Environment Agency, 2021). This massive reduction

54 Daily figures on the EUA price are provided on the EMBER website, available at https://ember-climate.org/data/carbon-price-viewer/.

55 FSR Climate is currently investigating obstacles and pathways to ETS linkages in its Life DICET project, which is co-funded by the EU LIFE Programme. More information on the project is available at https://lifedicetproject.eui.eu/.

56 See the EU ETS Handbook (European Commission, 2015) for more information on how the baseline year is set.

57 Detailed information is available at https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets/emissions-cap-and-allowances_en.

can be partially attributed to the EU ETS itself. However, other policies and factors affected the emissions from the sectors covered. For instance, decarbonisation of the power sector was facilitated by support schemes for renewables (Edenhofer et al., 2021) and the COVID-19 pandemic led to an additional 12% emissions reduction in 2020 compared to 2019. Nevertheless, the EU ETS appears well on track to enforce a 43% reduction by 2030.

The Fit for 55 Package plans a reduction of 61% compared to 2005 by 2030 in emissions in the sectors covered by the EU ETS. This means that the LRF yearly rate should be further strengthened from the current 2.2% to 4.2% given the EU ambition to raise the overall GHG reduction target to 55%. In parallel, the total cap of allowances will be adjusted downward as if the new LRF was applied at the beginning of 2021 (re-basing for Phase IV).

It is worth underlining that all explicit and implicit climate policies can impact the demand for allowances so that if the overall climate policy framework is changed the EU ETS should be aligned accordingly.

Which gases and sectors are covered by the EU ETS?

The EU ETS covers carbon dioxide (CO2), nitrous oxide (N2O) and perfluorocarbon (PFC) emissions from about 10,000 heavy-energy-using installations. In terms of sectors, the scope currently covers power stations and industrial plants (oil refineries, steelworks and plants producing iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals). Moreover, air flights that both depart and land within the borders of the European Economic Area (the EU plus Norway, Lichtenstein and Iceland) have been covered by the EU ETS since 2012.

Both to limit administrative costs (monitoring, reporting and verification) and to avoid disproportionately burdening small firms, in most sectors only industrial installations above certain production capacity thresholds are subject to the EU ETS. A list of all the activities covered and the related thresholds is provided in Annex I of Directive 2003/87/EC (European Parliament and the Council, 2003).

With the Fit for 55 Package, emissions from the maritime transport sector will also be gradually included in the EU ETS from 2023 onwards. This will consist of all emissions from boats at berth in EU ports from intra-EU voyages and 50% of emissions from non-EU voyages.

In addition, the European Commission has proposed creating a separate second emission trading system (EU ETS 2) for fuel distribution for road transport and buildings starting in 2025. Although final users, including households and car drivers, are ultimately emitting GHG emissions, fuel distributors will be regulated under the EU ETS 2. Monitoring and reporting of emissions from the sectors would start in 2024 but the cap and surrendering of emission allowances would be set in 2026. Overall, the sectors covered by the EU ETS 2 would have to reduce their emissions by 43% in 2030 compared to 2005.

Already before July 2021 (i.e., before the energy crisis and increased tension with Russia), pricing the carbon emissions of these sectors raised many concerns among civil society and some Member States regarding the distributional impacts on households, micro-enterprises and transport users (Euractiv, 2022). To alleviate the effects on consumers, the European Commission has proposed a Social Climate Fund using 25% of the revenue from ETS 2 on road transport and buildings. Nevertheless, the creation of this second ETS is being questioned by some political groups and stakeholders. For instance, environmental and consumer groups claim that it may not bring about the necessary behavioural change to drive down emission reductions. They favour instead tightening the ambition level of fuel economy standards.

How are allowances allocated?

The EU ETS has undergone many substantial reforms since its implementation. One of the most relevant changes concerns allowance allocation, which in Phase I (2005-2007) and II (2008-2012) was decentralised and mainly relied on freely allocated allowances. Since Phase III (2013-2020) the total volume of emission allowances has been determined at the EU level, a single set of rules has governed their allocation, and auctioning has been the default allocation mechanism. In Phase III it is estimated that 43% of total allowances were freely allocated while the rest (57%) were auctioned by the Member States.

Free allowances are still allocated according to the risk of carbon leakage in each sector. Intuitively, the risk of carbon leakage is higher for firms whose ETS compliance represents a relatively large share of overall costs or whose exports and imports represent a relatively large share of turnover. Carbon leakage refers to the situation that may occur if, for reasons of costs related to climate policies, businesses were to transfer production to other countries with fewer emission constraints. This could lead to an increase in their total emissions. As for the power sector, generators have had to buy all their allowances since Phase III, with derogations for three lower-income Member States (Bulgaria, Hungary and Romania).

Installations in the industrial sector are given free allowances depending on their efficiency relative to 52 product-specific benchmarks outlined by the European Commission (2019a). In addition, one of three fall-back approaches is applied whenever products from an installation are too heterogeneous or change frequently. These benchmarks are based on: 1) process emissions; 2) heat consumption; or 3) fuel consumption (European Commission, 2019c). As a rule, the benchmark corresponds to the average performance of the 10% most efficient installations. Industrial installations belonging to a sector deemed at risk of carbon leakage receive free allowances covering 100% of their benchmarked emissions, which are computed by multiplying the relevant benchmark by the installation's recent output level. By contrast, only a share of this benchmark value is freely allocated to industrial installations that are not deemed at risk of carbon leakage. This share of allowances allocated freely to sectors deemed not at risk of carbon leakage has been constantly reduced, going from 80% in 2013 to 30% in 2020 with the objective of gradually phasing out free allowances from the system (European Parliament and the Council, 2018).

Furthermore, as there exists a maximum number of allowances that can be freely allocated at the EU level, a uniform cross-sectoral correction factor is applied to all installations so that the final allocation of free allowances does not fully cover all benchmarked emissions.

Finally, there are special allocation rules for the aviation sector, with 82% of allowances freely allocated, 15% auctioned and 3% withheld for new entrants and fast-growing companies.

During Phase IV, free allocation will focus on sectors at very high risk of carbon leakage, with updates of the carbon leakage list every 5 years and two updates of the benchmark values to avoid windfall profits and reflect technological progress. Highly exposed sectors will receive allowances equivalent to 100% of the relevant benchmark for free. Free allocation for less exposed sectors will amount to 30% up to 2026 and will be progressively phased out by 2030.

Does the EU ETS lead to carbon leakage?

So far, scientific evidence does not support the hypothesis that the EU ETS induces some carbon leakage, mainly due to very low to moderate allowance prices in the past (Verde et al., 2021b). Furthermore, sectors that are the most exposed to carbon leakage receive a higher share of free allowances, thus partly reducing their costs and the risk of carbon leakage. However, as the allowance price has significantly risen and free allowance allocation will be curbed, the risk of carbon leakage could change accordingly.

Until Phase III (2013-2020), identification of sectors at risk of carbon leakage relied on two sectoral indicators computed at the EU level: carbon cost intensity (CCI) and trade intensity (TI). The former measured the carbon costs relative to gross value added whereas the latter measured the trade value relative to the size of the European market. To be classified as at risk of carbon leakage, firms needed to exceed 30% for either of the two, or 5% for CCI and 10% for TI.

As of Phase IV (2021-2030), a less lenient rule is applied to identify sectors at risk of carbon leakage. Specifically, a sector is classified as being at risk of carbon leakage if the product of the carbon emissions intensity indicator (CEI) (expressed in kgCO2 per euro of gross value added) and the TI indicator, CEI × TI, exceeds 20%. In addition, an adjustment to free allowance allocation is applied in cases of annual output variations exceeding +/-15%.

The first list of sectors at risk of carbon leakage – the 'carbon leakage list' – was defined in 2009 (European Commission, 2009) for the years 2013 and 2014. Of 258 sectors, 165 were classified as being at risk. A second list was defined in 2014 for the years 2015-2019 and later extended to cover 2020 (European Commission, 2014a). A third list was adopted in 2019 to cover all of Phase IV, with only 63 sectors still present (European Commission, 2019).

A central dimension in a European Green Deal-aligned ETS reform is free allocation of allowances. Especially if other complementary policies are introduced to mitigate the risk of carbon leakage, the number of free allowances allocated to sectors under the EU ETS would decrease in the second half of the decade 2020-2030. The Carbon Border Adjustment Mechanism proposal is especially relevant to this.

In the Fit for 55 Package, the European Commission proposed a gradual phasing out of free allocation in the sectors covered by the proposed Carbon Border Adjustment Mechanism.[58]

Moreover, the benchmarks will be updated and made more stringent to better target free allowances. In addition, uptake of low carbon innovation technologies and implementation of the recommendation for energy audits will be further incentivised through free allocation.

Furthermore, the European Commission is planning to focus on the EU ETS as the main policy tool to decarbonise aviation by eliminating free allowances in this sector by 2027.

What is the role of offsets in the EU ETS?

At its inception, the EU ETS was designed to be part of a nascent international carbon market and thereby contribute to its development. The EU ETS was directly connected to the Kyoto system,[59] and owners of regulated installations were allowed to use Certified Emissions Reductions (CERs) and Emission Reduction Units (ERUs) respectively generated by the Clean Development Mechanism (CDM) and Joint Implementation (JI) to meet their compliance obligations. CERs and ERUs certify the abatement of one tonne of CO2 in a sector or jurisdiction not covered by the EU ETS, thus granting firms purchasing them the right to emit an additional tonne of CO2 in their EU ETS-covered activities.

However, as the European carbon market was troubled by large oversupply, restrictions on the use of international credits were put in place quite soon: quantitative restrictions were introduced in Phase II and

58 In December 2021 the FSR organised a debate on the prospects for the global carbon market. The recording is available at https://fsr.eui.eu/the-global-carbon-market-after-cop26-is-the-glass-half-full-or-half-plenty/.

59 Detailed information is available at https://unfccc.int/process/the-kyoto-protocol/mechanisms.

later tightened and complemented with qualitative restrictions in Phase III. As of Phase IV (2021-2030), the use of offsets is no longer allowed. Besides the need to curb oversupply to preserve the cost-efficiency of the EU ETS, the use of offsets has received much criticism from scholars and NGOs due to the low environmental integrity of most offset projects. According to a report commissioned by DG Clima (Cames et al., 2016), only 7% of the potential CER supply for the period 2013-2020 had a high likelihood of delivering real measurable additional emission abatement.

Although the EU does not currently intend to use international offsets for compliance under the EU ETS in Phase IV, the Paris Agreement opens a new chapter for global carbon markets to achieve national and European targets.[60] Parties to the Paris Agreement can use different instruments for trading emission reductions at the international level through mechanisms established in Article 6 of the Agreement. Article 6.2 allows countries to develop decentralised cooperative approaches under which they could trade mitigation units, so-called Internationally Transferable Mitigation Outcomes (ITMOs), to reach their own nationally determined contributions (NDCs). Article 6.4 opens the possibility of setting up a new centralised UN mechanism to trade emission reduction credits related to specific sustainable development projects. Article 6 also provides the opportunity to account for international cooperation and integration of non-market approaches. Following the deal reached on Article 6 at the COP26 in Glasgow in November 2021 (IISD, 2021), only time and actual implementation of the Paris rulebook will show how the EU intends to engage with the different mechanisms.

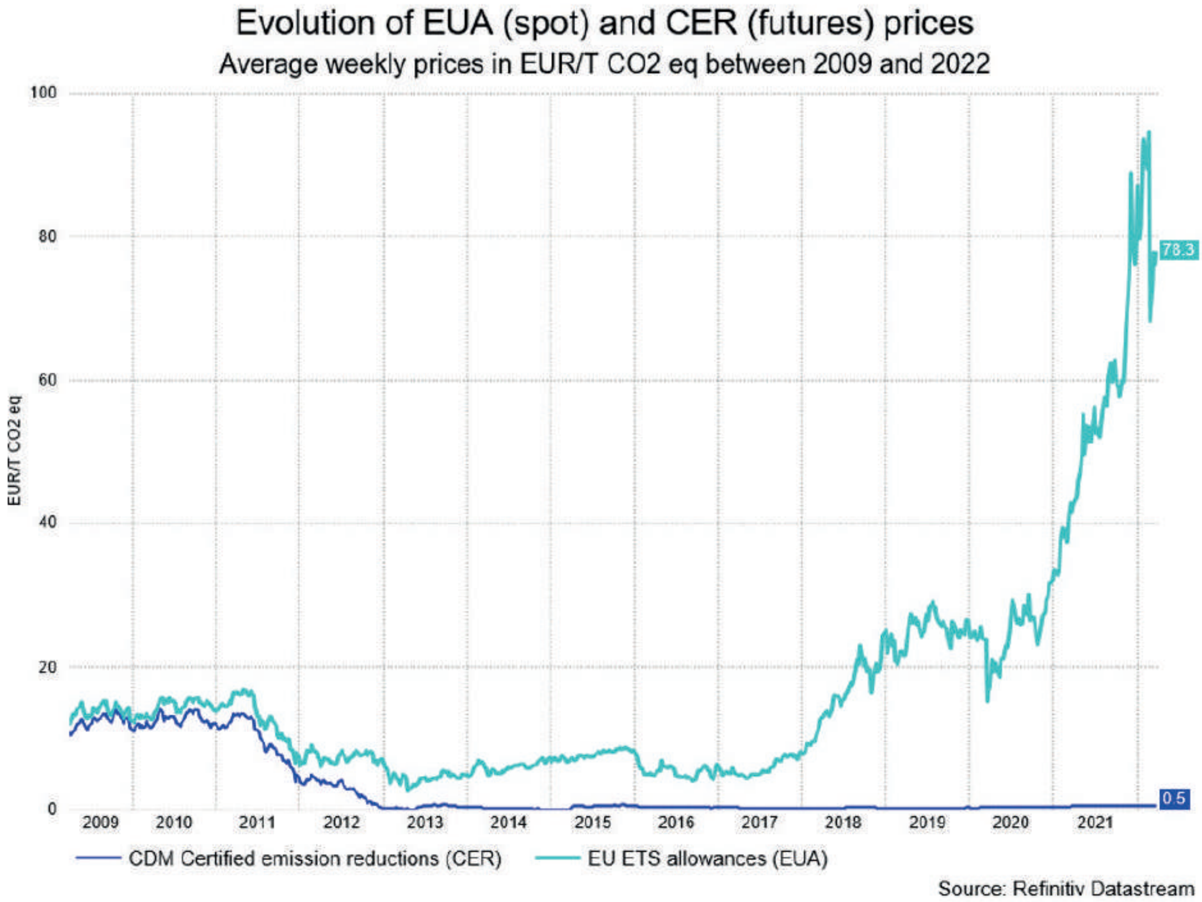
With the Fit for 55 Package the EU implements the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) for extra-European flights to and from countries outside the European Economic Area. When emissions from these flights reach a level above the 2019 level, they will have to be offset by credits from other sectors in countries that participate in the Paris Agreement, and from 2027 in CORSIA. Double accounting of emissions must be avoided and each credit should represent a tonne of CO2 emissions that has been reduced or avoided.

What is the historical trend in allowance prices?

The EU allowance (EUA) price has undergone significant variations since its first phases. In 2006 the first publication of verified emissions revealed that the regulated installations had been overallocated, causing an abrupt fall in demand. In 2008 the Global Financial Crisis hit the EU ETS hard with the shrunken aggregate demand carrying over into the carbon market. Subsequently, the EUA price further declined and then stagnated for several years due to the combined effect of the oversupply of offsets and effective companion policies (Verde et al., 2021a). Indeed, national policies facilitating the deployment of renewables and an increase in energy efficiency reduced demand for allowances by polluting firms.

60 Detailed information is available at https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets/international-carbon-market_en.

Figure 14: Evolution of EUA and CER prices



Because of all these effects, by the start of Phase III (2013) the EU ETS had accumulated a surplus of about two billion allowances (which is more than the total volume of annual emissions under the EU ETS). As expected, this large surplus of allowances severely depressed the EUA price. In 2012 the European Commission started tackling the problem by postponing the auctioning of 900 million allowances from 2014-2015 to 2019-2020, a measure known as 'backloading.' However, as further action proved necessary the Market Stability Reserve (MSR) was made operational in January 2019 and the backloaded allowances were stashed in it as an initial reserve.

In 2020 and 2021 the EUA price increased sharply and steadily, almost reaching the symbolic value of 100 €/tonne in February 2022. The increase can be explained by many different factors, including the rise in gas prices pushing power producers to use more coal, the more stringent rules in Phase IV of the EU ETS including a higher LRF and the announcement of the EU Green Deal and the EU's renewed ambition to cut its emissions (Euractiv, 2021). Some have argued that it can also be explained by disorderly trading or abusive behaviour, although these claims do not appear to be substantiated so far (ESMA, 2022). After the start of the war in Ukraine at the end of February 2022, the EU ETS has experienced a period of uncertainty and price instability.

How does the Market Stability Reserve control the volume of allowances available on the market?

The MSR is a rule-based mechanism that adjusts the number of allowances to be auctioned to the market surplus (i.e., the difference between the cumulative amount of allowances available for compliance at the end of a given year and the cumulative amount of allowances effectively used for compliance up to that given year). The surplus, known as the Total Number of Allowances in Circulation (TNAC), is published yearly and determines the response of the MSR:

- if the TNAC exceeds 833 million allowances, 12% (24% in the period 2019-2023) of the surplus allowances are withheld from auctions and added to the reserve;
- if the TNAC is less than 400 million, 100 million allowances are taken from the reserve and auctioned in the market;
- if the TNAC is between 400 and 833 million allowances, no response from the MSR is triggered.

The thresholds triggering adjustments to the supply of allowances delimit an interval of surplus values within which "experience shows that the market was able to operate in an orderly manner," according to the European Commission (2014b).

From 2023 onwards, the number of allowances held in reserve will be capped at the volume auctioned in the previous year and allowances in excess will be cancelled, thus effectively reducing the total EU ETS cap. The European Commission reviews the MSR every five years, with the first review held in 2021.

The Fit for 55 Package contains a few minor amendments to the MSR. First, the European Commission proposes to extend the 24% rate of intake to be added to the reserve until 2030. Moreover, a smoother intake of allowances into the MSR would be enabled to avoid a threshold effect. In addition, after 2023 allowances above the volume auctioned in the previous year would be invalidated and the number of allowances in the MSR would be limited to 400 million. Third, the aviation and maritime sectors would be included in the calculation of the TNAC.

A separate chapter of the MSR should be created to control the volume of allowances in the EU ETS 2 for buildings and road transport. Moreover, excessive and sudden price increases in the ETS 2 can also trigger a release of new allowances from the MSR in the ETS. This mechanism is activated when for more than three consecutive months the average price of allowances in the auctions is more than twice the average price during the six preceding months.

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2.3 Carbon border adjustment mechanisms and the World Trade Organization

Valerie Reif and Leigh Hancher

In this section, we introduce carbon border adjustment mechanisms (CBAM) and the World Trade Organization by answering four questions. First, what is a carbon border adjustment mechanism? Second, why are carbon border adjustment mechanisms relevant to the European Green Deal? Third, what does the proposal for a CBAM entail? Fourth, what is the World Trade Organization and why is it relevant to the EU carbon border adjustment mechanism?

What is a carbon border adjustment mechanism?

Carbon border adjustment mechanisms are a method to alleviate the negative impacts of uneven climate efforts between different jurisdictions. They seek to establish a level playing field between goods produced domestically and imported goods in terms of the cost of greenhouse gas (GHG) emissions associated with their production.

Carbon border adjustment mechanisms can basically come in two forms, as is described by the World Bank Group (2020). First, tariffs can be imposed on goods imported from countries where companies face a lower or no carbon cost. Second, rebates can be granted on the carbon cost of goods exported to markets where companies are competing with others that are not subject to equally stringent climate policies. This can happen, for example, through tax or regulatory relief or a refund of the cost of buying allowances. When integrated into an Emissions Trading System (ETS), a CBAM can require an importer to purchase emission allowances to cover the embedded GHG emissions from production of its imported goods. Alternatively, it can be imposed as a jurisdiction-wide tax that targets both foreign and domestic producers, or as an import levy.

Why are cross border mechanisms relevant to the European Green Deal?

The European Green Deal represents Europe's ambitious path towards climate neutrality by 2050. However, the fight against climate crises needs global action, which is still lagging in many parts of the world. The EU is concerned about the risk of carbon leakage as many international partners do not share the same ambitions as the EU. Carbon leakage can occur because production is transferred from the Member States to other countries that are less strict about emission reduction or because EU products are replaced with more carbon-intensive imports (EC, 2019).

Carbon leakage in large amounts is considered to risk global emissions not being reduced, climate-related efforts by the EU and its industries being less or not effective, and the competitiveness of EU industry being jeopardised. It may also have important unemployment implications. For these reasons, the European Commission has proposed a carbon border adjustment mechanism (CBAM) for selected sectors as part of the Fit for 55 Package to reduce the risk of carbon leakage stemming from differences in levels of ambitions worldwide.

The EU is not the only jurisdiction to consider introducing a CBAM. Some other countries such as Canada and Japan are planning similar initiatives. U.S. President Joe Biden also announced in his 'Plan for a Clean Energy Revolution and Environmental Justice' that his administration would impose carbon adjustment fees or quotas on carbon-intensive goods from countries that are failing to meet their climate and environmental obligations.[61] The EU sees this as an opportunity to expand cooperation between the continents and a global template for setting such measures (EC, 2020a).

In the carbon pricing literature, the option of introducing a CBAM has been repeatedly discussed. In practice, only California has so far implemented a CBAM. This applies to electricity imports from neighbouring states provided they are not linked to the Californian ETS. Mehling et al. (2017) explain that "legal uncertainties, implementation challenges, and fear of backlash from trading partners" have in most cases led policymakers to abolish any plans to implement a cross-border mechanism and to favour carbon pricing alternatives that are only applicable within the jurisdiction's geographical borders. An analysis of carbon pricing mechanisms[62] by the World Bank Group (2020) confirms that countries have so far used purely domestic measures to address both environmental and competitiveness risks. At the time of writing, 61 carbon pricing initiatives are in place or scheduled for implementation worldwide: 31 ETS and 30 carbon taxes covering about 22% of global GHG emissions.

In the EU, carbon leakage concerns have so far been addressed by compensating for two types of costs that firms and businesses face under the EU ETS (see also section 2.2). First, direct costs stem from obligations for businesses to buy CO2 certificates equivalent to their industrial emissions. The EU mandates compensation of direct costs by Member States granting free allowances under the ETS Directive 2003/87/EC. Second, indirect costs are additional costs that a firm incurs because a supplier is also subject to direct costs, which it then includes in the electricity price and passes on to consumers. Compensation of indirect costs is optional for Member States and subject to compliance with EU state aid rules. Empirical evidence does not confirm the existence of significant carbon leakage under the EU ETS so far. However, there is concern that more stringent climate policies foreseen under the Green Deal may lead to carbon leakage in the future.[63]

What does the CBAM proposal entail?

The European Commission primarily expects that the introduction of a CBAM will ensure that the price of imports accurately reflects their carbon content (EC, 2019). Various options for introducing a CBAM have been considered by the EC (2020), for example the introduction of a carbon tax on selected products (both imported and domestic), a new carbon customs duty or tax on imports, or extension of the EU ETS to imports.

61 See https://joebiden.com/climate-plan/. See also https://www.nytimes.com/2021/07/19/climate/democrats-border-carbon-tax.html for an update on the matter.

62 Carbon emission pricing exists in various forms. The two main approaches fall within the category of 'explicit carbon pricing,' which puts a price directly on GHG emissions (EP, 2020a). The first such approach is introduction of an emissions trading system (cap and trade), which is a quantity-based instrument. The second approach is carbon taxing, which is a price-based instrument. There is also 'implicit carbon pricing,' which refers to policies that implicitly price GHG emissions, like removal of fossil fuel subsidies or fuel taxation, and other mechanisms such as carbon crediting and internal carbon pricing.

63 See Verde (2020) for a detailed review on carbon leakage under the EU ETS and Verde et al. (2020) for a discussion of the potential of carbon leakage in the future.

In July 2021, the European Commission adopted its proposal for a CBAM, which essentially involves application to imports of a system that replicates the EU ETS regime applicable to domestic production (EC, 2021c). Under the proposed CBAM scheme, importers would buy carbon certificates corresponding to the carbon price that would have been paid had the production taken place in the EU under the EU's carbon pricing rules. The CBAM is not a 'cap and trade' system like the ETS. Instead, CBAM certificates would mirror the ETS price. The price of CBAM certificates would be calculated depending on the weekly average auction price of EU ETS allowances expressed in €/tonne of CO2 emitted. When a non-EU producer can show that it has already paid a price for the carbon used in production in a third country, the EU importer can fully deduct the corresponding cost.

The CBAM is an 'own resource' of the EU, just like customs duties. The application of the CBAM is directly linked to EU customs laws and it is through this system that the CBAM will be enforced. Imported goods must first be classified correctly (as CBAM application is linked to the customs classification code) and their origin must be determined correctly (in accordance with the customs rules on non-preferential origin), as only products from countries that are not exempted are covered. The person authorised for import must be the declarant in the customs meaning of the term (this means that a declarant that is not authorised, even by mistake, will have to pay the CBAM certificates and penalties). Then, EU importers must correctly calculate the embedded emissions and submit the calculation in the CBAM declaration. This will require detailed carbon accounting for the whole supply chain, which will be an exercise quite similar to what is required to claim preferential customs origin, though with the added complexity of how to calculate the carbon footprint.

According to the EC proposal, the CBAM would initially apply only to a selected number of goods considered to be at high risk of carbon leakage, such as iron and steel, cement, fertiliser, aluminium and electricity generation. In addition, it would only be phased in gradually with a transition period of three years (from 1 January 2023 to 31 December 2025). Over that period, a simplified system would be in force in which importers have to report emissions embedded in their goods without paying a financial adjustment. From 1 January 2026, the CBAM would fully enter into force. EU importers would start paying a financial adjustment by surrendering the amount of CBAM certificates that correspond to emissions embedded in their imports. Also, from 2026 and in the same time intervals, free ETS allowances would gradually be phased out for the CBAM sectors over a period of ten years.

In other words, to ensure that the mechanisms are not cumulative, the CBAM will only begin to apply to the products covered gradually and only to the proportion of emissions that do not enjoy free allowances. Only after free ETS allowances for CBAM-covered sectors are completely phased out in 2035 will the CBAM apply to the entire proportion of emissions. This is to ensure that importers are treated in an even-handed way compared to EU producers. Note that exports are not covered in the EC proposal and that there is a built-in review to consider extension of the coverage, especially to indirect emissions as well as other goods such as plastics.

The proposal requires the approval of the European Parliament and the European Council before taking effect. Some of the controversial topics still to be agreed include the use of CBAM revenues, the scope of the CBAM and speed of its phase-in, and the establishment of a centralized CBAM authority and central registry for importers at the EU level.[64]

64 See for example these two Euractive articles: https://www.euractiv.com/section/energy-environment/news/eu-lawmaker-drafts-complete-overhaul-of-carbon-border-levy/ and https://www.euractiv.com/section/energy-environment/news/eu-countries-agree-worlds-first-carbon-tariff-but-leave-out-controversial-issues/ (last consulted 29 April 2022).

In March 2022 the Council adopted its general approach on the CBAM, followed by the Parliament in June (Council, 2022, EP 2022) The Council introduced changes to the CBAM governance proposing a greater centralization (e.g., an EU level centralised registry) and exceptions for consignments with a value of less than €150. The Parliament position foresees the phasing in of the CBAM from 2027 with free allowances ending in EU emissions trading system by 2032. The Parliament voted also in favour of extending the scope of CBAM to organic chemicals, plastics, hydrogen, ammonia and indirect emissions. The trilogue meetings to reach a common position of the Council and the Parliament have begun in July.

What is the World Trade Organization and why is it relevant for the EU carbon border adjustment mechanism?

There is consensus among the European authorities that the design of a CBAM needs to comply with the rules of the World Trade Organization (WTO) and other international obligations of the EU such as free trade agreements. Compliance with international trade rules aims to ensure that the mechanism is not discriminatory and does not constitute a disguised restriction on international trade (EC, 2019; EP, 2020b).

How to design a WTO-compatible CBAM has been subject to discussion. On the one hand, WTO rules are designed to lower barriers against trade between countries and generally do not favour the introduction of trade restricting measures. More concretely, the fundamental principles of the WTO that are laid down in the general rules of the General Agreement on Tariffs and Trade (GATT) leave only a thin margin of possibility for the EU to implement a CBAM.[65] The GATT only allows for an exception of the general rule of non-discrimination between domestic and imported products on the grounds of human health and natural resources protection. It is on this ground that the European Commission's CBAM proposal makes it clear that CBAM should not be deemed a trade protectionism measure but rather an environmental tool. On the other hand, there is an ongoing debate about whether international trade rules, and specifically those of the WTO, are fit for an age with increased global climate ambitions under the Paris Agreement. Note that this is part of a wider debate about the suitability of the WTO system that predates the Paris Agreement.

Introducing the WTO

The World Trade Organization is a global international organisation dealing with the rules on trade between nations. It was established in 1995 as a successor of the General Agreement on Tariffs and Trade (GATT), which had been established in the wake of World War II and currently has 164 members.[66] The WTO operates a system of trade rules (known as the multilateral trading system) and offers a place where governments can negotiate trade agreements and settle trade disputes. The WTO system's overall objective is to help trade flow as freely as possible as long as there are no undesirable side effects.

The multilateral trade system[67]

At the heart of the multilateral trading system are WTO agreements, which are negotiated and signed by the majority of the world's trading nations and ratified by their parliaments. They cover goods, services and intellectual property. WTO agreements are essentially contracts among governments that provide the legal ground rules for international trade. Currently, there are 16 multilateral trade agreements to which all WTO members are parties and two plurilateral trade agreements to which only some WTO members, including the EU and its Member States, are parties.

65 For the point of view of the WTO, see for example a speech by the Deputy Director-General from September 2021, available at https://www.wto.org/english/news_e/news21_e/ddgjp_16sep21_e.htm (last consulted 28 April 2022).

66 The GATT was both an agreement, i.e. a set of rules, and an unofficial de facto organisation that was born out of that agreement. The GATT organisation was substituted by the WTO in 1995, while the GATT set of rules is still in place.

67 The following is mainly based on <https://www.wto.org/english/thewto_e/whatis_e/tif_e/fact2_e.htm>.

The WTO agreements are lengthy and complex but there are several fundamental principles that are common to all documents. The trading system should be:

- Non-discriminatory. Two principles apply here. First, probably the most important is the most-favoured-nation (MFN) treatment, which means that countries cannot normally discriminate between their trading partners. If one trading partner is granted a special condition, that condition must apply to all other WTO members as well. Second, national treatment means that a country should not discriminate between its own and foreign products, services or nationals. However, equal treatment of imported and locally produced goods only applies once the foreign goods, services, trademarks, copyrights and patents have entered the market. This means that charging customs duties on imports is not a violation of the national treatment principle.
- Freer. Members aim to gradually lower trade barriers such as customs duties (or tariffs), import bans or quotas through negotiations in order to encourage trade.
- Predictable. Trading rules should be clear, transparent and predictable to make the business environment stable and encourage investment. In the WTO system, this is ensured through countries 'binding' their commitments, for example with ceilings on customs tariff rates. A country can change its bindings only after negotiating with its trading partners, which can result in a need to pay compensation.
- More competitive. In principle, trade conditions and practices should be fair, yet despite best efforts it is complex and often challenging to establish what is fair and unfair and how governments can respond to unfair practices by trading partners.
- More beneficial for less developed countries. WTO agreements contain special provisions on developing countries to give them more time to adjust and to implement agreements and commitments, greater flexibility and special privileges. There are also measures to increase their trading opportunities and provide support for building their trade capacity, handling disputes and implementing technical standards. Note in this regard the special status of China as a 'developing country,' which is a major issue including regarding more general reforms of the WTO.

WTO rules are evolving as agreements are renegotiated from time to time, and new agreements can be added to the legal body. The current set of rules are largely the outcome of the 1986-94 Uruguay Round negotiations, which included a major revision of the original General Agreement on Tariffs and Trade (GATT). There are many agreements, annexes, decisions and understandings that form the WTO legal texts. To simplify matters, they fall in six categories: the umbrella agreement that established the WTO; agreements for each of the three broad areas of trade that the WTO covers (goods, services and intellectual property); dispute settlement; and reviews of governments' trade policies (Table 5). Note that many of the agreements are currently being negotiated under the Doha Development Agenda, which was launched in 2001.

Table 5: The basic structure of WTO agreements (WTO, 2021)

Umbrella	Agreement establishing the WTO		
	Goods	**Services**	**Intellectual Property**
Basic principles	General Agreement on Tariffs and Trade (GATT)	General Agreement on Trade in Services (GATS)	Trade-Related Aspects of Intellectual Property Rights (TRIPS)
Additional details	Other goods agreements and annexes	Services annexes	
Market access commitments	Countries' schedules of commitments	Countries' schedules of commitments (and MNF exemptions)	
Dispute settlement	Dispute settlement		
Transparency	Trade policy reviews		

Why is the General Agreement on Tariffs and Trade (GATT) relevant to a European CBAM?

Hillmann (2013) and Krenek et al. (2020) explain that it is necessary to distinguish between, on the one hand, the general rules for WTO members and parties to the GATT on introducing trade restricting measures and, on the other hand, exceptions to these rules. General rules relevant to the introduction of a CBAM include the MFN principle (Article I), the pacta sunt servanda principle, which means that existing laws that include national tariff schedules are to be respected (Article II), the national treatment principle (Article III), the rule that quantitative trade restrictions (quotas) are to be avoided above all (Article XI) and rules on (export) subsidies (Article XVI).

Regarding exceptions, Article XX allows a party to the GATT to deviate from the abovementioned general rules. This could be the key provision regarding implementing a CBAM. Indeed, Article XX includes provisions on acting in pursuit of interests greater than trade, such as protecting the environment, public health, animal or plant life and natural resources. This article could be used as an argument to demonstrate the necessity of a CBAM even though it violates general principles (Krenek et al., 2020). Making the case that a CBAM is necessary based on Article XX is not straightforward, however. Note that there are few precedents and little guidance on its application. Another way could be to leverage Article II.2(a) of the GATT, which allows the introduction of a tax or a tariff on imports as long as it is equivalent to the burden imposed on domestic (European) producers by an internal tax or the like (Krenek et al., 2020; Lowe, 2019).

The design of a European CBAM has been subject to heated political debate, the details of which go beyond the scope of this chapter. Among the key issues involved in determining the compatibility of a CBAM with international trade rules are an environmental nexus (i.e. reducing carbon leakage must be the main purpose of the CBAM), its relation with the EU ETS and the system of free allowances, the use of revenues generated by a CBAM, questions of fairness when it comes to climate obligations for the least-developed countries and the need to avoid a design that qualifies as an export subsidy and violates the most-favoured-nation treatment and national treatment principles. Overall, given the political reality and existing international trade law, it remains a complex political and legal challenge to design a CBAM in a way that adequately prices the amount of GHG emissions stemming from producing goods imported into the EU (Bacchus, 2021).

Why is there a debate on a reform of the WTO?

In parallel with discussion on how to design a WTO-compatible CBAM, there is a more fundamental ongoing debate on the nature of the WTO and the effectiveness of its multilateral trading system. For some time now, the WTO has been facing a crisis that affects all three of its functions as described by the EC (2021b): "negotiations have failed to modernise the rules, the dispute settlement system has de facto reverted to the days of the GATT where panel reports could be blocked, and the monitoring of trade policies is ineffective." There are multiple reasons for the crisis that go beyond the scope of this chapter, for example the trade relationship between the U.S. and China. In essence, the WTO members have become increasingly divided over what they expect from the WTO and (re-)discovering a common sense of purpose is deemed necessary to determine a way forward that allows the WTO to evolve in line with changes in global trade (EC, 2021b).

The European authorities see enhancing the WTO's contribution to sustainable development as one way to restore trust and a sense of common purpose. In Europe, there has been growing consensus on the need for the Paris Agreement to become one of the main guiding principles in trade policy, with all trade initiatives and policy tools being adjusted to reflect this. Note in this context that the Paris Agreement does not include a system of sanctions, which means that aligning it with WTO rules is important for it to be effective. The European Parliament is convinced that a multilateral WTO reform is needed to bring international trade law into line with the aims of the Paris Agreement and other aspects of international law (EP, 2020b). Indeed, the effectiveness of the WTO system, and in particular the GATT, in terms of sustainability and its relation to national and global climate ambitions has been subject to debate for some time now.

The WTO ruling that first exposed the weaknesses of the GATT system was related to renewable energy subsidies in Canada, namely Ontario's feed-in tariff (FIT) programme, which was challenged at the WTO by Japan and the EU in 2011 and 2012.[68] The complainants claimed that the FIT programme discriminated against foreign suppliers of equipment and components for renewable energy facilities, because it included a 'buy local' component that required power generating companies that were participating in the FIT programme to source a certain percentage of their equipment in Ontario. Canada argued that the very purpose of the FIT programme was to incentivise the construction of renewable energy generation facilities that would otherwise not have been built and to create green jobs. In 2013, the Appellate Body of the WTO reaffirmed the initial ruling of a WTO panel that Canada was indeed violating the GATT and the Agreement on Trade-Related Investment Measures (TRIMs). In 2014, Canada informed the WTO Dispute Settlement Board that the Government of Ontario had complied with the recommendations and rulings by no longer subjecting large renewable electricity procurement to domestic requirements and significantly lowering the domestic content requirements for small and micro-FIT procurement of wind and solar electricity under the FIT programme.[69] This dispute attracted the attention of many scholars, both legal and not. Legal scholars have repeatedly recognised that there is a mismatch between international climate change mitigation goals and WTO (subsidy) law (Espa and Marín Durán, 2018) and that a reform of the WTO's subsidy rules to enable government support for renewable energy may be needed. However, other academic work shows that local content requirements do not always work the way they are intended to (Bazilian et al., 2020), that the impact on domestic welfare is ambiguous and the total amount of renewable energy produced may even decrease under a FIT programme with local content requirements (Bougette and Charlier, 2015).

68 For a comprehensive overview of the case, see <https://www.citizen.org/wp-content/uploads/ontario-feed-in-tariff-briefing-paper.pdf>.

69 See the related WTO file at <https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds426_e.htm>. A similar case is the dispute between the United States and India relating to domestic content requirements for solar cells and solar modules. The WTO file is available at <https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds456_e.htm>.

In February 2021, the European Commission presented a revision of the bloc's trade policy putting sustainability at its core and prioritising WTO reform (EC, 2021a). The EC wants to put a focus on reinforcing the WTO's capacity to tackle competitive distortions and enhancing its contribution to sustainable development with initiatives that include liberalising trade in selected green goods and services, greening of aid-for-trade, transparency, including on CBAMs, and agreements to reduce fossil fuel subsidies (EC, 2020b). Going forward, the EU also plans to support an interpretation of WTO provisions in international trade negotiations that "recognises the right of Members to provide effective responses to global environmental challenges, notably climate change and the protection of biodiversity" (EC, 2021b). Many attempts have been made to start discussions on WTO reforms in the past, and it remains to be seen how effective the new attempts by the European authorities will be.

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2.4 Methane emissions

Maria Olczak and Andris Piebalgs

Methane is a short-lived but potent greenhouse gas (GHG) which causes 25% of the anthropogenic warming experienced today; yet compared to CO2 it has received relatively little attention. Mitigation of methane emissions will play a vital role in achieving the Paris Agreement (see section 2.1) objective of holding global temperature increases to 2-1.5°C by mid-century. In the EU context, reducing methane emissions will contribute to meeting both the 2030 GHG reduction target of 55% compared to 1990 levels and the European Green Deal objective to reach climate neutrality by 2050. In this section, we explain what methane emissions are, why they matter and how they can be reduced.

What are methane emissions and why do they matter?

Methane is the second most important greenhouse gas after carbon dioxide (CO2). Compared to CO2, methane remains in the atmosphere for a shorter time (around 10-12 years) but it is a much more potent greenhouse gas as it attracts more heat per unit of mass than CO2.

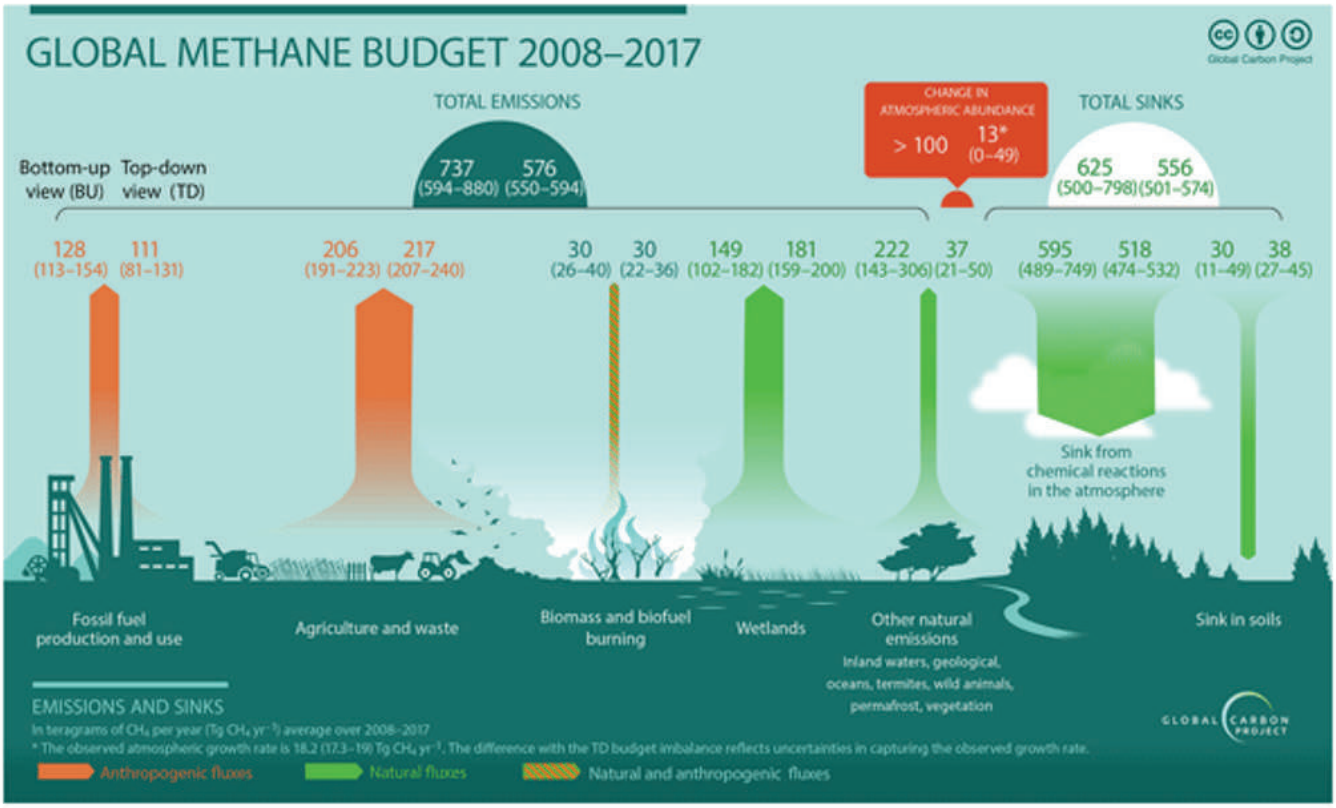
One way to compare the environmental impacts of the two gases is to use their global warming potential (GWP) to measure the heat absorbed by 1 tonne of methane over a given period of time compared to the emission of 1 tonne of CO2. Therefore, the GWP of CO2 is always 1, while the GWP of methane is calculated as 84 in a 20-year perspective and 28 in a 100-year perspective (IPCC, 2014).

Seeing the high heat-trapping potential of the gas, abatement of methane emissions would have an immediate effect on climate. Hence, reducing methane emissions is important to keep the Paris Agreement 1.5°C target within reach. An emissions decrease would also benefit air quality, as methane contributes to the formation of ground-level ozone, an air pollutant.[70]

The Global Methane Budget (Figure 15) provides an estimate of atmospheric sources and sinks of methane in the period 2008-2017 (Saunois et al., 2020). While the net change is well understood (13 Mt), there is more uncertainty regarding individual sources and sinks.

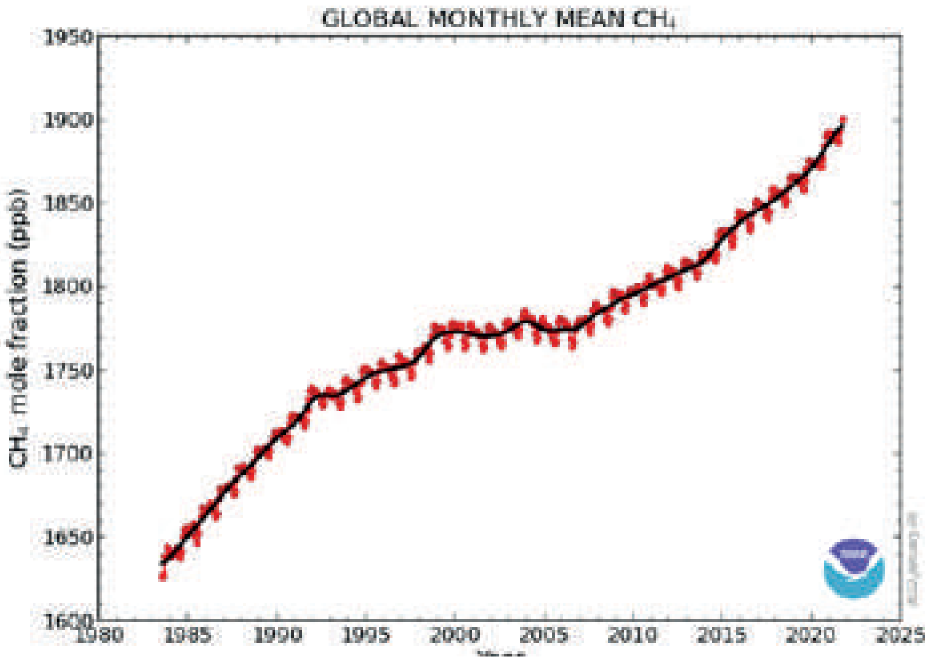
70 See <https://www.ccacoalition.org/en/slcps/methane> (accessed 04/02/2022).

Figure 15: Global Methane Budget. Source: Saunois et al., 2020



The concentration of methane in the atmosphere is increasing and is approximately 2.6 higher than pre-industrial levels (i.e., around year 1750). Methane concentration in the atmosphere surpassed 1900 ppb in 2021 (Figure 16) and the increase is driven by agriculture and fossil fuel use.

Figure 16: Trends in atmospheric methane. Ed Dlugokencky, NOAA/GML (gml.noaa.gov/ccgg/trends_ch4/)



What are the main sources of methane emissions?

The Global Methane Budget shows that annual global methane emissions are around 737-576 million tonnes (Mt), the majority of which (nearly 60%) is the result of human activity (Saunois et al, 2020). These emissions originate mostly in the agriculture (40%), energy (35%) and waste sectors (20%) (UNEP and CCAC, 2021).

Agriculture is responsible for contributing the largest amount of human activity-related emissions, both globally and at the EU level. Farm-related emissions primarily come from enteric fermentation (i.e., fermentation within the digestive systems of animals), manure management and rice cultivation. The energy sector follows closely. Methane is mainly emitted during the extraction, transport, distribution and use of fossil fuels (oil, gas and coal). Finally, in the waste sector, landfills (organic waste, landfill gas) and to a lesser degree waste water treatment are the major sources of emissions.

What is the role of methane emissions in the oil and gas sector?

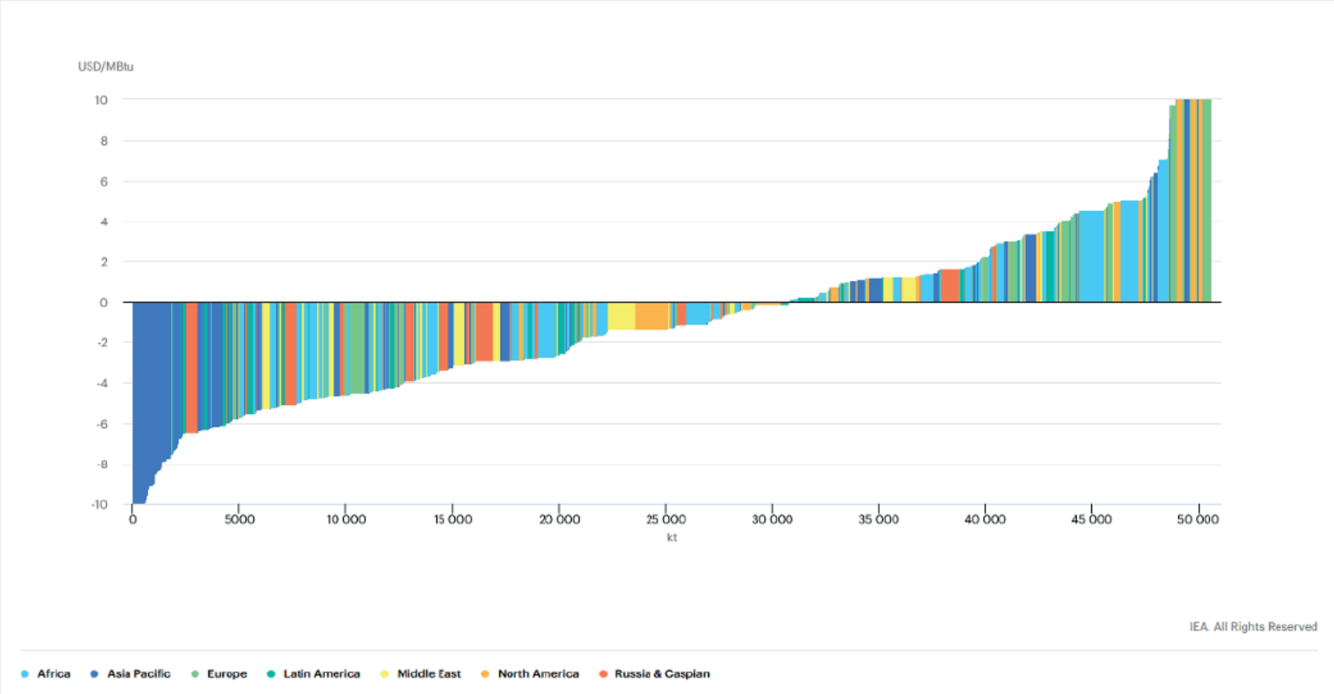
As was mentioned above, energy-related methane emissions – although lower than those from agriculture – are considerable in size. Specifically, the oil and gas sector is the biggest emitter of methane in the energy sector, accounting for 63% of total methane emissions from fossil fuels (coal mining accounts for 33%). Other industries (metals, chemicals), fossil fuel fires (e.g., Kuwait oil and gas fires) and transport constitute the remaining 40%) (Saunois et al, 2020).

There are three types of methane emissions from the oil and gas sector – fugitive, venting and flaring emissions – which pose different challenges in terms of measurement and abatement. Fugitive emissions are unintentional releases of methane, e.g. resulting from wear and tear in instruments. Since it is difficult to predict when and where they can happen, operators carry out regular inspections at their facilities to detect and fix leaks. Venting is an intentional release of methane, e.g. for safety reasons. In principle, we know when, where and how much is emitted but in some cases the equipment vents more than it is supposed to. In order to reduce venting emissions, operators can replace high-bleeding pneumatic devices with low-bleed pneumatic devices, install new devices such as vapour recovery units or flare the excess methane instead. In some cases (e.g., lack of offtake infrastructure) methane is combusted in flares and transformed into CO2. But in many cases not all methane is burnt and some of it is released in a methane slip as unburnt gas.

The size of the phenomenon begs the question of what we can do about it. For one thing, a large part of fossil fuel emissions can be reduced cost-effectively with the use of existing abatement technologies (IEA, 2021a). Moreover, unlike CO2, methane has a commercial value in itself as it is the main component of natural gas so efforts to capture methane can often be monetised as is shown Figure 17.[71] In the decades to come – and even in strong decarbonisation scenarios, such as the IEA's Sustainable Development Scenario – natural gas is expected to continue to play a significant role in the energy system as a 'transition fuel.' This role that gas will play in the transition to a carbon-neutral energy system is heavily dependent on industry's ability to reduce methane emissions.

71 IEA-estimated methane emissions abatement potential by country: <https://www.iea.org/articles/methane-tracker-database> (accessed 04/02/2022).

Figure 17: Marginal abatement cost curve for oil- and gas-related methane emissions by region at higher natural gas prices. Source: IEA, 2021



In fact, unabated methane emissions have the potential to question the environmental benefits of switching from oil and coal to natural gas or blue hydrogen.

According to the recently published EU Hydrogen Strategy (European Commission, 2020a), even in future low-carbon energy systems in which fossil gas will be replaced with renewable and low-carbon gases (biogas, biomethane and blue hydrogen), the issue of methane emissions is likely to persist.

What measures is the EU oil and gas sector taking to reduce methane emissions?

Currently, most actions to reduce methane emissions in the EU oil and gas sectors are voluntary. Here we cover three important industry initiatives.

First, a group of companies led by Gas Infrastructure Europe (GIE) and Marcogaz have compiled a report investigating potential ways in which the industry can contribute to reducing methane emissions (GIE and Marcogaz, 2019). This publication constituting a first-of-a-kind summary of industry initiatives to tackle methane emissions was presented and discussed at the Madrid Gas Regulatory Forum in 2019.[72]

Second, a group of companies are developing an Oil and Gas Methane Partnership (OGMP) 2.0 Reporting Framework (UNEP et al., 2020). The companies participating in this initiative will voluntarily report emissions from their facilities annually using a standardised methodology focused on emissions measurement. The aggregated data will be made publicly available.

Third, the Methane Guiding Principles initiative is organising training to raise awareness of the issue of methane emissions among oil and gas companies, and it is sharing best practices and advocating policies and regulations to address methane emissions.[73]

72 The 32nd European Gas Regulatory Forum. 5-6 June 2019. Madrid, Spain.

73 See https://methaneguidingprinciples.org/ (accessed 04/02/2022).

What is the Global Methane Pledge?

This is a joint EU-US initiative with a collective aim to reduce man-made methane emissions by at least 30% compared to 2020 levels by 2030. The Pledge was launched on the margins of the COP26 climate negotiations in Glasgow in 2021. Over 100 countries supporting this initiative also committed to improve the methane quantification methodologies used in their inventories, especially from high emission sources. Together they account for nearly half of all anthropogenic methane emissions.

Although the Pledge was not a part of the negotiation mandate at COP26, this initiative together with an IPCC report earlier that year helped to focus attention on methane and its short-term impact on climate (IPCC, 2021). However, the effectiveness of this initiative is undermined by the absence of some of the major methane producing countries (Australia, China, India and Russia) and of a formal mechanism to track progress towards meeting the Global Methane Pledge objective.

What is the EU framework to reduce methane emissions?

The EU methane strategy and a proposal for an EU methane regulation are currently the most important elements in the EU policy framework on methane emissions. On 14 October 2020, i.e. 24 years after the publication of the first EU Methane strategy in 1996, the European Commission (2020b) presented an EU strategy to reduce methane emissions. The 1996 strategy helped to reduce methane emissions in the EU but was not a complete success (Olczak and Piebalgs, 2019a).

The 2020 strategy covers all sources of emissions – agriculture, waste and energy (including emissions related to biogas and biomethane production and use) – and sets an objective to reduce EU methane emissions by 35-37% compared to 2005 levels by 2030. The strategy combines cross-sector and sector-specific actions and sets a clear priority – robust methane emissions measurement and reporting – with roles for corporate reporting (based on voluntary initiatives such as the OGMP 2.0), satellite observations (Copernicus Programme) and the establishment of an International Methane Emissions Observatory.

The strategy specifies actions targeting emissions from the agriculture and waste sectors, which currently account for 53% and 26% of all man-made methane emissions in the EU. The actions include: 1) better emissions measurement and quantification (i.e., analysis of life-cycle methane emissions metrics in agriculture and enhanced measurement, reporting and verification (MRV) in the waste sector), 2) mitigation (e.g., by providing Member States with assistance to tackle unlawful practices and technical assistance to address substandard landfills and biodegradable waste treatment, and reviewing the Landfill Directive in 2024); 3) research activities financed through the Horizon Europe 2021-2024 programme.

Another important factor is the external dimension of the strategy. As it is one of the major natural gas importers in the world, the EU has both responsibility and leverage to advocate for reducing energy-related methane emissions globally. According to some estimates, methane emissions from imported natural gas are 3-8 times higher than those within the EU borders (Carbon Limits, 2020). The strategy suggests the following actions: 1) creating an International Methane Emissions Observatory (IMEO) tasked with developing a Methane Supply Index (an index demonstrating the methane footprint of imported gas); 2) satellite data sharing on super-emitters (Olczak et al, 2020); 3) cooperation with energy buyers and suppliers (North America, China, South Korea, Japan); and 4) cooperation through multilateral fora and institutions such as the World Bank, the United Nations Environment Programme (UNEP), the International Energy Agency (IEA) and the Climate and Clean Air Coalition (CCAC).

On 15 December 2021 the European Commission presented a proposal for a regulation on methane emissions reduction in the energy sector as part of the Hydrogen and Gas Decarbonisation Market Package (European Commission, 2021). The proposal introduces new requirements in terms of MRV of emissions and abatement measures including regular leak detection and repair (LDAR) and restrictions on venting and flaring. The regulation also puts forward rules to increase transparency on methane emissions associated with fossil fuel imports and to create a publicly available methane transparency database (Art. 28) and a methane emitters global monitoring tool (Art. 29).

The proposal targets emissions arising along the entire value chain (with the exceptions of end-use and biogas production), including monitoring obligations regarding emissions from inactive wells and closed and abandoned coal mines. The proposal will now be addressed by the European Parliament (ENVI Committee) and the Council through the ordinary legislative procedure. It is likely that the final version of the regulation may be adopted in mid-2023.

What are other regions doing to reduce methane emissions?

Over the course of the last few years, more and more jurisdictions have been adopting methane policies and setting methane reduction targets. North America has been one of the most dynamic regions in this respect.

In 2016, the US, Canada and Mexico set a joint objective to reduce methane emissions in the oil and gas sector by 40-45% from 2012 levels by 2025, and all three have already adopted methane-specific regulations to achieve this target (Olczak and Piebalgs, 2019b). It should be noted that the US federal regulations on methane adopted in 2016 were rolled back in 2020, yet methane emissions in the oil and gas sector are regulated in several US states, including Colorado, Pennsylvania and North Dakota.

The major EU natural gas suppliers – Norway and Russia – use economic instruments to reduce methane emissions in the oil and gas sector. In Norway, each tonne of methane released in the air during oil and gas production is taxed, while in Russia an environmental charge on methane release is applied. The Canadian province of Quebec and the state of California include methane emissions in their cap-and-trade programmes (IEA, 2021b).

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2.5 Renewable energy policy

Athir Nouicer and Daniele Stampatori

In this section, we first give an overview of what renewable energy is and explore why the EU cares about it. We then look at how renewable energy is used in different sectors. Finally, we describe the most relevant strategies and legislation to mainstream renewable energy in the EU.

What is renewable energy?

According to Directive (EU) 2018/2001 (Art. 2) (EP, 2018), solar thermal and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogas are renewable energy.[74] It is important to note that renewable and non-greenhouse gas (GHG) emitting energy sources are not synonyms according to this definition. For example, nuclear power plants do not pollute the air or emit GHG when producing electricity, but the material most often used to generate nuclear energy, uranium, is generally a non-renewable resource and as a consequence nuclear energy is not considered renewable. A proposal to amend the aforementioned Directive (EC, 2021a), which we will discuss more extensively below, includes new definitions of RES technologies and some modifications of the existing ones. One of the main updates is a 'generalisation' of the definition of renewable fuels of non-biological origin (which replaces the previous renewable liquid and gaseous transport fuels of non-biological origin).

The (increasing) penetration of renewable energy sources (RES) in an energy system is typically measured using metrics such as the RES share in primary energy demand or in gross final consumption of energy.[75] Regarding the power system, other metrics such as electricity production (in GWh) and installed capacity (in GW) are typically used.[76]

Why does the EU care about renewable energy?

Several reasons justify the EU's interest in promoting RES. Among them, there is the aim to achieve a more environmentally sustainable energy system. This is seen in how RES contribute to reducing GHG emissions and local pollutants and consequently to climate change mitigation and improvement of air quality.

Furthermore, penetration of RES in the energy mix can also help with other traditional aims of EU energy policy, such as competitive energy prices and reducing reliance on fossil fuel imports. Moreover, promoting renewable energy can create new opportunities for local employment, help ensure the leadership of EU manufacturers in green technologies and contribute to overall economic growth. The benefits and risks related to decarbonisation of the energy sector are also taken into account in a Communication from the EC that updates the 2020 New Industrial Strategy (EC, 2021b). Among other things, the document aims to promote investment in renewables and increase the ambitions of Member States but without overlooking

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74 A discussion of what renewable gas is can be found in the March 2018 FSR Topic of the Month, available at https://fsr.eui.eu/what-is-renewable-gas/ (accessed 31 March 2021). A more recent discussion on renewable gases is provided in Conti (2020).

75 Gross final consumption of energy is defined in Article 2 of Directive 2009/28/EC as the "energy commodities delivered for energy purposes to industry, transport, households, services including public services, agriculture, forestry and fisheries, including the consumption of electricity and heat by the energy branch for electricity and heat production and including losses of electricity and heat in distribution and transmission."

76 Data and statistics on the penetration of RES in the European energy mix can be found in the EU energy statistical pocketbook, which is published every year by the European Commission and is available at https://ec.europa.eu/energy/data-analysis/energy-statistical-pocketbook_en (accessed 31 March 2021).

dependency on foreign countries for raw materials that are strategic in new technologies. The EU's commitment to renewable energy has long been established and is attested by Art. 194 of the Treaty on the Functioning of the European Union (TFEU), which states that the Union policy on energy shall promote the development of new and renewable forms of energy in a spirit of solidarity between the Member States. However, the same article specifies that the promotion of RES shall be without prejudice to the right of Member States to determine the conditions for exploiting their energy resources, their choices between different energy sources and the general structure of their energy supply (see section 1.2).

How is renewable energy used in different sectors?

The use of RES has experienced rapid growth in recent years in the EU, driven by falling costs and policy support. Through appropriate technologies, RES can be used in different sectors, mainly electricity, transport and heating and cooling. For the time being, RES penetration in the electricity sector has attracted most attention due to the availability of relatively more mature technologies like solar photovoltaics (PV) and onshore wind.

However, electricity currently represents only a fifth of European final energy consumption. The transport sector and the heating and cooling sector represent relatively larger parts of final energy consumption, about 28% and 50% respectively.[77] As a result, they cannot be ignored if one aims to achieve significant decarbonisation of the energy system. Even so, efforts to increase the use of RES in these sectors have so far obtained limited results. Therefore, to reach decarbonisation objectives, electrification of the transport and heating and cooling sectors should go hand in hand with mainstreaming the use of RES in these sectors.

RES in the electricity sector

In the electricity sector, RES are used to produce electricity with negligible or zero direct GHG emissions. The most relevant sources in this regard are bioenergy, hydro, solar and wind energy. Their penetration in the electricity system depends on several factors, such as the availability of primary energy resources, their cost-effectiveness vis-à-vis other energy sources and the presence of other environmental and power system constraints. Hydropower and bioenergy are considered flexible as their inputs (water and biomass) can be stored cost-effectively. In contrast, wind and solar energy are known as Variable Renewable Energy (VRE) or non-dispatchable or intermittent renewables due to their intermittent availability, which makes electricity generation not fully controllable. Therefore, a massive uptake of VRE challenges the traditional approach to electricity system operation, based on the idea that supply follows the load.

RES in the transport sector

In the transport sector, the penetration of RES is driven by the switch to renewable transport fuels and by the uptake of electric mobility (electrification), which is obviously conditional on the electricity being generated from renewable sources. Renewable transport fuels can be biofuels, power-to-fuels (e.g., hydrogen and synthetic liquid fuels) or biogas. Biofuels are frequently divided into three categories or generations: first-generation biofuels are directly produced from food crops; second-generation biofuels are derived from a set of different feedstocks and do not generally involve food crops; finally, third-generation biofuels – still at an early development stage – are obtained from algae and other such micro-organisms.

77 See Eurostat energy statistics, available at https://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_statistics_-_an_overview#Final_energy_consumption (accessed 4 March 2022) and https://energy.ec.europa.eu/topics/energy-efficiency/heating-and-cooling_en#:~:text=Heating%20and%20cooling%20plays%20a,of%20both%20transport%20and%20electricity.

RES in the heating and cooling sector

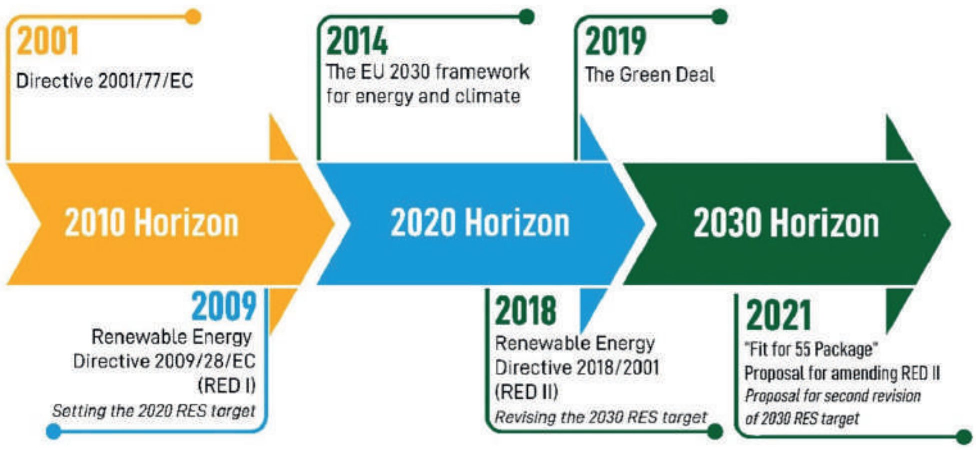
In the heating and cooling sector, RES are used in various forms. Traditionally, biomass was utilised as fuel for heating spaces and water and cooking. More recently, heat pumps are being installed to provide heating and cooling with the use of ambient or geothermal energy and electricity, possibly derived from RES too. However, most of the heating and cooling needs in the EU are still satisfied with the use of fossil fuels. Consequently, the European Commission has recognised decarbonisation of the heating and cooling sector as a priority in the years to come. Further electrification, development of highly efficient cogeneration and district heating, and uptake of power-to-gas are considered among the main pathways to achieve decarbonisation of the sector.

What are the most relevant strategies and legislation to mainstream renewable energy in the EU?

The promotion of RES is a long-term EU strategy, and several legislative initiatives have been taken over the years to achieve it. Among them are the establishment of an Emission Trading Scheme (ETS) (see section 2.2), the adoption of targets to limit GHG emissions from sectors not covered by the ETS, the introduction of an electricity market design that better reflects the specificities of RES-based generation, the deployment of measures supporting energy efficiency and the definition of long-term Energy and Climate Plans[78] at the national level.

In addition to these policies, the EU has adopted a series of specific measures and targets for RES penetration in the energy mix. These measures and targets, which reflect the conditions in the various countries and end-use sectors, have evolved over time and aim to provide clear signals to Member States, investors, firms and energy consumers. They can be grouped according to the time horizon they refer to: 2010, 2020, 2030 (Figure 18).

Figure 18: Overview of EU policies and legislation related to renewable energy



78 For a brief overview of the NECPs, see for example a FSR blog post available at https://fsr.eui.eu/national-energy-and-climate-plans-necps/ (accessed 31 March 2021).

Horizon 2010

After some early and limited attempts to promote 'alternative energy sources' in the 1970s and 1980s, the EU started to draw up a common policy on RES in the second half of the 1990s. In 1997, the European Commission issued a 'White Paper for a Community Strategy and Action Plan' (EC, 1997), which was later followed by adoption of Directive 2001/77/EC (EP and Council, 2001). The Directive established two targets for the use of RES in the energy sector: by 2010, 12% of gross domestic energy consumption had to be satisfied with RES; for electricity, the aim was set at 22.1%. Each Member State received an indicative target, which, combined with those of all the other Member States, would enable the EU to reach the overall Community target. Although national targets were not binding, Member States were expected to provide detailed justification if they had failed to meet them. With the 10 new Member States joining the Union in 2004, the 22.1% target initially set for electricity was reduced to 21%.

Horizon 2020

Disappointment with the results of earlier policies, the increasing threat posed by climate change and the urgency to ensure security of supply led to the adoption of the Renewable Energy Directive 2009/28/EC (RED I; EP and Council, 2009). The Directive was part of the 2009 EU Climate and Energy Package, also known as the '2020 Package,' and set an EU-wide target of a RES share of 20% of gross final energy consumption by 2020. This target was then allocated to individual Member States by means of binding and differentiated national targets. The Directive also set a 10% target for the total share of RES in the transport sector (this target was identical for all Member States).

In the heating and cooling sector, RED I did not include extensive requirements. These were later introduced in Directive 2012/27/EU (EP and Council, 2012) on energy efficiency, which provided specific measures aiming at increasing the efficient use of cogeneration and district heating. Beyond setting targets for 2020, RED I is also important because it defined a set of policies that Member States had to implement to support the deployment of RES (e.g., direct support schemes, guarantees of origin, etc.). The Directive also foresaw mechanisms to ensure cooperation between the Member States and third countries, such as joint projects to enhance cross-border exchanges of renewable energy and to facilitate the achievement of national and European targets in a cost-effective manner.

Horizon 2030

Discussions on strategies for the post-2020 era began soon after the 2009 Conference of the Parties (COP) 15 in Copenhagen. Notably, in 2011 the European Commission published a roadmap to 2050[79] and later issued a green paper on an energy and climate framework for 2030 (see section 1.1). Building on the expected results of the 2020 Package but at the same time departing from some of its elements, the European Council adopted a clear set of goals and policy choices in October 2014 (Council, 2014). In particular, it was agreed that the EU should cover at least 27% of its final energy consumption with RES by 2030.

The political decisions taken in October 2014 were later turned into legislative proposals and subjected to the ordinary legislative procedure. As part of the Clean Energy Package, the Renewable Energy Directive (EU) 2018/2001 (RED II),[80] which was adopted after intense political negotiations, revised the 2030 climate and energy framework by moving the target for RES in 2030 upwards: 32% of final energy consumption instead of the initial 27%. In addition, Member States are obliged to define NECPs in which they explain

79 https://www.roadmap2050.eu.

80 A presentation of RED II and the novelties it contains vis-à-vis RED I can be found in Nouicer et al. (2020).

in detail how they plan to contribute to the common European targets and what measures they expect to put in place.

In July 2021, the Commission proposed a recast of the aforementioned RED II (EC, 2021) that aimed to enhance the 2030 targets in order to reach the long-term goal of net-zero GHG emissions by 2050. This proposal resulted in a first legal text, published in July 2021 in the 'Fit for 55' Package, setting a binding 40% share of final energy consumption to be covered by RES in 2030. The renewable share target is supported by a comprehensive framework of sub-targets that cover all sectors of the economy, such as transport, building and industry. In this respect, by 2023 Member States must coherently update their previously approved NECPs in order to reflect shifting EU climate objectives.

Negotiations with the Parliament and the Council are currently underway. The first, consistently with the REPowerEU plan, proposed to increase the 2030 target to 45%, while the second supports the initial proposal by the Commission (Council, 2022).

RES in the electricity sector

RES integration will be fostered by eliminating regulatory and administrative barriers to long-term renewable power purchase agreements, speeding up permit-granting, setting clear criteria for site selection and adequate spatial planning, guaranteeing third-party access to district heating, and forcing TSOs and DSOs to make available information on the share of RES and GHG content in the electricity they transport. In addition, each Member State will agree to establish at least one joint project with one or more other Member States to produce renewable energy. In particular, countries bordering a sea basin will cooperate to jointly define the amount of offshore renewable energy they plan to produce in the sea basin by 2050, with intermediate steps in 2030 and 2040. The RED II recast intertwines with the EU strategy on offshore renewable energy (EC, 2020), which aims to further foster the deployment of offshore renewable energy. More details are discussed in section 3.3.

Moreover, in the RED II recast, the Commission has reconsidered the role played by biomass as a sustainable primary energy source. In fact, an obligation to phase out support for electricity production from biomass from 2026 (with limited exceptions) has been proposed, while other proposed measures aim to reduce the risk of unnecessary market distortions resulting from RES support schemes and to prevent Member States from supporting the use of certain raw materials for energy production.

RES in the transport sector

Regarding the transport sector, the previous (RED II) minimum target of 14% renewable energy in final energy consumption has been maintained but new sub-targets have also been proposed in the RED II recast, namely decreasing the GHG intensity of transport fuels by 13% and reaching a minimum 2.2% share of advanced biofuels and a 2.6% share of renewable fuels of non-biological origin (i.e., mainly hydrogen). In this regard, the Directive encourages the use of advanced biofuels and biogas by limiting the amounts of first-generation biofuels that can be counted towards the target. Each Member State is to pass this obligation on to fuel suppliers which, however, have the possibility to exchange credits obtained from renewable production. The Council approach adopted in June 2022 offers to Member States the flexibility to choose between a 13% reduction in GHG intensity or a 29% RES share in the final consumption of energy in the transport sector by 2030.

RES in the heating and cooling sector

For the heating and cooling sector, each Member State is mandated to increase the RES share by 1.1% year on year in the period 2021-2030[81] and a new target of 49% of energy use in building coming from RES is fixed. The starting point is the RES share in the heating and cooling sector recorded in 2020. RED II published in 2018 includes provisions on increasing the efficiency of district heating and cooling. Furthermore, it allows consumers with non-efficient district heating and cooling systems to terminate or modify their contracts. In this respect, the new proposal to amend RED II emphasises provision of consumer access to information on energy performance and the share of RES in their district heating and cooling systems.

RES in the industry sector

According to the proposal in the Fit for 55 Package, Member States will endeavour to increase the share of renewable sources in the energy sources used for final energy and non-energy purposes in the industry sector with an indicative minimum annual increase of 1.1% by 2030. In this regard, the contribution of renewable fuels of non-biological origin used for final energy and non-energy purposes will be 50% by 2030.

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81 Annual average percentage points are calculated for the period 2021 to 2025 and 2026 to 2030, starting with the share of renewable energy in the heating and cooling sector in 2020.

2.6 Energy efficiency policy

Valerie Reif and Daniele Stampatori

In this article we first give an overview of what energy efficiency is and explore why the EU cares about it. We then look at areas in which energy efficiency measures are most relevant. Finally, we describe the most relevant strategies and legislation to mainstream energy efficiency in the EU.

What is energy efficiency?

According to Article 2 of the Energy Efficiency Directive 2012/27/EU, energy efficiency means "the ratio of output of performance, service, goods or energy, to input of energy." In simple words, energy efficiency means using less energy to perform the same task by eliminating energy waste.

Energy efficiency brings a variety of benefits. It helps reduce greenhouse gas emissions, demand for energy imports, dependence on suppliers of fossil fuels, lower the energy bills of individual households and cut costs at an economy-wide level. Improving energy efficiency is a no regret option and often the easiest and cheapest way to reduce the use of fossil fuels. Enormous opportunities for improvements in energy efficiency can be found in all sectors of the economy, from buildings to transport, industry and energy.

Why does the EU care about energy efficiency?

Saving energy has been a policy objective of the European institutions and EU Member States since the first oil crisis in 1973. When that crisis passed, however, so did a great deal of the effort to improve energy efficiency. Over time, a realisation emerged that it was possible to delink economic growth and energy consumption, which would allow an increase in Gross Domestic Product (GDP) without a commensurate increase in energy consumption. Different energy efficiency measures were passed by the Council in the 1970s and 1980s but they did not meet expectations.

In 1998, the Commission noted that "market barriers and falling prices … have limited the scope and extent to which delinking has occurred, especially regarding the final or end-use of energy" and that many of the market barriers to the rational use of energy from the 1970s had persisted to that day (EC, 1998). This was the beginning of more than two decades of sustained effort to design common co-ordinated policies and measures at both the EU and Member State levels to increase energy efficiency.

Today, energy efficiency is recognised as a guiding principle in EU energy policy and a prerequisite for reaching the Green Deal objectives. It allows ensuring cost-effective achievement of the EU's current and future climate ambitions and contributes to other EU policy objectives. Moreover, using energy more efficiently and thereby consuming less can contribute to lowering energy bills and making energy more affordable for all consumers, help protect the environment, mitigate climate change, enhance competitiveness and improve energy security by reducing the EU's reliance on external suppliers of fossil fuels.

This requires the EU and its Member States to improve energy efficiency along the full energy value chain from production to final consumption. It also means that the benefits of energy savings must outweigh the costs, for example those that result from renovations. EU measures therefore focus on sectors with the greatest savings potentials (e.g., heating and cooling, industry, energy services) and in which a harmonised approach across Member States is necessary (e.g., energy labelling).

In which areas are energy efficiency measures most relevant?

In the following, we briefly describe the relevance of energy efficiency measures in the areas of buildings, heating and cooling, cogeneration, energy labelling and ecodesign.

Energy efficient buildings

Today, buildings are responsible for about 40% of the EU's total energy consumption and for 36% of its greenhouse gas emissions from energy. Buildings are therefore the single largest energy consumer in Europe. At present, about 35% of the EU's buildings are over 50 years old and almost 75% of the building stock is energy inefficient. The building sector is therefore crucial in achieving the EU's energy and climate goals. Better and more energy efficient buildings can also help to improve the quality of life of EU citizens and bring additional benefits for the economy and society.

Heating and cooling

Heating and cooling in buildings and industry accounts for half the EU's energy consumption, making it the biggest energy end-use sector, ahead of both transport and electricity. While cooling still accounts for a fairly small share of total final energy use, demand from both businesses and households usually increases during the summer months and is expected to generally increase due to climate change and rising temperatures. In 2020, renewable energy accounted for only 23.1% of total energy use for heating and cooling in the EU (Eurostat, 2022). Reducing energy consumption in the heating and cooling sector and cutting its use of fossil fuels is therefore important to reach the EU climate goals.

Cogeneration of heat and power

Cogeneration is the simultaneous generation in one process of thermal energy and electrical or mechanical energy. In a regular power plant, heat is viewed as a by-product of electricity generation and it is released into the environment, for example through cooling towers or cooling water. In a combined heat and power (cogeneration) plant, the heat is recovered for use in homes, businesses, and industry. Cogeneration plants can achieve much higher energy efficiency levels of up to 90%. Note that there are also trigeneration plants, or combined cooling, heat and power (CCHP) plants, which produce cooling for air conditioning as well as heat and electricity.

Energy labelling and ecodesign

The EU has set up a legislative framework for ecodesign and energy labelling to help improve the energy efficiency of products on the EU market. Ecodesign sets common EU-wide minimum standards[82] to eliminate the least performing products from the market. Energy labels provide an indication of the energy efficiency and other key features of products that aim to help consumers to reduce their household energy bills and contribute to overall EU climate efforts. The EU estimates that energy savings resulting from the implementation of ecodesign and energy labelling will amount to up to 230 Mtoe by 2030.[83]

Several regulations on ecodesign and energy labelling were adopted in 2019 and were subsequently mod-

82 Specific harmonised standards are the objects of other directives and regulations specific to each kind of technology. For examples, ecodesign requirements for air conditioners are regulated by Regulation (EU) No. 206/2012, which specifies, among other things, COP and EER values for minimum energy efficiency requirements and the maximum power consumption of devices in standby mode. See also https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/ecodesign_en (accessed 2 March 2022).

83 See https://ec.europa.eu/info/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/energy-label-and-ecodesign/about_en.

ified by so-called 'omnibus regulations' in 2021: Regulation (EU) 2021/341 on ecodesign and Regulation (EU) 2021/340 on energy labelling. Note also that since 1 January 2019 suppliers have been mandated to register appliances which require an energy label in the European Product Database for Energy Labelling (EPREL) before selling them in the European market. On 1 March 2021, a new A to G scale started to apply for fridges, dishwashers, washing machines and televisions in order to guide consumers towards choosing efficient products. In fact, the energy efficiency of products has continued to improve, leaving lower classes virtually empty. However, at the same time surveys show that differences between A+ and A+++ are unclear to consumers. In addition to the four product groups mentioned above, the energy labels for light sources such as light bulbs were rescaled on 1 September 2021 and other product groups will follow. Each new energy label is designed so that the A class is initially empty in order to leave room for innovation and development of new, more energy efficient models.

What are the most relevant strategies and legislation to mainstream energy efficiency in the EU?

This subsection provides an overview of the most relevant strategies and legislation to mainstream energy efficiency in the EU with a view to the 2010, 2020, 2030 and 2050 horizons. Note that it is not the aim to be exhaustive due to the broad range of areas that are relevant to energy efficiency measures.

Horizon 2010

In 1998, the Commission published a Communication on energy efficiency and the rational use of energy (EC, 1998). It recognised an urgent need to strengthen both Union and Member State commitments to promote energy efficiency more actively, especially but not only in the light of the Kyoto agreement to reduce CO2 emissions (see section 2.1). The available potential for energy savings between 1998 and 2010 in all sectors combined (industry, transport, domestic and tertiary) was estimated to be 18% of final annual energy consumption in 1995.

The Communication was followed by an Action Plan to improve energy efficiency two years later (EC, 2000). The initiatives planned were, among others, related to transport efficiency, an energy efficiency labelling scheme, minimum efficiency standards for equipment manufacturers, energy services offered by utilities and SMEs, and buildings. The action plan also highlighted the potential for the use of cogeneration as a way to save energy, avoid network losses and reduce emissions. It included an aim to double the use of combined heat and power (CHP) to 18% of EU electricity production by 2010. This later led to the adoption of Directive 2004/8/EC on the promotion of cogeneration, under which EU countries were required to publish national reports on cogeneration every four years.

Under the Energy Services Directive 2006/32/EC, Member States were for the first time required to prepare energy efficiency action plans, in which they described how they planned to achieve a 9% (or higher) energy efficiency improvement by 2016.

Horizon 2020

In the 2000s, the EU was facing significant energy challenges resulting from increased import dependence, concerns over available supplies of fossil fuels worldwide and the effects of climate change. Moreover, the EU was still wasting considerable amounts of energy due to inefficiencies.

To boost the energy performance of buildings, the Energy Performance of Buildings Directive 2010/31/EU ('2010 EPBD') was introduced. Together with the later Energy Efficiency Directive 2012/27/EU, it promoted policies that aimed to achieve an energy efficient decarbonised building stock by 2050, create a stable environment for investment decisions and enable consumers and businesses to make more informed choices to save energy and money. The 2010 EPBD introduced a definition of 'nearly zero energy buildings (nZEBs)' and required all new buildings in the EU to meet the standard by the end of 2020, and all new public buildings already by the end of 2018. It also required energy performance certificates (EPCs) based on a common and easily identifiable A-G scale to be used when advertising, selling and renting buildings.

As part of the 2009 EU Climate and Energy Package (also '2020 Package'), the Energy Efficiency Directive 2012/27/EU ('2012 EED') set a target of improving energy efficiency by 20% by 2020. In other words, this was a commitment to a 20% reduction in energy consumption compared to a business-as-usual scenario. The main features of the 2012 EED are still relevant today and include (EP, 2021):

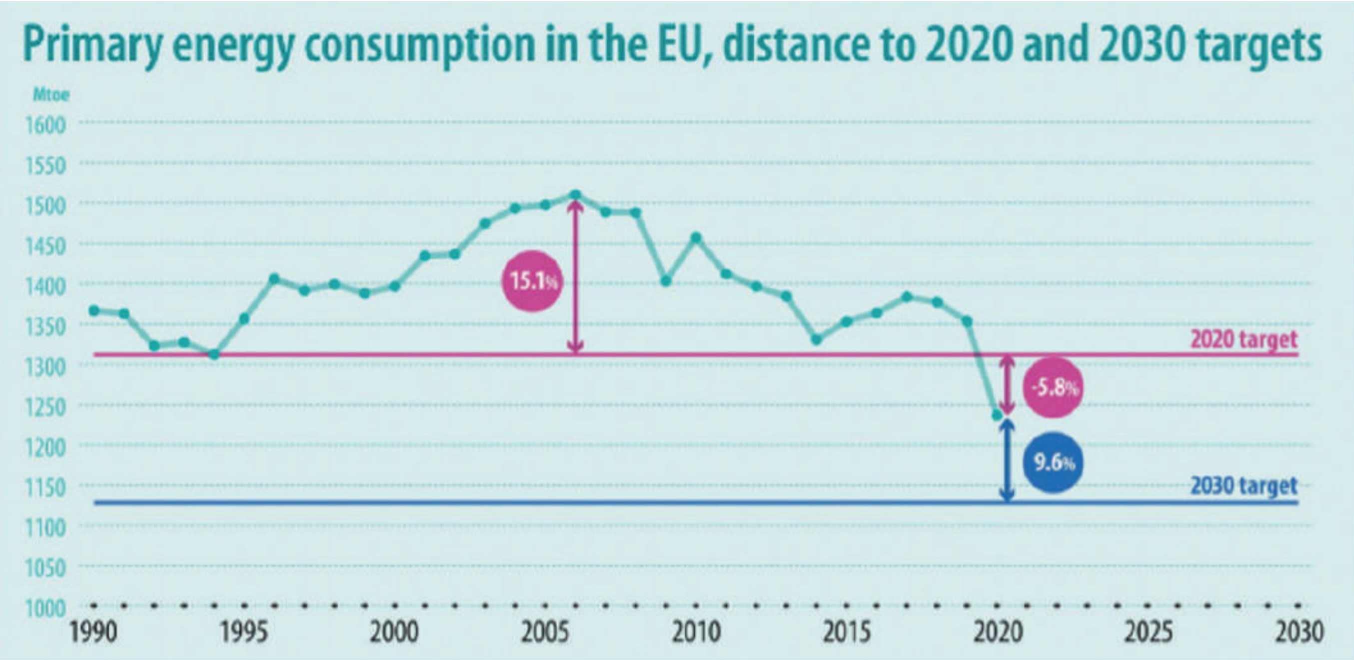
- setting upper limits on EU final and primary energy consumption;
- requiring all Member States to use energy more efficiently at all stages in the energy chain, including generation, transmission, distribution and end-use consumption;
- seeking to deliver annual energy savings through obligations schemes or alternative measures;
- prioritising energy efficiency renovation of public sector buildings;
- introducing mandatory energy efficiency certificates for the sale or rental of buildings;
- promoting energy efficient products and services; and
- upholding energy consumer rights, especially in terms of accurate and frequent consumption data.

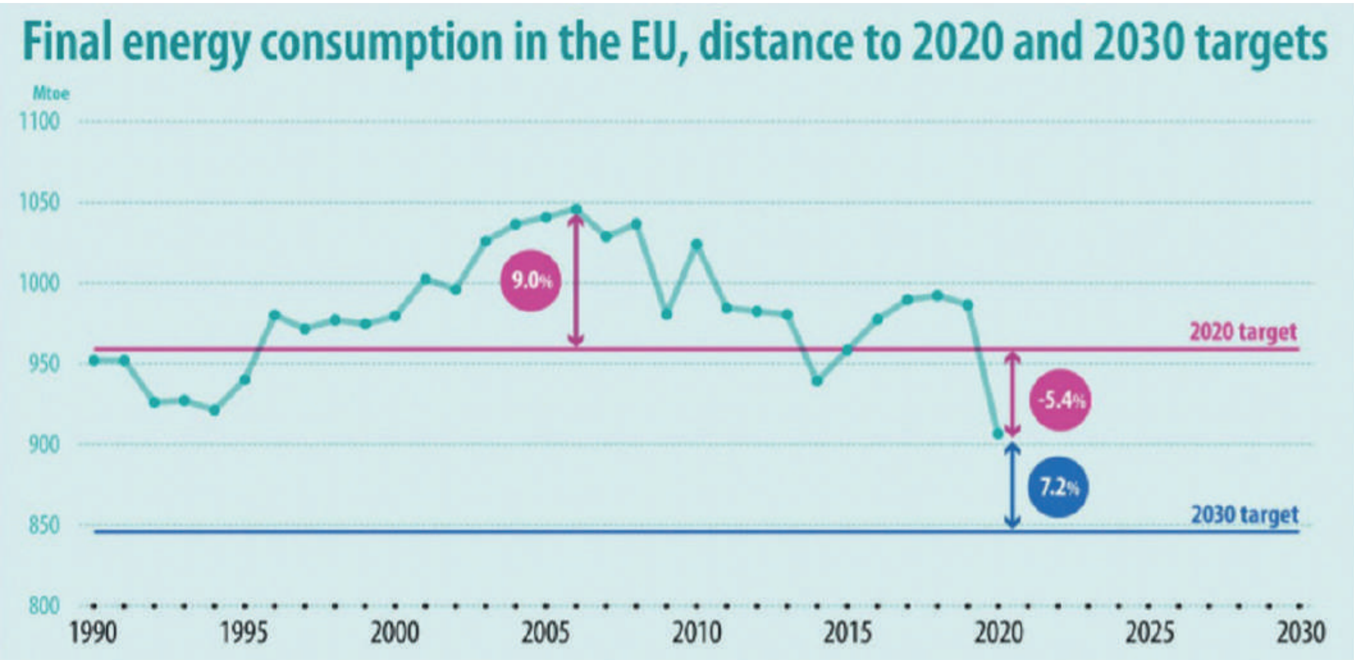
The latest available data show that the effects of the Covid-19 pandemic contributed to the achievement of the 2020 EU energy efficiency target.[84] In fact, the restrictions imposed on citizens' mobility led to the EU outperforming its targets by 5.8% and 5.4% in terms of primary and final energy consumption respectively. However, the termination of those restrictions is likely to lead to a rebound in energy consumption. Moreover, consumption level in 2020 is still 9.6% away from the 2030 target for primary energy consumption and 7.2% for final energy consumption (Figure 19).[85] In addition, the update of the 2030 GHG target as part of the European Climate Law means that Member States will need to make more effort to curb energy consumption if the EU is to meet the 2030 target and the overall goal of carbon neutrality by 2050.

84 For more details look at: https://www.eea.europa.eu/ims/primary-and-final-energy-consumption.

85 The European Environmental Agency made an assessment of progress at the individual Member State level, which is available at https://www.eea.europa.eu/ims/primary-and-final-energy-consumption-1 (accessed 4 March 2022).

Figure 19: Distance to 2020 and 2030 targets for primary and final energy consumption (Eurostat, 2021).[86]





86 Note that primary energy consumption typically fluctuates over the years due to economic developments, structural changes in industry, the implementation of energy efficiency measures and specific weather situations. Diverging trends between primary and final energy consumption are often the result of fundamental changes in the energy system such as the switch (and therefore the increase in efficiency) between electricity generation from fossil fuels and nuclear power to wind and solar.

Horizon 2030 and Horizon 2050

A first step towards 2030 was made by the Clean Energy Package, which included three legislative acts that are relevant to energy efficiency:

- Energy Efficiency Directive (EU) 2018/2002;
- Energy Performance in Buildings Directive (EU) 2018/844;
- Governance Regulation (EU) 2018/1999.

A revision of the first two Directives is proposed in the Fit for 55 Package to align them with the updated 2030 GHG target. In the following, we first describe the changes brought by the Clean Energy Package and then list the proposed changes under the Fit for 55 Package.

Clean Energy Package

The Energy Efficiency Directive (EU) 2018/2002 (2018 EED) increased the 2030 energy efficiency target to at least 32.5% compared to a business-as-usual scenario. As had already been the case under the previous directive, it did not impose binding national targets. Instead, the targets were to be met collectively across the EU.

An enhanced integrated framework to assess and enforce Member State progress towards the 2030 targets was agreed in the form of Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action. The regulation requires each Member State to establish a 10-year National Energy and Climate Plan (NECP) for the period from 2021 to 2030 outlining how it intends to contribute to the 2030 targets for energy efficiency, renewable energy and GHG emissions. The measures laid down in these plans include:

- Long-term building renovation strategies and targets;
- Roll-out of infrastructure for electro-mobility;
- Supporting and pushing SMEs to introduce energy management systems;
- More efficient management and use of commercial and industrial waste heat;
- Educational and awareness-raising initiatives (also involving the public sector);
- Support for local energy communities to implement energy efficiency measures.

The European Commission's assessment of the final NECP's showed that the cumulative energy efficiency ambition would amount to a reduction of 29.7% for primary energy consumption and 29.4% for final energy consumption by 2030. This revealed a gap compared to the EU's 2030 target of at least 32.5%, which is 2.8 percentage points for primary energy consumption and 3.1 percentage points for final energy consumption (EC, 2020b). To address the gap, Member States were encouraged to speed up building renovation, which would also provide recovery stimulus at the levels of local economies and small and medium enterprises.

The Energy Performance of Buildings Directive (EU) 2018/844 (2018 EPBD) updated its predecessor, aiming to send a strong political signal of the EU's commitment to modernise the buildings sector in the light of technological improvements and to increase building renovations. It included updated measures related to the national long-term renovation strategies that had previously been covered under the 2012

EED. In these, each Member State was required to provide a roadmap with measures, progress indicators and indicative interim milestones towards the 2050 horizon to meet the Union's climate targets and facilitate the cost-effective transformation of existing buildings into nearly zero-energy buildings.

The 2018 EPBD also set rules on energy performance certificates, ICT use, smart automation and control technologies in buildings, infrastructure for electric vehicle recharging, national financial measures to support energy efficiency and a 'smart readiness indicator' to rate the capacity of buildings to adapt to the needs of the occupant, optimise operation and interact with the grid.

Fit for 55 Package

To be in line with the updated 2030 GHG emission target set in the European Climate Law, the European Commission proposed an update to the 2030 energy efficiency target as part of the Fit for 55 Package.

The proposal for a recast of the Energy Efficiency Directive (EC, 2021a) ('proposed recast EED') foresees a new energy efficiency target that must collectively ensure a further reduction in energy consumption of at least 9% by 2030 compared to projections made in the EU's 2020 reference scenario (EC, 2021e). This is a new method to calculate EU energy efficiency that essentially translates into increased targets for reducing EU primary (-39%) and final (-36%) energy consumption by 2030.

As in previous versions of the Directive, the target would be binding at the European level with only indicative national contributions. In some cases, the European Commission could require Member States to adopt further energy efficiency measures if their actions are evaluated as not in line with their indicated trajectories.

The proposed recast EED gives special attention to the 'energy efficiency first' principle, which is that energy efficiency (including energy saving and demand response initiatives) should be a priority in any policy or investment decisions regarding the energy system development. Moreover, whenever efficiency improvements prove to be more cost-effective or valuable than investing in supply-side infrastructure such improvements should be prioritised. The principle should ensure that energy production is only related to real needs, investments in stranded assets are avoided and demand for energy is reduced and managed in a cost-effective way.

This principle was already included in the 2018 EED and the Governance Regulation (EU) 2018/1999 but lacked a clear legal definition. The proposed recast EED would establish a clear legal basis for applying the principle, which would now apply to energy systems and all non-energy sectors that have an impact on energy consumption and energy efficiency, public procurement processes (contracts and concessions) above a certain value and energy transformation, transmission and distribution systems. The proposed recast EED also includes an obligation for EU countries to ensure that energy efficiency solutions are considered in energy system and non-energy sector planning, policy and investment decisions.

The European Commission has published a recommendation to EU countries (EC, 2021c) and detailed guidelines (EC, 2021d) on proper application of the principle. Note also that the principle is gaining further momentum in the light of the REPowerEU initiative (EC, 2022a) to reduce dependence on Russian fossil fuels.

The proposed recast EED also includes:

- almost a doubling of the annual energy savings obligation: Member States must achieve new savings each year of 1.5% of final energy consumption from 2024 to 2030 (the current level is 0.8%);

- measures to address energy poverty, boost building renovation rates, increase uptake of energy efficiency investments, and empower and protect consumers;
- an obligation for Member States to disclose the energy consumption of their data centres;
- definitions of efficient heating and cooling systems based on minimum shares of RES that the system uses (and requirements for a gradual increase in these shares) and of efficient cogeneration to ensure fully decarbonised heat or cooling supply in efficient district heating and cooling systems by 2050;
- a requirement for Member States to carry out comprehensive assessments of the potential for high-efficiency cogeneration and efficient district heating and cooling that is coherent with the NECPs and long-term renovation strategies.

The public sector is expected to lead by example: Member States must ensure the final energy consumption of all public bodies combined is reduced by at least 1.7% per annum, and that at least 3% of the floor space in public buildings is renovated annually to nearly net-zero energy building (nZEB) standards.

In September 2022, a final report was approved by the relevant Committee in the European Parliament (EP, 2022). The report sets more ambitious targets than the Commission's original proposal: a 40% reduction in final energy consumption and a 42.5% reduction in primary energy consumption. These targets are slightly more ambitious than the revised targets proposed by the Commission as part of the REPowerEU plan. The report contains more ambitious targets for the public sector also: it proposes annual Energy Saving Obligations (ESOs) of 2% of final energy consumption between 2024 and 2030, (a third more than the Commission's proposal). On the other hand, the EU Council supports the energy efficiency targets in the original Commission proposal (Council, 2022). According to the general approach, national contributions would remain indicative (non-binding) and based exclusively on final (non-primary) energy consumption. The renovation targets for public buildings would only become binding after four years and would be limited to buildings owned by public authorities. The increase of the annual ESOs would be more gradual than in the Commission proposal, rising from 1.1 % (2024-2025) to 1.5 % (2028-2030) and allowing for more flexibility in accounting between years.

The proposal for a revision of the Energy Performance of Buildings Directive (EC, 2021b) in the Fit for 55 Package sets the vision and outlines the tools to achieve a zero-emission building stock by 2050. These developments build on a wider initiative to accelerate the building renovation process which was first initiated by the Commission through the Renovation Wave strategy in 2020.[87] The proposal refines existing definitions such as of 'nearly-zero energy buildings' (nZEBs) and 'deep renovation' and introduces a new definition of a zero-emission building. This is a building with very high energy performance in line with the energy efficiency first principle,[88] which has its very low amount of energy required fully covered by energy from the building itself or from locally produced renewables. Zero-emission buildings would replace nZEBs as the standard for all new buildings from 2027 and for all renovated buildings from 2030.

Existing provisions on renovation would be made more ambitious and complemented by the introduction of minimum EU-level efficiency standards. The aim is to trigger an increase in the renovation rate of the worst-performing buildings, where the potential for efficiency improvements is greatest and the risk of energy poverty is highest. Additionally, new provisions related to energy performance certificates (EPC) are

87 See the FSR online debate on the Renovation Wave from 18 February 2021 available at https://fsr.eui.eu/buildings-need-to-get-to-the-centre-of-the-net-zero-stage-and-we-are-all-actors-in-this-play/ (last consulted 2 April 2021).

88 For more discussion on the Energy Efficiency First principle under the Green Deal, see, for example, a recording of an FSR debate on 31 March 2021, available at https://fsr.eui.eu/event/implementing-the-energy-efficiency-first-approach/ (accessed 1 April 2021).

proposed with the aim of making them more stringent and comparable across the EU. In future, they will be rescaled with a view to achieving a zero-emission building stock by 2050.

Currently existing long-term renovation strategies would be replaced by national building renovation plans. These are more operational with a stronger monitoring framework and concrete targets for renovation by 2030, 2040 and 2050. They would be scrutinised by the EC and fully integrated into the ten-year national energy and climate plans (NECPs) prepared under the Governance Regulation (EU) 2018/1999.

Other provisions in the EPBD are related to:

- calculation of the life-cycle global warming potential of new buildings;
- renovation passports;
- a smart readiness indicator for buildings;
- mandatory installation of building automation and control systems for non-residential buildings; and
- phasing out of national subsidies for fossil fuel boilers.

Regarding the Governance Directive, Member States will need to update their NECPs by the end of June 2023 in draft form and by 30 June 2024 in final form in order to reflect the increased climate ambitions at the EU level (i.e., the new GHG emissions target under the Climate Law and the proposed new EE target under Fit for 55).

Note also that a proposal for a revised Construction Products Regulation (CPR) was adopted in March 2022 (EC, 2022b). The CPR should ensure that the design of new and renovated buildings is in line with the needs of the circular economy, and lead to increased digitalisation and climate-proofing of the building stock.

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3. EU security of supply policy

In this chapter, we focus on EU security of supply policy in four sections. First, we discuss the existing EU energy security of supply policies for oil, natural gas and electricity. Second, we explain the concept of resource adequacy and the use of capacity mechanisms in Europe and their history in the electricity sector. Third, we provide an overview of the history and future of network planning in the EU. Finally, we look at road transport and (electro) mobility infrastructure.

3.1 Security of supply for oil, natural gas and electricity

Athir Nouicer and Andris Piebalgs

Energy security, or security of supply, was one of the three pillars in the first EU energy policy in 2007. The Energy Union strategy in 2015 reconfirmed the importance of this pillar by including energy security, solidarity and trust among its five dimensions. In this section, we investigate the topic in four subsections. First, we introduce the EU energy mix. We then discuss security of supply of oil, natural gas and electricity in three successive subsections.

The EU energy mix

EU gross energy consumption has been relatively steady over recent decades, especially between 1990 and 2010, with a decrease following the 2009 financial and economic crisis. In 2020, EU gross energy consumption was 1,236 Mtoe, dropping from 1,479 Mtoe in 2019. The EU energy mix has a diverse portfolio. Nevertheless, fossil fuels accounted for 68.4% of all energy in the EU in 2020 ('gross available energy').[89] Crude oil and petroleum products represent the biggest EU energy source with a 34.5% share. Natural gas comes second with 23.7% while solid fossil fuels accounted for 10.2%. The share of renewable energy is continually increasing and accounted for 17.4% in 2020, surpassing solid fossil fuels. Finally, nuclear energy accounted for 12.7% of the gross available energy in the EU in 2020 (Eurostat, 2022a). These shares differ among the national energy mixes of the Member States.

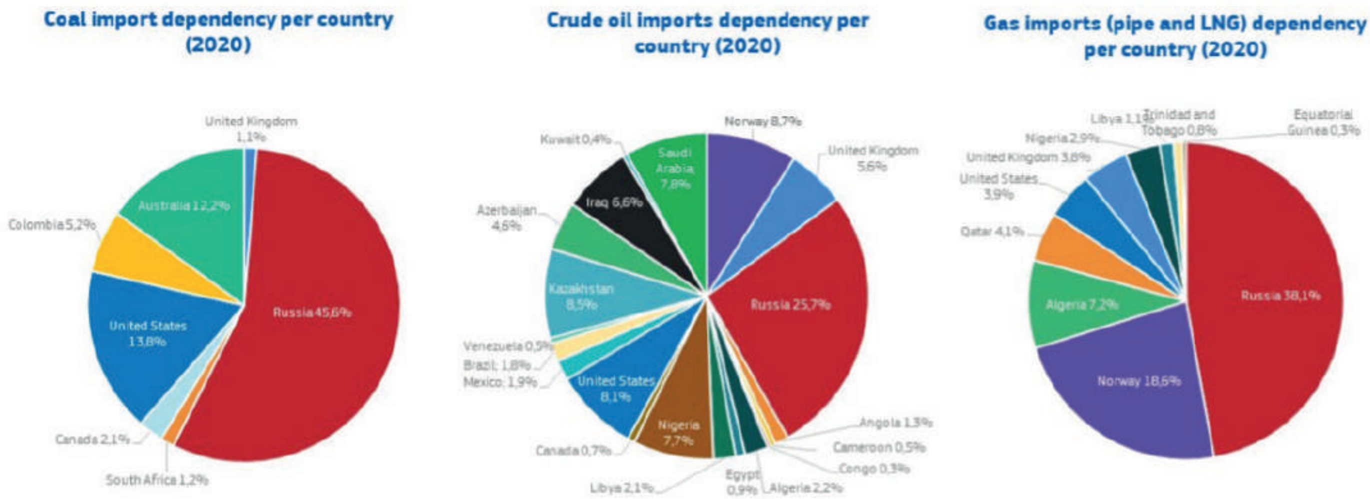
The drop in energy consumption in 2020 was provoked by the Covid-19 crisis. This drop, while not driven by successful structural energy efficiency measures, led to overachievement of the 2020 energy efficiency target by 5.8% but was still 9.6% away from the 2030 target. The drop also led to lower levels of CO2 emissions. At the beginning of 2020, EU coal demand fell by 20% while RES shares reached record levels.

The energy consumed in the EU comes from locally produced energy and energy imported from non-EU countries. In 2020, the EU imported more than half (57.5%) of the gross available energy. EU energy dependence has been steady at over 50% in the last decade and reached a peak of 60.5% of gross available energy in 2019 (Eurostat, 2022b). The EU imports mostly come from a few supplying countries. Russia has continued to be the main supplier of different forms of energy (see Figure 20). In 2020, it supplied 25.7% of EU crude oil, 45.6% of EU coal and 38.1% of EU gas needs. Electricity imports in the EU come from countries that are electrically connected. They grew significantly in recent years from Morocco, Russia, Turkey, Ukraine and the western Balkans (IEA, 2020a). Nonetheless, they remain limited when compared to the overall EU electricity consumption. Energy import dependence on a few countries, especially for natural gas and oil, raises concerns regarding the security of energy supply in the EU. These concerns

89 Gross available energy refers to the gross inland energy consumption in addition to the international maritime bunkers.

have been particularly debated in recent years, especially in times of international conflict, such as in 2022 following Russia's invasion of Ukraine, and prior to this regarding the gas transit tariff conflict between the same two countries.

Figure 20: EU energy dependence by supplying country in 2020, Source: European Commission (2022)



Security of oil supply

In the EU, oil is the largest energy source in the energy mix, with a relatively strong but slightly declining trend in use. Oil supply consists of crude oil, which the EU mostly imports, and refined oil products, of which the EU is a net exporter (IEA, 2020). Due to the high EU reliance on oil, it is crucial for the Member States to maintain emergency oil stocks to guarantee security of supply.

The European Commission's (2007) Energy Policy for Europe communication highlighted the need to enhance the security of energy supply at the EU and Member State levels by reviewing the EU's oil stock mechanism to guarantee availability in the event of a crisis.

The EU's Oil Stocks 2009 Directive (2009/119/EC) requires the Member States to maintain a minimum emergency stock to cover at least 90 days of net imports or 61 days of consumption, whichever is higher. These stocks are to be kept available so they can be used during the event of a crisis. The Member States are to send a monthly statistical summary of their stocks stating how many net import or consumption days the stocks cover. They also have to put in place emergency measures for the use of these stocks. In the case of a supply crisis, the Commission is to organise a consultation between the Member States. Following this, withdrawals from the stocks are permitted. In very urgent circumstances the withdrawal can happen before the consultation.

Other emergency measures include demand restraining programmes (e.g., driving bans, car pooling and speed limits in the transport sector), fuel switching where possible in transport and industry, surge production of spare crude and allocating supply to prioritised consumer groups (IEA, 2020). Coordination of security of supply actions across the Member States is managed by the Oil Coordination Group.

There have been several times in recent years when these reserve oil stocks have been used by some

Member States. For instance, summer 2018 was particularly dry and led to low water levels in the Rhine and Danube rivers. Particularly in some places these low levels were not sufficient for the passage of fully loaded barges with energy commodities such as coal, oil and biomass (IEA, 2020) and therefore reserve stocks were used to cover the shortages.

Security of natural gas supply

The EU is the largest importer of natural gas globally. Natural gas represents its second most important energy source after oil (IEA, 2020a). In the period 1990-2020 imports of natural gas more than doubled, which was due to inter alia a decrease in EU natural gas production (Eurostat, 2022a). EU gas imports reached their highest level in 2019. Russia has historically been the largest source of EU natural gas imports, constituting 45.3% of the total in 2021 (EC, 2022).

The European Commission's (2007) Energy Policy for Europe Strategy introduced measures to promote diversification of supply for Member States that depend on one gas supplier. The Commission committed to monitoring the implementation and effectiveness of Gas Security Directive 2004/67/EC measures. The Commission added that more projects are to be developed to bring natural gas from new regions, establish new gas hubs in central Europe and the Baltic countries, optimise the use of strategic storage and promote new construction of liquefied natural gas (LNG) terminals. The Commission also highlighted the role of mechanisms, such as the Energy Correspondents Network and the Gas Coordination Group, in strengthening solidarity between the Member States. Furthermore, more investment in storage capacity and pipelines was needed to enhance gas supply security, yet the cost should be justified to consumers.

This was in a period with high geopolitical tension regarding the 2006 and 2009 disruptions in the supply of Russian gas to the EU through Ukraine, which exposed some fragilities of Gas Security Directive 2004/67/EC. Regulation (EU) 994/2010 repealing and replacing Directive 2004/67/EC on measures to safeguard natural gas supply security was the answer to these crises. It aimed to put in place the basic building blocks of security of gas supply at the national level and improve the Member States' resilience in the case of a crisis, requiring them to put in place appropriate tools to manage gas shortage effects. For instance, it introduced the so-called protected customer category and included detailed protective measures for them. In addition, it required the Member States to develop full assessments of security of gas supply risks. Regulation (EU) 994/2010 also took the first steps in establishing links and consultation between the Member States to develop more coordination regarding security of gas supply.

However, the issue of security of gas supply became very relevant again in 2014 following renewed tension between Russia and Ukraine as a result of the annexation of Crimea. In June 2014, Russian gas giant Gazprom interrupted exports to Ukraine because of increasing non-payment of debts to Gazprom. In September there were also many cuts in some Member States, such as Austria, Poland and Slovakia, which might have been to try to prevent Ukraine from purchasing gas from European traders at border points between Ukraine and the EU (De Micco, 2014). These events required further efforts at the EU and Member State levels to guarantee security of supply in winter 2014/2015 and beyond.

In 2015 as part of the Energy Union strategy the Commission announced a revision of Security of Gas Supply Regulation (EU) No 994/2010, further promoting resilience and diversification of gas supply. This resulted in Security of Gas Supply Regulation (EU) 2017/1938. The revised regulation allowed the Member States to assess common risks and enhance regional resilience. It also expanded gas risk assessment to the regional dimension by creating regional risk groups and introducing EU-wide simulations of gas disruption scenarios (IEA, 2020a). Furthermore, the Regulation asked ENTSOG to carry out a Union-wide gas supply and infrastructure disruption simulation to produce an overview of the possible major supply risks for the EU. It also included detailed rules to safeguard solidarity among the Member States as they are to help each other preserve security of supply, in particular to vulnerable consumers.

As in the oil sector, there have recently been some security of supply crises in the gas sector. For instance, in winter 2017/2018 and soon after Security of Gas Supply Regulation (EU) 2017/1938 entered into force, Austria's Baumgarten facility suspended operations following an explosion and a fire. This led to the Trans Austria Gas (TAG) pipeline, through which half of Italian imports flow, ceasing operation entirely for several hours putting some parts of northern Italy on red alert. A state of emergency was declared in Italy, which was already in a situation of tight supply-demand balance because of the cold winter. The state of emergency allowed the country to use extraordinary measures to meet energy demand, such as allowing coal and oil power plants to function at maximum capacity. Italy also increased its imports from all remaining supply routes, in particular from Switzerland and Algeria. There was also an increase in LNG supply from the Adriatic LNG facility. In this disruption, gas storage reactivity played a key role in maintaining the necessary gas supply volume (IEA, 2020; EC, 2018).

In 2021 and 2022 security of supply, in particular of natural gas, was again under the spotlight. Gas prices increased, both worldwide and in the EU. The price increase was for various reasons, among which were an increase in industrial activities following the Covid pandemic and lagging investments, e.g. in upstream infrastructure. Dutch TTF prices reached over 200 €/MWh in March 2022, while they did not exceed 30 €/MWh in 2019 and 2020. There were fears that a worst-case situation with increasing demand in winter 2021-2022 would lead to demand curtailment and trigger the Security of Gas Supply Regulation, such as via the solidarity mechanism.

In December 2021, a Hydrogen and Decarbonised Gas Market Package proposal was published. While its main objective is to promote the deployment of renewable and low-carbon gases, it also includes provisions aiming at improving energy security and positively impacting gas prices in the medium term. For instance, promoting domestic production of renewable gases in the EU would decrease import dependence.

The Package extends the scope of the Security of Gas Supply Regulation to cover renewable and low-carbon gases. It also includes specific measures to improve cooperation and resilience in response to the EU-wide energy price increase in the form of more effective and coordinated use of storage facilities and facilitation of operational solidarity arrangements between Member States. Indeed, the Member States must explicitly include storage in their security of supply risk assessments and state the risks linked to control of such facilities by entities from third countries. In addition, the Package sets conditions for establishing voluntary joint procurement of strategic gas stocks that can be used in emergency situations.

REPowerEU

In March 2022 following Russia's invasion of Ukraine, the European Commission proposed a plan to cut the EU's dependence on Russian fossil fuels by 2030, starting with gas. The plan also includes measures to respond to the rising energy prices, which further increased with the conflict due to uncertainty of supply, and to refill gas stocks for the next winter.

REPowerEU aims to diversify EU gas supply sources, accelerate the uptake of renewable gases and replace gas use in heating and electricity generation. These measures can reduce EU Russian gas demand by two thirds by the end of 2022 (EC, 2022a).

Diversifying gas supplies can be done by investigating new and old importing sources of LNG (e.g., from

Qatar, the USA, Egypt, etc.) and pipeline imports (e.g., from Azerbaijan, Algeria, Norway) and by increasing EU production of biomethane. Additional renewable hydrogen use in addition to the Fit for 55 targets can further reduce the use of imported Russian gas.

The REPowerEU was followed by the Commission proposal on storage filling measures aiming at ensuring an annual adequate gas storage level by next winter. The proposal, published on 22 March 2022, amends the Security of Gas Supply Regulation (EU) 2017/1938 and Regulation (EC) No. 715/2009 on conditions for access to natural gas transmission networks. The proposal sets that the Member States are to ensure the filling of the underground gas storage infrastructures in their territories up to at least 80% of their capacities for the next winter 2022/2023. The target will rise to 90% in the following years. For the upcoming winter, intermediate targets are set for August, September and October of 2022 for each Member State, considering specific technical characteristics.

The Member States that do not have storage capacities must ensure that at least 15% of their annual gas consumption is stored in another EU country by 1st of November. Alternatively, the Member States without storage capacities may jointly develop a burden-sharing mechanism with Member States with storage facilities.

In May 2022 the European Commission presented the REPowerEU Plan with concrete actions to be taken (EC, 2022b). The plan is a follow-up of the previous document and aims to outline the strategy to energy independence from Russia fossil fuels by 2027. In order to accomplish this goal, the EU should reduce of 2/3 Russian gas consumption by the end of 2022 and move away from its relationship with Russia. Building on the Fit for 55 Package of proposals and completing the actions on energy security of supply and storage, the Plan puts forward an additional set of actions to save energy, diversify supplies, accelerate Europe's clean energy transition and smartly combine investments and reforms.[90]

Security of Electricity Supply

In this subsection we first present the electricity mix in the EU. We then introduce the concept of security of electricity supply. Finally, we discuss legislation relating to network security of supply.

The EU electricity mix

In the EU electricity is playing an increasingly central role in the energy transition. Considerable shares of the energy used in EU transport and heating are expected to be electrified in the future. In the past two decades, the EU's electricity supply peaked at 2,818 TWh in 2008 before falling in 2009 due to the economic crisis. In 2019, the EU's electricity supply slightly decreased by 1.2% compared with 2018 and by 2.6% compared with the 2008 peak value (Eurostat, 2021). In 2020, available data showed that electricity consumption went down by 4% due to the pandemic (Agora Energiewende and Ember, 2021).

Regarding the EU electricity mix, in 2020 renewables became the largest source of electricity in the EU, generating 38% of EU-27 electricity (compared to 34.6% in 2019) and for the first time overtaking fossil-fired generation, which fell to 37%. Nuclear stood at 25% of electricity generated in 2020. Coal experienced a larger fall in fossil fuel use than natural gas in 2020. This was due to the EU Emissions Trading System (EU ETS), which was described in section 2.2 and which made gas generation of electricity cheaper. With the end of the Covid-19 pandemic, electricity demand is expected to rebound (European Commission, 2020; IEA, 2020b).

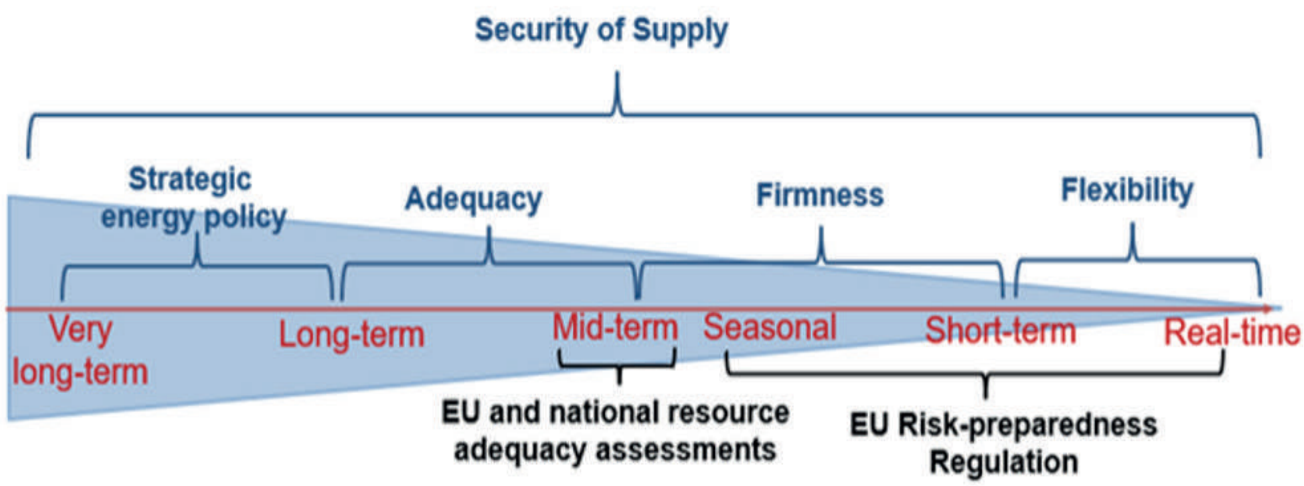
90 For more details on the recent legislative developments see https://fsr.eui.eu/first-look-at-repowereu-eu-commission-plan-for-energy-independence-from-russia/.

The concept of security of supply in electricity systems

Security of electricity supply is a very crucial concern in electricity systems in the context of the energy transition. It has several dimensions. On a time scale we can distinguish four dimensions,[91] which are shown in Figure 21: strategic energy policy; adequacy; firmness; and flexibility.

- Strategic energy policy is a long to very long-term issue. It relates to the availability of energy resources and infrastructure. This entails adopting measures for fuel provision and energy mix diversification. It also has to take into account the evolution of fuel prices, environmental constraints and development of interconnections.
- Adequacy is a long-term issue. It refers to the existence of sufficient available resources in terms of generation, storage, demand response and network capacity to meet expected demand at all times. Note that some reports refer to flexibility for long-term needs, that is optimising network capacity investment, which would fall in this category.
- Firmness is a short to mid-term issue. It is the ability of the power system with already installed facilities to keep the balance between generation and demand.
- Flexibility is a short-term to real-time issue. It is the ability of electricity systems to cope with short-term variability, due, for instance, to intermittent. renewable generation, and unexpected events and disturbances.

Figure 21: Security of supply dimensions, own illustration



In the remaining part of this section, we focus mostly on measures to enhance network security of supply, i.e. measures relevant to transmission and distribution. Resource security of supply, or adequacy, will be discussed in section 3.3 on resource adequacy and capacity mechanisms.

Legislation relevant to electricity network security of supply in the EU

Directive 2005/89/EC, called the Security of Electricity Supply Directive, established the main framework for security of electricity supply. It required the Member States to adopt measures ensuring security of supply but, being a directive, it left implementation to the Member States. The directive aimed to set an

91 There is no common taxonomy relevant to security of supply in the literature or legislation. Rodilla and Batlle (2013) distinguish four dimensions for security of supply while Fulli (2016) adopts five dimensions. Also, AF Mercados et al. (2016) report to the European Commission and Rodilla and Batlle (2013) refer to security of electricity supply as a synonym to system reliability, while Léautier (2019) divides security of supply into adequacy and system reliability.

adequate level of generation capacity, appropriate interconnections between the Member States and an adequate balance between supply and demand.

The experience with the Italian blackout in 2003 was one of the reasons that action was taken at the European level on security of electricity supply.[92] For network security Directive 2005/89/EC asked the Member States to ensure that TSOs set minimum operational rules, and to comply with them. For generation adequacy, Member States were allowed to take additional measures to facilitate the entry of new generation capacity and promote interruptible contracts.

The Third Energy Package clarified the role of NRAs and TSOs. It made ENTSO-E responsible for adopting an EU-wide ten-year network development plan. The CEP Regulation (EU) 2019/941 on risk preparedness in the electricity sector eventually repealed Directive 2005/89/EC. Instead, it established a common framework for rules on risk identification and assessment. ENTSO-E was tasked with establishing a common methodology to identify regional electricity crisis scenarios and assess possible seasonal and short-term adequacy issues. The process is subject to public consultation and approval by ACER. The regulation also established EU-level monitoring of electricity crises. When there is a crisis, the Member State's competent authority is to carry out an ex-post evaluation of the crisis and its impact.[93]

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92 The final report of the investigation committee on the 2003 Italian Blackout is available at https://www.entsoe.eu/fileadmin/user_upload/_library/publications/ce/otherreports/20040427_UCTE_IC_Final_report.pdf (last accessed 30 March 2022).

93 An example of the mandated ex-post evaluations is provided the report issued in July 2021 regarding the Continental Europe Synchronous Area separation that took place on 8 January 2021. More information is available at https://www.entsoe.eu/news/2021/07/15/final-report-on-the-separation-of-the-continental-europe-power-system-on-8-january-2021/.

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3.2 Resource adequacy and capacity mechanisms

Athir Nouicer

Adequacy is an essential dimension of security of supply in the electricity sector. With increasing participation by demand-side and storage solutions, the terminology evolved from generation adequacy to resource adequacy. In this section, we first introduce the different types of capacity mechanisms and the reasons why some countries implement them. We then present recent regulatory developments limiting the use of capacity mechanisms.

Different types of capacity mechanisms

Capacity mechanisms (CMs) can differ in several key respects. They can be an additional source of revenue for all market participants or can be targeted at specific resources. They can be price-based or volume-based. In price-based mechanisms, policymakers set the price for the capacity allocated in advance, ideally stimulating investment in this capacity. In volume-based mechanisms, the central authority, e.g. the TSO, defines the total required capacity while the price is set by the market. In addition, CMs can be centralised or decentralised. In centralised CMs a designated buyer purchases the capacity required on behalf of suppliers or consumers, e.g. via a capacity auction. In decentralised CMs an obligation is put on certain parties (typically suppliers) to contract the capacity they require. Table 6 summarises the classification of CMs and descriptions of them.

Table 6: Descriptions of capacity mechanisms, based on Erbach (2017)

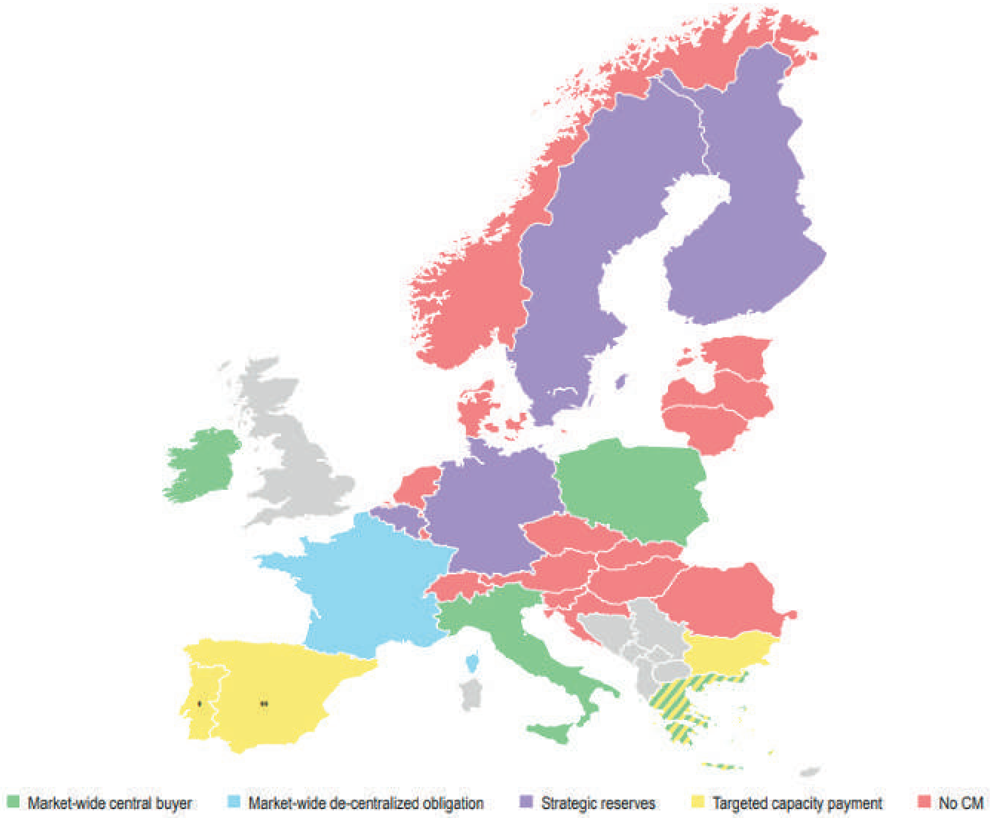
CMs	Price vs Voume-based	Cetralised vs Decentralised	Targeted vs Market-wide	Description
Strategic Reserves	Voume -based	Centralised	Targetted	A central agency (a TSO or a government agency) decides on the amount of capacity needed to make up any shortfall in the market a few years in advance. The level of payment for the contracted capacity is set in a competitive tendering process. The contracted power plants cannot participate in the electricity market and are only activated in the case of extreme conditions. The 2016 European Commission Sector Inquiry highlighted strategic reserves as the most appropriate mechanism for circumstances in which temporary or local adequacy concerns are identified. Strategic reserves are used, for instance, in Belgium, Sweden and Finland.

Capacity Payments	Price-based	Centralised	Targeted or Market -wide	This is a price-based mechanism. It pays a fixed amount (set by the regulator) for the capacity available to all or to some of the declared or available generators. The plants receiving capacity payments continue to participate in the energy-only market. The payment can also be made when the plant does not run, but certain availability criteria have to be met. They have been used in the not well-interconnected markets on the periphery of Europe. Targeted capacity payments are currently used in Italy and Spain. Ireland used a market-wide capacity payment until 2018.
Capacity Auctions	Volume -based	Centralised	Market -wide	The capacity volume to be auctioned is decided centrally (by the TSO or regulator) a few years in advance. The price is determined by auction and is paid to all resources (existing and new) clearing the auction. Capacity providers bid to receive a payment that reflects the cost of building new capacity. The new capacity participates in the energy-only market. In Portugal, capacity auctions have been operational since 2017.
Capacity Obligations	Voume -based	Decentralised	Market -wide	This mechanism is also called capacity requirements. It is an obligation on suppliers or large consumers to contract with generators for a certain level of capacity related to their self-assessed future consumption or supply (e.g. three years ahead) plus a reserve margin that is decided on by an independent body. If not enough capacity is contracted, the supplier or the consumer will pay a buy-out price/fine. The price for capacity is determined in a decentralised way through contracts. This model can also include a market for exchangeable obligations (secondary market). This mechanism has been used in France with delivery starting in 2017.

Reliability Options	Voume -based	Centralised	Market -wide	This mechanism is based on a forward auction (e.g. three years ahead). A capacity provider enters into an option contract with a counter-party (a TSO or a large consumer or supplier). The contract offers the counterparty the option to procure electricity at a predetermined strike price. The capacity provider must be available to the counterparty for dispatch above the strike price. In the 2016 Commission Sector Inquiry, reliability options were highlighted as the most appropriate mechanism when long-term adequacy concerns are identified. This mechanism is used in Italy and Ireland.

In the EU, about half the Member States have adopted various CM designs (see Figure 22). The most common mechanism in Europe is strategic reserves. It is used in Belgium, Finland, Germany and Sweden. For Italy, reliability options were approved by the European Commission in February 2018. Their procurement occurred in an auction held in 2019 for a first delivery in 2022/2023. Nevertheless, in 2020, the Commission invited Italy to ensure that the capacity mechanisms' design is compliant with the electricity regulation's requirements, where necessary. It shall also comply with Article 107 of the Treaty on the Functioning of the European Union (European Commission, 2020).

Figure 22: Capacity mechanisms in Europe – 2020, source: ACER and CEER (2022)



Reasons for the implementation of capacity mechanisms

The question of resource adequacy and the need for CMs has been extensively debated in academia (see, for instance, Batlle and Pérez-Arriaga (2008), Hancher et al. (2015), Schittekatte and Meeus (2021) and Pototschnig et al. (2022)).

The economic arguments range from a missing money argument to a missing markets argument. The missing money problem refers to the situation where marginal generators do not receive enough revenue to cover their investment costs. In the early 2000s, the California crisis showed that companies might sometimes abuse their market power, driving up electricity prices and earning windfall revenues. Therefore, most US electricity markets introduced price caps to limit this abuse, which in turn could create a missing money problem if the caps were applied too strictly. This problem can also emerge because of market interventions other than price caps. For instance, operating reserve targets and system operators' reliability constraints may also complicate price formation processes in a situation of scarcity (Joskow, 2006). Furthermore, with the increasing penetration of RES, the missing money problem has been aggravated due to the price impact of subsidised RES at the expense of other technologies with higher variable costs (Roques, 2019). Indeed, subsidised RESs with close-to-zero marginal production costs drive down wholesale prices to a level where technologies with higher variable costs, such as coal and gas, have no incentive to produce electricity. An example of missing markets is that companies would like to hedge their exposure to volatile power prices in the long term, but the contract length of transmission rights across borders is typically limited to one year (Meeus and Nouicer, 2020).

Others have argued that CMs can be explained by political economy rather than microeconomics. After the financial and economic crisis of 2008/2009, many new gas-fired power plants that required substantial investments were not running much because of the drop in demand and the penetration of renewables. CMs paying these plants were seen by some as state aid to national companies that made wrong investment decisions, while others see them as essential to ensure backup capacity. Furthermore, Léautier (2019) argues that in most countries employees of system operators, regulators and governments favour implementing CMs as they do not want to be blamed in the case of a blackout.

Schittekatte and Meeus (2021) and Pototschnig et al. (2022) look at the future of resource adequacy in the context of more frequent extreme weather events and volatile prices. Pototschnig et al. (2022) state that high sudden prices may be worrying for investors as they might attract government intervention, potentially introducing price caps. They suggest that hedging requirements for suppliers in combination with CMs could provide stable revenue for the entities selling electricity. However, they question whether CMs will be a temporary measure as presented in EU legislation and what the preferred CM would be to address long-term adequacy concerns. They argue that reliability options are a mechanism that meets all the requirements for CMs stated in EU legislation. This was highlighted in the 2016 European Commission Sector Inquiry as the most appropriate mechanism to address long-term adequacy concerns. They add that when combining reliability options and hedging instruments the latter should not provide cover for prices above the reliability option's strike price.

Schittekatte and Meeus (2021) argue that continuing to consider resource adequacy to be a public good would lead to over-procurement of capacity in fully centralised CMs and therefore high costs for consumers. With the increasing fluctuations in the supply-demand balance and the asymmetry of information between regulators and consumers adopting behind-the-meter technologies, they suggest that the time has come to start considering resource adequacy to be a private good. This would be translated into letting consumers individually choose their reliability levels. Several priority service schemes have been proposed in the literature with different levels and durations of guaranteed supply and for different prices. However, the implementation of such a scheme has not yet taken place.

Limiting the use of capacity mechanisms

CMs risk fragmenting the internal market, distorting competition and creating market entry barriers. In 2014, the Guidelines on State Aid for environmental protection and energy (EEAG) 2014-2020 for the first time adopted criteria to be applied by the Commission when assessing CMs. In 2015, the Commission launched a state aid sector inquiry into the national CMs, which provided information on CM implementation, their contribution to security of electricity supply and the distortions they create. It complemented the Commission Energy Union Strategy and provided input for the CEP, which created a legal framework to introduce CMs.

The CEP preserves the Member States' national competencies in the matter of security of supply and the implementation of CMs. Nevertheless, CMs are only to be implemented if the need for them is demonstrated by an EU-wide adequacy assessment,[94] which can be complemented by national adequacy assessments.[95] When CMs involve state aid, they are subject to the EU state aid rules, i.e., they must represent compatible state aid under Art 107(3)c) TFEU (see section 4.8 of the 2022 Climate, Energy and Environmental Aid Guidelines (CEEAG)).

If adequacy assessments identify adequacy concerns, the concerned Member States are first to adopt an implementation plan that includes measures to eliminate the causes of the adequacy problems, i.e. regulatory distortions and/or market failures, by increasing interconnection and internal grid capacity with a timeline for adopting these measures. If there are residual concerns, meaning there are problems that market reforms cannot solve, then CMs can be introduced as a measure of last resort. The CEP Electricity Regulation provides implementation principles for CMs. Among the principles to be followed, the Member States are to conduct a study of the cross-border effects of such mechanisms and consult with neighbouring countries. Member States are also to first assess the alternative of strategic reserves. Moreover, CMs must be temporary, i.e. the Commission will approve them for no more than ten years. In addition, they are to be open to participation by all suitable resources, including DERs and mechanisms other than strategic reserves, and open for explicit cross-border participation.[96]

A novelty in CM principles is the introduction of measures aiming to reduce the impacts of CMs on climate. This is to be in line with the European Union's energy transition goal of a climate-neutral economy. The Electricity Regulation sets emission limits for Member States willing to subsidise generation units, reflecting the principle that CMs shall not be a vector for the most polluting coal power plants in Europe to receive state aid. An Emission Performance Standard (EPS) for CMs was introduced in the Electricity Regulation. Generation capacities that went online after 4 July 2019 can only participate in CMs if they emit less than 550 g of CO_2 of fossil fuel origin per kWh. A grandfathering clause was also introduced for mechanisms

94 The Electricity Regulation (EU) 2019/943 sets the high-level characteristics of the European resource adequacy assessment (ERAA). It is to identify resource adequacy concerns by assessing the electricity system's overall adequacy for the current and projected electricity demand and covers each year in a ten-year period. The ERAA's methodology was drafted by ENTSO-E and approved by ACER in 2020 for implementation as of 2021 (ACER, 2020). The Member States are to assess the adequacy assessment outcome against their reliability standards in order to identify adequacy concerns.

95 See the Commission approval process of the Belgian capacity mechanism which investigated whether it was in line with the EU State aid rules or not (European Commission, 2021).

96 Cross-border participation in capacity mechanisms is not very common between Member States. Nevertheless, this situation is changing. For instance, France and Ireland are developing plans to allow cross-border participation in their capacity mechanisms (RTE, 2019). The Electricity Regulation also sets cross-border participation rules in capacity mechanisms, which are to be open to explicit cross-border participation to limit distortions to cross-border trade and to provide incentives for interconnection investments to ensure EU security of electricity supply at the least cost.

that were concluded before 31 December 2019. Generation capacities that went online before 4 July 2019 will not be able to receive capacity payments or commitments for future payments starting from 1 July 2025 if they emit more than 550 g CO_2 of fossil fuel origin per kWh of electricity and more than 350 kg CO_2 of fossil fuel origin on average per year per installed kWe.

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3.3 Planning future networks

Athir Nouicer and Alberto Pototschnig

This section first presents the state of transmission planning in the EU and the main recent developments. Second, we introduce the impact of offshore generation on the transmission grid infrastructure. Third, we describe the latest developments in distribution network planning. Finally, we present the recent provisions on planning hydrogen and CO2 networks.

Transmission planning: electricity, natural gas and hydrogen

Across the Member States there are significant differences in the size and topology of electricity and gas networks. National TSOs typically prepare their National Development Plans (NDPs) in a process that can, for instance, involve the National Regulatory Authority (NRA) or the relevant ministries. NDPs, which are binding for TSOs, include the network upgrade needs for the medium to long term and typically consider different development scenarios.

One important regulatory innovation to promote new electricity cross-border infrastructure was allowing commercial parties to invest in them. More specifically, Regulation EC 1228/2003 opened the door for third party investment in transmission, which is referred to as merchant transmission line investment, under certain conditions listed in Art. 7 of the above-mentioned Regulation. In return the private investors receive congestion rent, i.e. the price difference between the two bidding zones at each end of the interconnector multiplied by the congested capacity of the interconnector. To date, only seven exempted projects have been carried out in the EU (Gautier, 2020). The actors behind these projects are different in nature. Examples are BritNed, which is a joint venture of two TSOs, and ElecLink, an owned subsidiary of Getlink, the company owning the Channel Tunnel (Schittekatte et al., 2020).

Europeanisation of network planning came in the Third Energy Package with the establishment of ENTSO-E and ENTSOG, requiring them to develop Ten-Year Network Development Plans (TYNDPs) for electricity and gas on a biennial basis and building on the NDPs. Although they are non-binding, TYNDPs aim to provide market participants with a vision of the evolution of European transmission systems over a ten-year period and indicate the key infrastructure that needs to be built or upgraded.

Probably the most important tool to allow the establishment of a truly European transmission network for energy is the development of Trans-European Networks, which were established by Energy Regulation (EU) 347/2013, referred to as the TEN-E Regulation. The TEN-E Regulation made the TYNDP the unique basis for transmission projects to be included in the Projects of Common Interest (PCI) list. A PCI is defined as a necessary project to implement energy infrastructure priority corridors and areas that are listed in Annex I of the same regulation. Priority corridors established by the TEN-E Regulation are, for instance, the Northern Seas offshore grid for electricity and the North-South gas Interconnections in Western Europe (NSI West Gas). Besides electricity cables and gas pipelines, other examples of the areas considered are smart grids and cross-border carbon dioxide (CO2) networks. The PCI list has been updated every two years since the publication of the first list in 2013. Projects that obtain PCI status benefit from enhanced transparency and public consultation on the permit granting process, i.e. via one single national competent authority, improved environmental assessment, a permit-granting process that should not exceed 3.5 years and the possibility of receiving financial assistance under the Connecting Europe Facility (CEF).

In December 2020, the European Commission published its proposal for revision of the TEN-E Regulation as part of the Green Deal. A political agreement was reached in December 2021. The European Parliament adopted its position in first reading on the Regulation in April 2022. Then, the Council adopted its position TEN-E in May 2022 (Council, 2022) The final text of the revised TEN-E Regulation was published in June 2022 on the Official Journal of the European Union.[97] This revision aims to better align the regulation with the Green Deal climate objectives. The revised regulation targets supporting the infrastructure that serves clean energies and should stop supporting infrastructure projects transporting fossil fuels in general. Candidate projects should, for instance, meet mandatory sustainability criteria.

A new focus is given to offshore electricity grids, hydrogen infrastructure, smart electricity and gas grid investment, certain types of electrolyser facilities and CO2 infrastructure. Natural gas infrastructure and oil pipelines lose their PCI status eligibility under the revised TEN-E Regulation. Although it is recognised that natural gas will play a role in the energy transition during the next decade, in the longer term it will be replaced by renewable gases, as described in section 5.3, e.g. biogas and hydrogen. So far, the TEN-E Regulation has promoted the development of a European secure interconnected natural gas network. After completion of ongoing projects, the Member States will benefit from diversified supply, and the Commission does not see further needs to support cross-border natural gas projects (European Commission, 2020d). In addition, some part of the natural gas infrastructure is expected to be repurposed to transport hydrogen. Such repurposing of the natural gas infrastructure can contribute to a cost-effective energy transition, e.g. reducing stranded assets, and would cost up to 90% less than building new hydrogen pipelines (European Commission, 2020a). However, there is still some uncertainty about the future demand for hydrogen transport capacity, since the volumes and the geographical distribution of hydrogen demand and supply are still unclear. In this context, the revised TEN-E Regulation allows continuing until 31 December 2029 the financing of dedicated natural gas infrastructure converted to transport and store a pre-defined blend of hydrogen with natural gas or biomethane. However, the blending ratio is not mentioned.

The recast Gas Directive in the Hydrogen and Decarbonised Gas Market Package promotes a more integrated approach to network planning between the electricity and gas sectors and hydrogen. TYNDPs should be based on a joint scenario framework that is developed by the relevant infrastructure operators, including relevant electricity and gas distribution system operators. The TYNDPs are to be in line with the integrated national energy and climate plans (NECPs) and their updates, and also with the integrated national energy climate reports under the European climate law (Regulation (EU) 2021/1119). This will allow more cost-effective development of energy infrastructure and allow transnational information exchange on the use of transmission systems. The TYNDP joint scenario report by ENTSOG and ENTSO-E (2020) is a good example of such practices.

CO2 networks and storage

CO2 infrastructure aims to capture, transport and store CO2 before it is released in the atmosphere. The revised TEN-E Regulation continues to support such infrastructure for the purpose of permanent CO2 storage. CO2 networks are particularly relevant in decarbonising energy intensive sectors in which CO2 production is unavoidable despite electrification, renewable integration and energy efficiency measures. CO2 storage is needed for achieving climate neutrality by 2050.

The revised TEN-E Regulation included of CO2 storage projects in transport projects. CO2 could be trans-

97 https://www.consilium.europa.eu/en/press/press-releases/2022/05/16/ten-e-council-gives-green-light-to-new-rules-for-cross-border-energy-infrastructure/.

ported for injection into storage through pipelines or other dedicated modes of transport such as ships, barges, trucks, and trains. As CO2 storage potential capacities are not equally distributed among countries in Europe (GEUS and CATF, 2021), cross-border cooperation will be essential to allow industrial emitters in the EU to be connected to permanent CO2 geological storage.

Offshore renewable energy and grid infrastructure

Offshore renewable energy can come from a multitude of clean sources via different technologies that are at different levels of readiness. For instance, offshore bottom-fixed wind today has already 12 GW of installed capacity in EU waters, representing 42% of the global cumulative installed capacity. The EU is followed by the UK with 9.7 GW and China with 6.8 GW (European Commission, 2020b). Floating offshore wind is an emerging technology with multiple designs being developed. The EU installed capacity for this technology is 40 MW and there are currently large projects being announced in some Member States. Ocean energy technologies, mainly wave and tidal, are in the same situation with a current installed capacity of 13 MW in the EU. Other technologies, such as biofuels from algae, ocean thermal energy conversion, floating photovoltaic installations and thermal energy conversion, are in earlier development stages, i.e. demonstration stages (European Commission, 2020c).

The European Commission (2020b) offshore strategy proposes to increase Europe's offshore renewable energy capacity. It estimates that to reach the Green Deal decarbonisation objectives at least 60 GW of offshore wind and 1 GW of ocean energy will be needed by 2030, with a view to reaching 300 GW and 40 GW respectively of installed capacity by 2050. This is realistic and achievable and will also reduce the EU's dependence on imported fossil fuels and generate benefits for EU consumers. The REPowerEU plan aims to accelerate independence from imported fossil fuels and renewable hydrogen production, and proposes an additional 80 GW of solar and on- and off-shore wind capacity by 2030, without specifying sub-targets for each technology type.

Currently, most offshore wind farms are radially connected, meaning that the farms are individually connected to the shore. This means that there is no coordination between projects, and each one is developed independently. This way of developing and connecting offshore renewable energy is foreseen to continue, especially where the offshore deployment is in an early stage of development (European Commission, 2020b). Such projects could apply for PCI status under specific conditions such as transferring electricity from generation sites with capacities higher than 500 MW and being developed in areas with low offshore renewable energy penetration. The other alternative is hybrid projects connected via a meshed offshore grid that is similar to an onshore transmission grid in which electricity flows in different directions. This could be schematised as an interconnector between two countries, to which the offshore generation is connected. Offshore renewable generation projects could then be linked to an offshore meshed network in a cross-border setting, moving away from the traditionally national focus in offshore generation. Hybrid projects have important potential for cost savings in areas with increasing penetration of offshore renewable energy. They also require less space than radially connected projects and reduce impacts on the environment and other maritime activities (European Commission, 2020b).

The revised TEN-E Regulation introduces simplified and accelerated permitting and authorisation procedures for promoters of offshore grids for renewable energy projects. Unique points of contact are to be established for cross-border offshore projects of common interest and projects of mutual interest that connect the EU with third countries and contribute to the EU's energy and climate objectives.

In addition to electricity grids, another option to connect offshore generation is offshore hydrogen production and transport through hydrogen pipelines to the shore. This alternative will also be considered in electricity and gas network planning (European Commission, 2020b). With further technology readiness and cost reduction, it could be cheaper to produce green hydrogen from northern Europe offshore wind farms and transport it to the shore.

To realise the planned offshore generation and grid investments, different EU funding instruments are relevant (European Commission, 2020c), namely:

- The InvestEU programme to support emerging technologies and provide guarantees.
- The CEF to promote grid infrastructure development and offshore cross-border RES projects.
- The Renewable Energy Financing Mechanism pursuant to Implementing Regulation (EU) 2020/1294, whereby Member States contributing to RES projects will receive statistical benefits in return.
- Horizon Europe to promote the development and testing of innovative technologies and solutions.
- The Innovation Fund under the EU Emission Trading System (EU ETS), which can further support the demonstration of innovative green technologies on a commercial scale, e.g. ocean energy, new floating offshore wind technologies and projects coupling offshore wind with battery storage or hydrogen production.
- The Modernisation Fund under the EU ETS to support the development of the power sectors and wider energy systems, including offshore renewable energy, in the ten lower-income eligible Member States: Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania and Slovakia.

Distribution network planning

To put things in perspective, in Europe 60% of the electricity network is composed of low voltage lines, 37% of medium voltage and 3% of high voltage lines (Eurelectric, 2020).

The increasing decarbonisation of energy systems with more decentralised renewable generation and the increasing electrification of transport and heating will require more optimised planning of distribution grids taking into account new technologies such as distributed storage, electric vehicles (EVs) and demand response. The CEP Electricity Directive (EU) 2019/944 requires the Member States to define regulatory frameworks that include incentives for DSOs to procure flexibility services. DSOs have to include the use of demand response, energy storage facilities, energy efficiency and other resources as an alternative to expanding their networks. NRAs can opt for administrative approaches, i.e. administratively setting the price for provision of flexibility, if market-based processes are not economically efficient or when they would result in market distortions or higher congestion (CEER, 2020; Nouicer et al., 2020).

The Hydrogen and Decarbonised Gas Market Package proposes new provisions regarding rules on firm capacity for renewable and low carbon gases. Gas DSOs are to ensure firm capacities for renewable and low carbon gas production facilities. The package extends membership of the DSO entity established by the CEP to gas DSOs. This aims to provide a way for DSOs, and now also gas DSOs, to contribute to the development of distribution-relevant rules in the EU, and ensure close cooperation with gas TSOs and ENTSOG. In addition, vertical cooperation between DSOs and TSOs is key to facilitate coordinated access to distributed resources, especially with the emergence of bidirectional flows of electricity and gas (reverse flows). Moreover, similarly to the transmission level, more coordination between electricity and gas DSOs and hydrogen stakeholders is required to feed the joint electricity and gas TYNDP foreseen in the revised TEN-E Regulation. These plans should be taken into account in distribution network planning. Other stakeholders such as the DSO entity and relevant hydrogen sector stakeholders shall also be involved in the process.

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3.4 Road transport and (electro) mobility infrastructure

Daniele Stampatori

This section focuses on the future decarbonised EU transport sector, specifically on road transport. First, we describe some fundamental features of the EU transport sector. Second, we explain why the transport sector is important to achieve the Green Deal objectives. Third, we explain the vision for a decarbonised and digitalised EU transport sector. Finally, we explore the most relevant EU strategies and legislation.

Transport sector in the spotlight

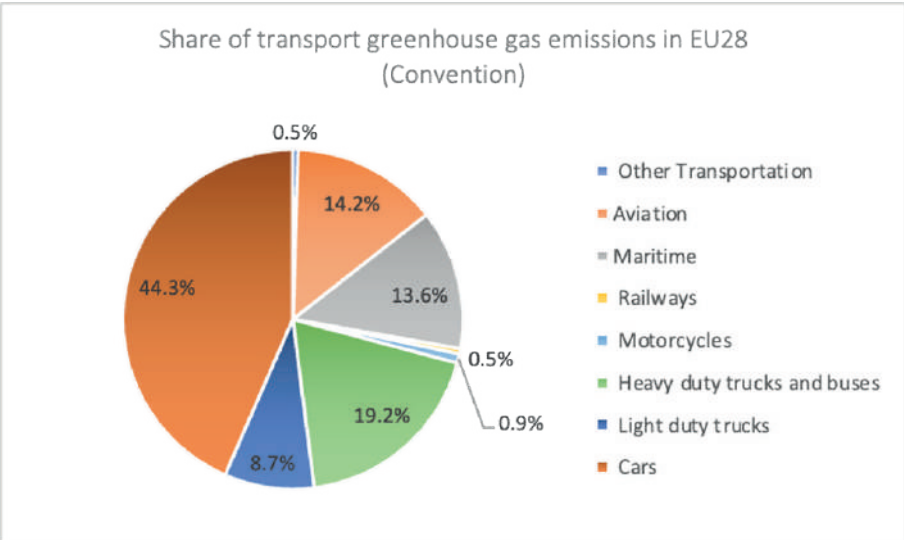
In 2018, the transport sector accounted for 4.6% of EU GDP and employed more than 10 million people (EU, 2020). These estimates include road, water and air transport, but in this section we will focus in particular on the first (which includes cars, light and heavy-duty vehicles,[98] buses, etc.) because of its relevance in terms of economic and environmental impacts.

Generally speaking, transport refers to moving goods and people, while mobility is the ability to freely move. In recent years, the term transport has been substituted with mobility. This shift in language seems coherent with the new perspective on mobility (in particular for people) based on access to a service rather than on ownership of a vehicle.[99]

Why is the transport sector important in achieving the Green Deal objectives?

Before the Covid-19 pandemic, transport produced almost a quarter of the EU's greenhouse gas emissions (GHG) and it is currently the main cause of air pollution in cities. More specifically, according to the European Environmental Agency (EEA), in 2016 road transport was responsible for almost 72% of total GHG emissions in the sector. Figure 23 indicates the shares of the various modes of transport GHG emissions in total transport emissions within the EU-28 in 2016. It clearly shows that cars are the leading source of emissions.

Figure 23: Shares of transport greenhouse gas emissions in the EU-28 in 2016 (own illustration, data source: EEA)



98 Light-duty vehicles includes passenger cars and vans, while heavy-duty vehicles encompass trucks, buses and coaches.

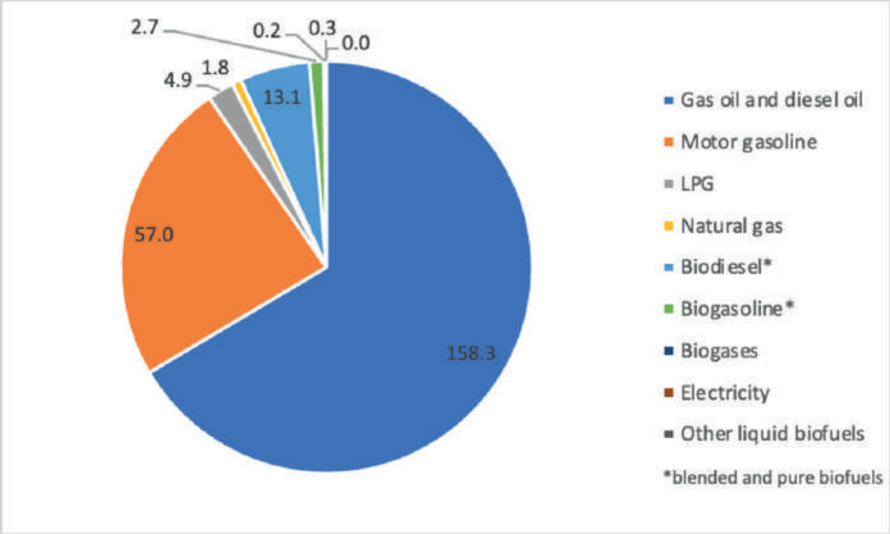
99 See the blogpost on the difference between transport and mobility by Forum for the Future in November 2019: https://www.forumforthefuture.org/blog/transport-or-mobility (accessed 4 March 2022).

Transport is relevant not only in terms of GHG emissions but also in terms of pollution, even though in recent years the situation has gradually improved with significant reductions in emissions of carbon monoxide, non-methane volatile organic compounds, sulphur oxides and nitrogen oxides. Since 2000, there has been a reduction in particulate matter emissions (44% for PM2.5 and 35% for PM10).[100]

The Covid-19 pandemic and the resulting economic standstill led to a drop in CO2 equivalent emissions in the transport sector. According to IEA, the global emission reductions resulting from a drop in oil use in the transport sector accounted for more than 50% of the total global reduction in CO2-equivalent emissions in 2020. In the EU, final energy consumption by road transport dropped from 270 Mtoe to 238 Mtoe between 2019 and 2020, a reduction of about 12% (Eurostat, 2020).

In terms of energy consumptions, road transport is dominated by internal combustion engines, in particular oil and gasoline, as is shown in Figure 24. The road to decarbonised mobility is still long.

Figure 24: Shares of modes of road transport by fuel in the EU-27, 2020 in Mtoe (own illustra tion, data source: Eurostat, 2020)



Even though the modal split[101] varies considerably among EU Member States, in 2018 road transport accounted for 75.3% of total inland freight transport in the EU in terms of tonnes per kilometre. Rail transport accounted for 18.7% of the EU total, while the share of inland waterways was 6% of total inland transport. Interestingly, in terms of tonnage, maritime transport was the most significant mode of long-distance goods transport to and from the EU (with almost two-thirds going to or from ports outside the EU). Of the 20 top EU cargo ports in 2018, 11 were located in the Mediterranean, 8 on the North Sea coast of Europe and one on the Atlantic coast.

In 2017, passenger cars were by far the predominant mode of inland passenger transport in the EU Member States (they constituted 91% of all passenger transport in Lithuania). However, there were relevant differences among Member States, as is shown in Figure 25.

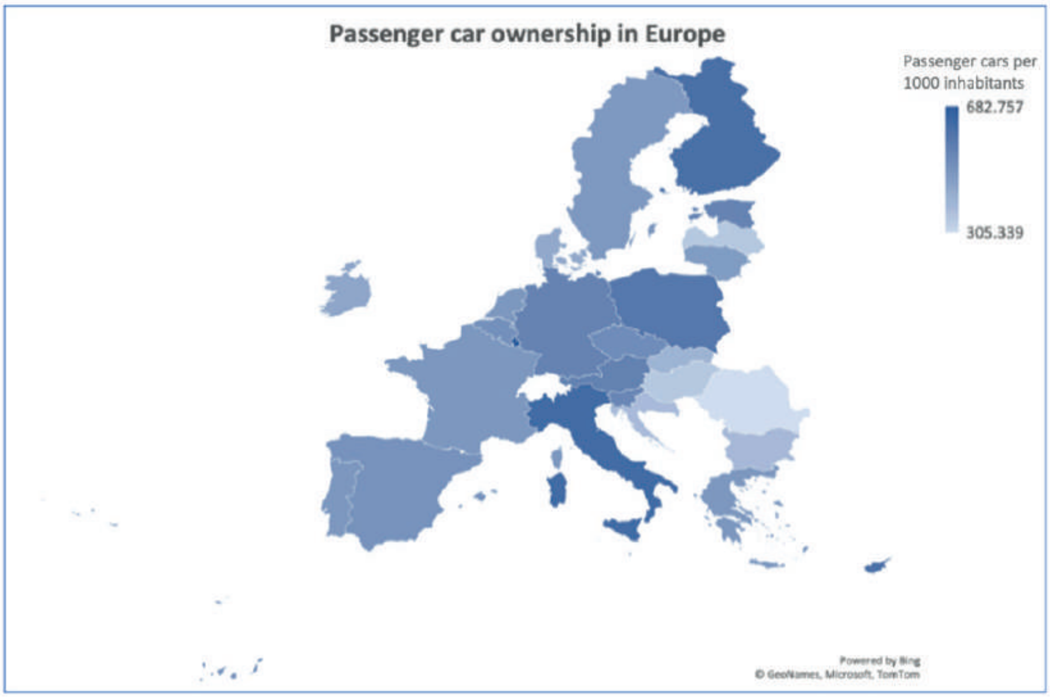
The total number of air passengers transported in the EU reached almost 1 billion in 2018. Germany was the EU Member State carrying the highest number of passengers that year. When it comes to maritime

100 Since 1990 emissions of air pollutants have decreased for all modes of transport except shipping, for which nitrogen oxide emissions have increased, and aviation, for which emissions of all pollutants (except non-methane volatile organic compounds) have increased.

101 The 'Modal split' of transport refers to the relative shares of each mode of transport, for example road, rail and sea. It is based on passenger-kilometres (p-km) for passenger transport and tonne-kilometres (t-km) for freight and goods transport and it is usually defined for a specific geographical area and/or time period.

transport, the total number of passengers embarking and disembarking in EU ports in 2018 was estimated at around 410 million.

Figure 25: Passenger car ownership in EU in 2017 (own illustration, data source: EEA)



What is the vision for the green and digital transformation of the EU transport sector?

In order to reach carbon neutrality by 2050, the European Green Deal includes a target to reduce transport-related GHG emissions by 90% (compared to 1990 levels) by 2050, delivering a smart, competitive, safe, accessible and affordable transport system. To do this, all modes of transport need to be made more sustainable, sustainable alternatives need to be made widely available in a multimodal transport system and the right incentives to drive the transition need to be put in place. In this regard, policy actions must strive to reduce the current dependence on fossil fuels, promote intermodal transport and internalise external environmental costs.

In December 2020, the Commission published its Sustainable and Smart Mobility Strategy (EC, 2020), which targets all modes of transport. It includes a roadmap that sets out how the EU transport system can achieve this transformation and sets concrete milestones to keep the transport system's journey towards a smart and sustainable future on track. The strategy pays close attention to three key objectives, namely making the EU transport sector sustainable, smart and resilient. The main milestones that the strategy sets are the following.

By 2030:

- at least 30 million zero-emission cars in operation on European roads;
- 100 climate-neutral European cities;
- carbon neutral scheduled collective travel for journeys under 500 km;
- large scale deployment of automated mobility;
- ready-for-market zero-emission vessels.

By 2035:

- ready-for-market zero-emission large aircraft.

By 2050:

- zero emissions from nearly all cars, vans, buses and new heavy-duty vehicles;
- a doubling of rail freight traffic and a tripling of high-speed rail traffic
- a fully operational multimodal trans-European transport network (TEN-T) for sustainable and smart transport with high-speed connectivity.

What are the most relevant EU strategies and legislation to decarbonise transport?

To achieve the targets, not only transport but also the related infrastructure is an important element to consider. Below we explore in more detail proposals related to the Fit for 55 Package concerning emission standards and the deployment of an alternative fuel infrastructure. We also look at the revision of the TEN-T Directive, which is part of the Mobility Package released by the European Commission in December 2021 (EC, 2021a).

Emission targets

Since 1 January 2020, CO2 emission standards for new passenger cars and vans have been regulated by Regulation (EU) 2019/631 (EP and Council, 2019). The current targets are that average CO2 emissions from new passenger cars and vans have to be 37.5% lower in 2030 than in 2021 and for new vans the reduction is 31% by 2030.

As part of the Fit for 55 Package, the European Commission proposed revising Regulation (EU) 2019/631 setting more ambitious CO2 emission targets for new cars and vans from 2030 onward (EC, 2021b). It contains significant goals:

- 55% reduction of emissions from cars by 2030;
- 50% reduction of emissions from vans by 2030;
- zero emissions from new cars and vans by 2035.

In June 2022, the Parliament adopted its position on the basis of a document drafted by the deferred Committee (EP, 2022) It supports the proposed targets for 2030 and 2035, abolishes the post-2025 incentive mechanism for zero-and low-emission vehicles (ZLEVs), and gradually reduces the maximum contribution of eco-innovations to manufacturers' targets. The position also introduces a number of obligations for the Commission, which will have to define in the coming years calculation methodologies for the life-cycle assessment of CO2 emissions from cars and vans, as well as the fuel and energy consumed by these vehicles, and measure and compare the efficiency of ZLEVs. Furthermore, by December 2024, the Commission is to submit a legislative proposal to set minimum energy efficiency thresholds for new cars and vans. Contextually, the Council adopted its general approach, which largely follows the Commission's proposal (Council, 2022).

In addition to the revision of Regulation (EU) 2019/631, the EC proposed establishing a separate Emission Trading System (ETS) (EC, 2021c) for the transport sector from 2026. The aim is to put a price on GHG emissions from transport, stimulating cleaner fuel use and re-investing in clean technologies. The new EU ETS would apply to fuel suppliers and the revenue could be used not only for investment in technological developments but also to address social impacts arising from the new emission trading system. The mechanism should work in combination with a credit mechanism introduced in the revision of RED II. In order to promote electro-mobility, economic operators that supply renewable electricity to EVs via public charging stations will receive credits that they can sell to fuel suppliers, who can use them to satisfy their fuel supplier obligations (see also section 2.2).

The Commission is also proposing carbon pricing for the aviation sector, which has so far benefited from an exception, and to promote sustainable aviation fuels – with an obligation for planes to be powered by sustainable blended fuels for all departures from EU airports.

Regarding maritime transport, the FuelEU Maritime proposal (EC, 2021d) aims to promote low-carbon fuels by introducing limits on the carbon intensity of ships and mandates the use of onshore power supply in EU ports. As of 2025, the GHG intensity of energy used on board would start to decrease by 2% compared to a 2020 baseline. More stringent additional targets are set for 2030 and 2050, with improvements of 6% and 75% respectively.

Alternative fuel infrastructure

The need to deploy alternative fuel refuelling and recharging infrastructure in the Member States and guarantee long-term investment in alternative fuels and vehicles led to the adoption of the Alternative Fuel Infrastructure Directive (AFID) in 2014 (EP and Council, 2014). While not setting mandatory targets, AFID sets the direction for the national policy framework (NPF) of each Member State. Its main objectives are to ensure the deployment of an adequate public recharging infrastructure for electric vehicles (EVs) and to instal shore-side electricity supply for inland waterway vessels and seagoing ships. Adequate infrastructure deployment should also be guaranteed for natural gas supply, while the possibility of including hydrogen refuelling infrastructure in their NPFs was left to the Member States.

The AFID is being reviewed as part of the Green Deal. The proposal is to replace the directive with a regulation (AFIR) that sets mandatory national targets for the deployment of alternative fuel infrastructure (EC, 2021e). Together with provisions in the proposed amended Renewable Energy Directive (RED III), it is intended to form the backbone of the turnaround in mobility on the road.

Recharging stations for electric vehicles

For electric vehicles, the AFIR proposal sets out both national fleet-based targets for light-duty road vehicles and national distance-based targets for both light-duty and heavy-duty vehicles. For every EV a total power output of at least 1 kW should be provided at publicly accessible recharging stations. Publicly accessible recharging pools dedicated to light-duty vehicles should be deployed in each direction of travel with a maximum distance of 60 km between them. For heavy-duty vehicles the same target is applied in the TEN-T core network, while in the TEN-T comprehensive network the limit is fixed at 100 km. Other targets concern electricity supply for vessels in port and stationary aircraft.

Smart and bi-directional charging

Smart recharging can facilitate the integration of electric vehicles in the electricity system as it enables demand response (DR) through aggregation and through price-based demand response. In this regard, the AFIR proposal sets out that by 30 June 2024 at the latest (and periodically every three years thereafter) the regulatory authority of each Member State should assess the potential contribution of bi-directional charging to the penetration of renewable electricity in the electricity system on the basis of data made available by TSOs and DSOs.

Recharging operations should be facilitated by paying easily and conveniently at all publicly accessible recharging and refuelling points, which should accept payment instruments that are widely used in the Union, and in particular electronic payments.

Refuelling stations for hydrogen and LNG vehicles

For hydrogen, the AFIR proposal sets out that publicly accessible refuelling stations should be deployed with a maximum distance of 150 km between them in the TEN-T core network by the end of 2030 and with a minimum capacity of 2 t/day and equipped with at least a 700 bar dispenser. Liquid hydrogen will be made available at publicly accessible refuelling stations with a maximum distance of 450 km between them. Lastly, MSs will have to provide a minimum coverage of publicly accessible LNG refuelling stations for heavy-duty vehicles at least in the TEN-T core network and in maritime TEN-T ports.

The trans-European transport network

Regulation (EU) No 1315/2013 (EP and Council, 2013) sets out guidelines for developing a trans-European transport network (TEN-T). The regulation lists compulsory targets to be reached, which are defined by key performance indicators. TEN-T has a dual-layer structure consisting of a core network and a comprehensive network. The core network consists of nine interconnected multimodal transport corridors going through several countries, while the complementary network aims to ensure accessibility and connectivity for all regions in the EU. Due to its economic relevance, the core network must be completed by 2030, while the deadline for realisation of the comprehensive network is 2050.

In December 2021, the Commission proposed a revision of the TEN-T regulation (EC, 2021f) to reflect the priorities in the European Green Deal, the Sustainable and Smart Mobility Strategy and the Global Gateway Connectivity Strategy.

In addition to introducing a midterm target of 2040 for completion of the core extended network, the proposed revision of the TEN-T introduces a series of novelties compared to the 2013 regulation regarding infrastructure standards, synergies between infrastructure planning and the operation of transport services, requirements for deploying charging and refuelling infrastructure, use of innovative technologies like 5G, increased resilience of infrastructure to natural disasters and a requirement for 424 major cities in the TEN-T network to have sustainable urban mobility plans by 2050.

The revision of the TEN-T Regulation intertwines with revision of other policy initiatives in the package of measures for efficient and green mobility, namely:

- A revision of the Intelligent Transport Systems Directive (EC 2021g) that stimulates faster deployment of new intelligent services by proposing that certain crucial road, travel and traffic data are made available in digital format;
- An Action Plan on Rail (EC, 2021h) that aims to boost long-distance and cross-border passenger rail services;
- An EU Urban Mobility framework (EC, 2021i) that aims among other things to ensure neither capacity bottlenecks nor insufficient network connectivity in urban nodes can hamper multimodality in the trans-European transport network.

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4. EU energy markets

This chapter is divided in four parts. First, we introduce electricity wholesale markets. Second, we present gas wholesale markets. Third, we outline retail markets and the new deal. Finally, we look at the concepts of a just energy transition and energy poverty.

4.1 Electricity wholesale markets

Tim Schittekatte and Leonardo Meeus

This section is split int two parts. In the first part, we give an overview of how electricity markets are organised in Europe. In the second part, we provide more information on the European regulations that shape these markets: the EU Electricity Network Codes and Guidelines.

Part I – Overview of electricity market organisation in Europe

In this first part, we provide an overview of how electricity markets are organised in Europe by answering three questions. First, why do we have so many electricity markets? Second, which electricity markets are there and how do they work? And third, what does the future hold?

Why do we have so many electricity markets?

Electricity can be considered a commodity just as copper, oil and grain are. However, electricity markets differ substantially from other commodity markets. This is due to the physical characteristics of electricity:

- *Time*: large volumes of electricity cannot (yet) be stored economically. Therefore, electricity has different values over time.
- *Location:* electricity flows cannot be easily and efficiently controlled, and transmission components must be operated under safe flow limits. If not, there is a risk of cascading failures and blackouts. Therefore, electricity has different values over space.
- *Flexibility*: demand and generation must match each other at all times. Otherwise, there is a risk of blackout. However, demand and the availability of renewable energy resources can sharply vary over time, while some power stations can only change their outputs slowly and can take many hours to start up. In addition, power stations can suddenly fail. Therefore, the ability to change generation/consumption of electricity at short notice has a value.

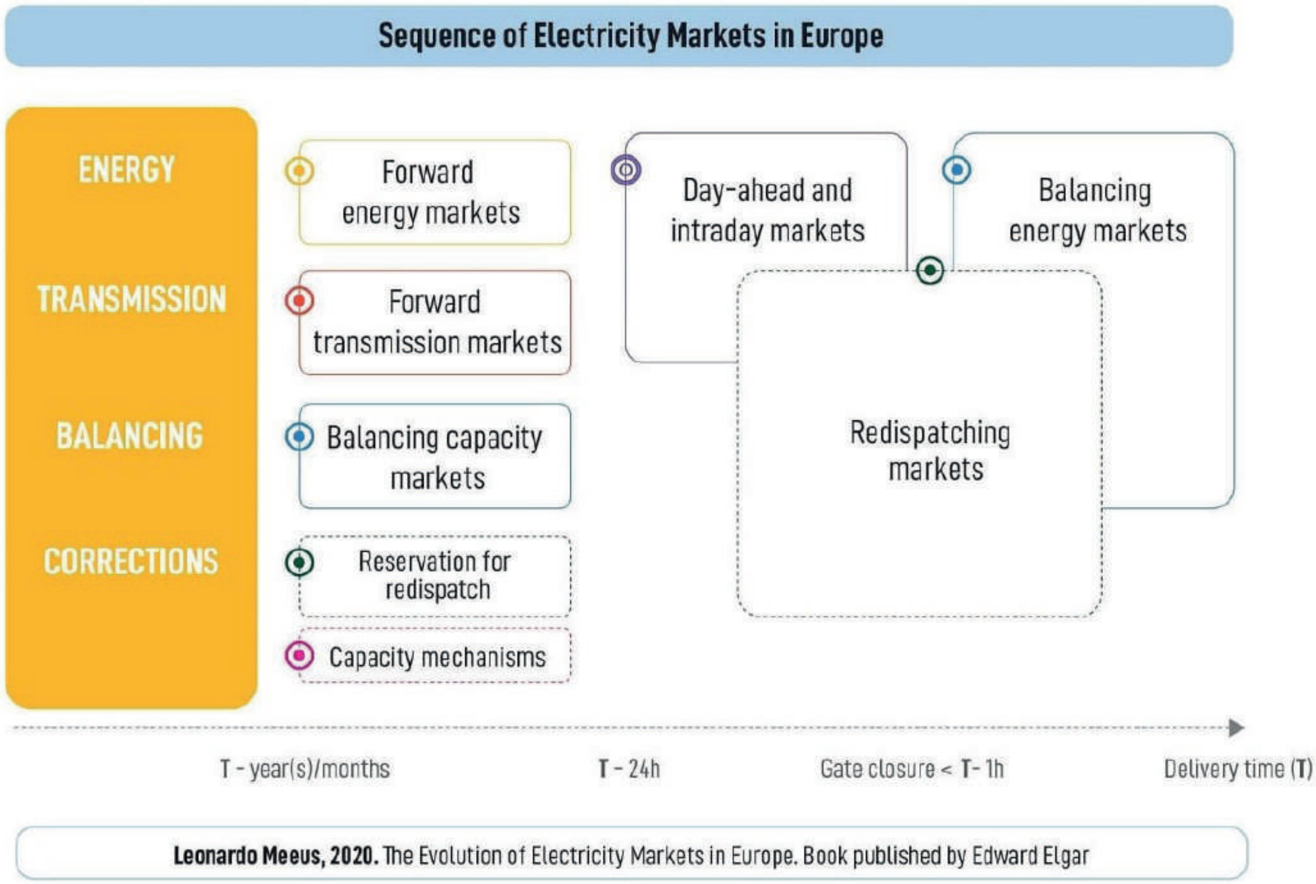
These three unique physical characteristics explain why there is not just one electricity market. Electricity is not only energy in MWh. Transmission capacity and flexibility are scarce resources and should be priced accordingly. Therefore, electricity (energy, transmission capacity, flexibility) is exchanged in several markets until actual delivery in real time. Note that while in the EU electricity markets have been deregulated, other regulatory models can be in place in other parts of the world.[102]

Which electricity markets do we have in Europe and how do they work?

Figure 26 shows a schematic overview of the electricity markets that currently exist in the EU. We group the markets in four clusters and address them one by one in the following subsections.

102 For a comprehensive overview of regulatory models in the power sector, see <https://fsr.eui.eu/regulatory-models-in-the-power-sector/>.

Figure 26: Schematic overview of the typical sequence of existing electricity markets in the EU. Markets in dotted lines are optional (Meeus, 2020)



Long-term markets (forward energy markets, forward transmission markets and capacity mechanisms)

Forward energy markets trade in electricity more or less four years up to one month before delivery. A financial exchange organises trade using standardised products, or market parties can make bilateral over-the-counter (OTC) deals. The energy prices negotiated are denominated by bidding zone,[103] which in most cases overlaps with national borders. The market does not consider potentially limiting network elements in a bidding zone, i.e. the bidding zone is seen as a copper plate. This is the essence of the so-called zonal electricity pricing system in place in the EU. Figure 27 shows the current bidding zone configuration in Europe. If a market party wants to hedge prices across bidding zones, long-term cross-zonal transmission rights need to be acquired separately on the Joint Allocation Office (JAO) platform. The platform is a joint TSO service company.

Besides forward energy and forward transmission markets, in the longer-term timeframe Member States can decide to set up a capacity mechanism if deemed necessary for adequacy reasons. Capacity mechanisms exist in many forms and are often organised by the TSO. Capacity procurement takes place one to about four years before delivery (see section 3.2 for more on capacity mechanisms).

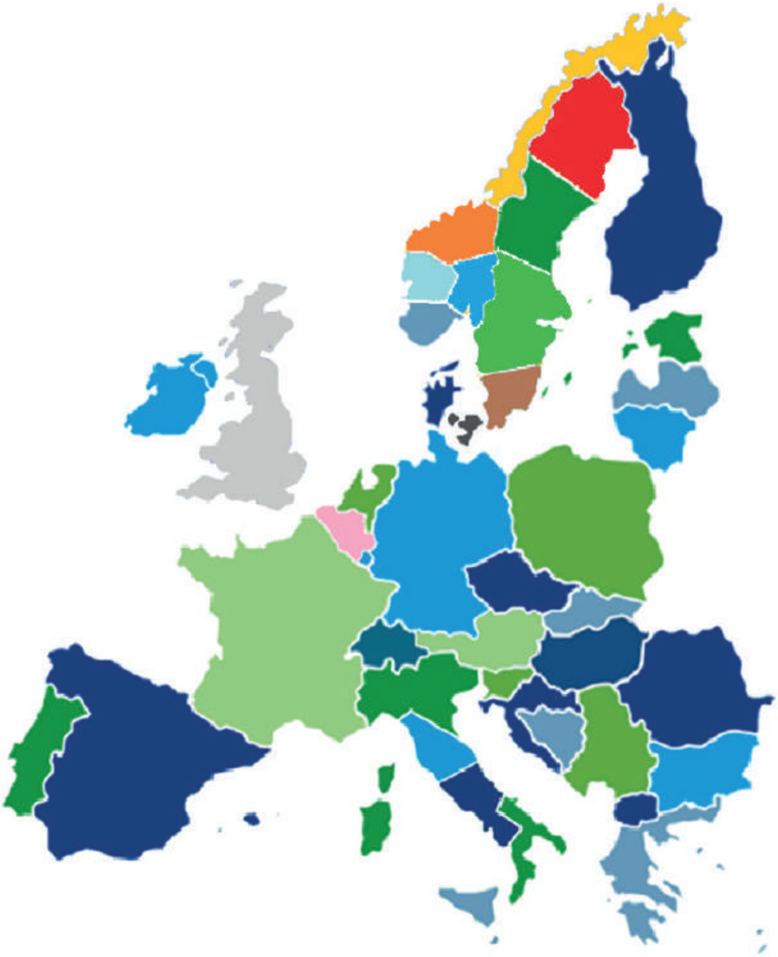
Wholesale or spot markets (day-ahead and intraday markets)

There is no obligation for market parties to buy and sell their energy on the spot market. Spot markets

103 For a comprehensive explanation of the concept of bidding zones, see Schittekatte et al. (2020).

are often used to adjust long-term positions closer to delivery. Importantly, although volumes traded in the wholesale markets are in some cases only a fraction of the final volume of electricity generated, the wholesale prices serve as the price reference in long-term contracts (see also Pérez-Arriaga, 2013).

Figure 27: The bidding zone configuration in Europe in March 2021 (modified from Schittekatte et al., 2020)



The day-ahead market consists of one pan-European auction at noon for the 24 hours of the following day. All bids accepted are paid the marginal offer. Trading is organised by one or several power exchanges (PXs) in each Member State. At the time of writing, single day-ahead coupling (SDAC) allowing efficient trade between all European bidding zones in the day-ahead timeframe is almost finalised. Electricity prices in neighbouring bidding zones diverge for a particular hour if all cross-zonal transmission capacity available for trade is utilised ('market congestion').[104] If not, prices converge between bidding zones. After the day-ahead market is cleared, the intraday market opens. Currently, trading in the intraday market is done via continuous trading (as on a stock exchange) in some countries and via auctions in other countries. Under continuous intraday trading, cross-zonal trading is typically possible on a first-come-first-served basis until the available cross-zonal capacity is fully utilised. It has recently been decided that the future intraday European model will consist of a combination of continuous trading with three European-wide auctions at pre-defined times.

104 This is true under the simplest form of cross-zonal capacity allocation (net transfer capacity allocation) but is slightly more complicated in a setting with flow-based market coupling.

Balancing markets (balancing capacity and balancing energy markets)

After trading in the intraday market closes, a balancing mechanism is in place to ensure that supply equals demand in real time. Each TSO is responsible for the real-time balance in its control area.[105] To do this, each TSO organises balancing markets where it procures the resources needed to balance the system. Balancing markets consist of balancing capacity markets and balancing energy markets. In balancing capacity markets, contracted balancing service providers (BSPs) are paid an availability payment. Contracting is done between one year ahead and one day ahead of delivery to make sure that there will always be enough balancing energy available in real time. The BSPs contracted in the balancing capacity market (and other BSPs without contracted balancing capacity) then offer their balancing energy in the balancing energy markets. The volume of energy activated depends on real-time imbalances.

Transmission re-dispatch 'markets' (Reservation for re-dispatch and re-dispatching markets)

Redispatch is needed when the market outcome (in this case in the day-ahead or intraday market) results in generation and consumption schedules that would lead to potential violation of operational limits (e.g. thermal limits, voltage ranges, etc.) of a certain network element in a bidding zone. Such a situation occurs regularly, as typically transmission network elements in a bidding zone are not considered when trading in wholesale markets. Only the physical limits of network elements between bidding zones are considered.[106] Typically, re-dispatch involves increasing or decreasing the output of a generator at the end of a potentially congested line. The Clean Energy Package prescribes organising re-dispatching by default in a market-based manner (Regulation (EU) 2019/943, Art. 13). Currently, in most EU Member States generators are still legally obliged to participate in re-dispatch and prices are regulated, i.e. the audited costs (in the case of upward activation) or foregone opportunity costs on the wholesale market (in the case of downward activation) are paid to the owner of the re-dispatched resources. Some Member States have merged the balancing energy and re-dispatching markets.

What does the future hold?

Europe started the process of harmonising and integrating national electricity markets with the first Electricity Directive in 1996 (see section 1.2). Since then, we have seen much progress. For example, ACER and CEER's (2020) Market Monitoring report states that market coupling has so far benefitted European consumers approximately 1 billion euros a year. However, we are facing important challenges, of which we briefly describe one at high-voltage levels and one at low-voltage levels in the following.

At high-voltage levels, the current bidding zone configuration is under pressure. Grid expansion cannot keep up with the impressive capacities of renewables installed, and consequently, among other problems, redispatch costs are high and still rising. How bidding zones can be reconfigured is subject to heavy debate at the European level.[107] At low-voltage levels, distribution networks would need to be expanded in order to deal with the increasing number of PV panels installed by consumers, and electrification of transport (electric vehicles) and heating (heat pumps). Electrification is expected to accelerate even more driven by the ambitions set out in the European Green Deal. Flexibility markets can be used to limit costly grid expansions at low-voltage levels. How these new flexibility markets will be integrated in the existing

105 A control area is defined as a coherent part of the interconnected system operated by a single system operator. More information can be found in Schittekatte et al. (2020).

106 In practice, some internal transmission network elements are considered in the market coupling algorithm but not priced. However, there are only a few of these and ACER (2016) strongly discourages inclusion of internal network elements in market coupling.

107 See, for example, the event highlights at the FSR policy workshop on bidding zones in June 2020, available at <https://fsr.eui.eu/bidding-zones-configuration-liquidity-and-competition-in-the-electricity-market/ >.

sequence of markets remains an open issue (Schittekatte and Meeus, 2020).[108]

Part II – EU Electricity Network Codes

In this part of the section, we provide more information about EU electricity network codes. First, we explain what a network code is, describe the background to the EU electricity network codes, and list the eight currently existing network codes. We then explain how these network codes were developed and who they apply to. Finally, we explain the difference between network codes and guidelines and give an outlook on changes that the Clean Energy Package brought to the network code landscape.

What is a network code?

A network code (NC) is a set of technical rules enabling the development of the internal energy market in Europe. The NCs address the major barriers impeding the cross-border flow of electricity and gas, transforming a mere patchwork of national energy markets into a single European energy market. The NCs guide the integrated operation of cross-border energy networks to allow increasing competitiveness, more cost-efficient integration of renewables and a secure supply of energy at prices that are affordable for European consumers.

Network codes address market, system operation and grid connection rules, the so-called 'software' of the EU internal energy market. The Trans-European Energy Networks (TEN-E) Regulation (EU) No 347/2013 addresses cross-border infrastructure investment, the 'hardware' of the internal energy market.[109]

Background to the electricity network codes and guidelines

The currently adopted EU electricity network codes originated in the 2009 Third Energy Package (see section 1.2). The Third Energy Package is a set of laws that are part of the process liberalising the electricity and gas markets initiated back in the mid-1990s. More specifically, Regulation (EC) No 714/2009 set out the areas in which electricity network codes can be developed and a process for developing them.

In 2017, after a four-year co-creation process carried out by the European Network of Transmission System Operators for Electricity (ENTSO-E), the European Union Agency for the Cooperation of Energy Regulators (ACER), the European Commission (EC) and many involved stakeholders from across the electricity sector, eight network codes and guidelines were developed and entered into force. After the development of the network codes, the implementation phase started.

Eight electricity network codes and guidelines adopted

Currently, there are eight network codes and guidelines that have been published in the Official Journal of the European Union as Commission Regulations. Commission Regulations usually enter into force twenty days after publication unless explicitly stated otherwise. Figure 28 illustrates how these eight regulations can be subdivided in three groups.

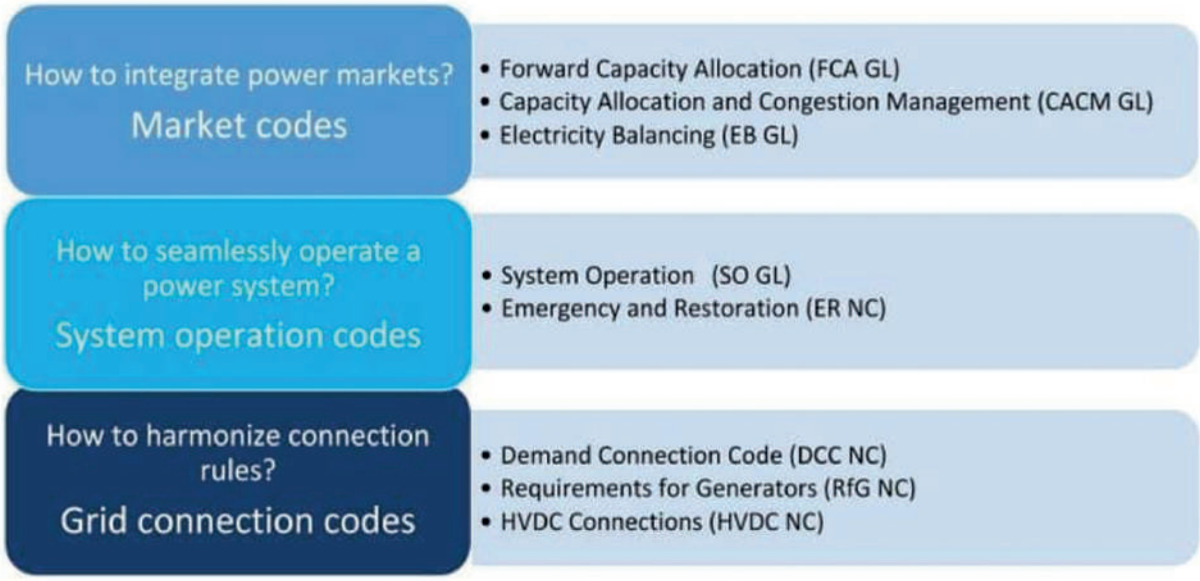
In the following, we list the eight regulations and give some examples of topics covered in each of them.[110]

108 A detailed overview of the evolution and organisation of electricity markets in Europe and a discussion of open issues is provided in the open access book by Meeus (2020) and the technical report by Schittekatte et al. (2020).

109 For a comprehensive overview of the TEN-E Regulation, see <https://fsr.eui.eu/the-ten-e-regulation/>.

110 An in-depth description of network codes and guidelines is provided in Schittekatte et al. (2020).

Figure 28: Electricity network codes and guidelines. Own illustration



- The capacity allocation and congestion management guideline (CACM GL). The CACM GL fosters efficient integration of the European power markets in the day-ahead and intraday timeframe. The guideline covers topics such as governance of power exchanges, criteria for bidding zone delineation and allocation of cross-zonal transmission capacity in the day-ahead and intraday timeframe.[111]

- The forward capacity allocation guideline (FCA GL). The FCA GL harmonises the allocation rules on long-term cross-zonal transmission rights. The guideline covers topics such as setting up a pan-European platform for the allocation of long-term transmission rights, types of long-term transmission rights and rules on curtailment of long-term transmission rights.

- The electricity balancing guideline (EB GL). The EB GL aims to harmonise and integrate the European balancing energy markets. The guideline covers topics such as the European platforms for the exchange of balancing energy, imbalance settlement and allocation of cross-zonal transmission capacity in the balancing timeframe.

- The electricity transmission system operation guideline (SO GL). The SO GL sets minimum system security, operational planning and frequency management standards to ensure safe and coordinated system operation across Europe. Examples of topics that are covered are balancing capacity requirements and setting up regional security centres.

- The network code on electricity emergency and restoration (ER NC). The ER NC sets out rules for the management of the transmission system in the case of emergencies and blackouts, and other different system critical states that are defined in the SO GL. It also addresses suspension and restoration of market activities.

- The network code on requirements for grid connection of generators (RfG NC). The RfG NC covers requirements for generators (synchronously and asynchronously connected) to be connected. The RfG

111 Note that there is an ongoing process to amend and improve the CACM GL. More information is provided by ACER at https://www.acer.europa.eu/events-and-engagement/news/acer-provides-recommendation-reasoned-amendments-capacity-allocation-and (accessed 17 March 2022).

NC fosters robustness of the European electricity network and intends to establish a level playing field in terms of connection requirements for generators. Examples of topics covered are frequency bands to remain connected, voltage limits and reconnection and re-synchronisation capabilities.

- The demand connection network code (DC NC). The DC NC covers requirements for demand facilities and distribution systems to be connected. The DC NC fosters robustness of the European electricity network and intends to establish a level playing field in terms of connection requirements for load. As under the RfG NC, examples are frequency bands to remain connected, voltage limits and reconnection and re-synchronisation capabilities.
- The requirements for grid connection of high voltage direct current systems and direct current-connected power park modules network code (HVDC NC). The HVDC NC covers requirements for long distance direct current (DC) connections. The HVDC NC fosters the robustness of the European electricity network and intends to establish a level playing field in terms of connection requirements for HVDC connections.

How were these network codes developed?

The key actors involved in the development of the network codes were the European Commission, the Agency for the Cooperation of Energy Regulators (ACER) and the European Network of Transmission System Operators for Electricity (ENTSO-E). They had unequal roles.

The development process for the network codes resulting from the Third Energy Package is detailed in Regulation (EC) No 714/2009. First, after having consulted ACER, ENTSO-E and other relevant stakeholders the European Commission drafted annual priority lists, which identified possible areas for network code development.

Following a request from the Commission, ACER prepared non-binding Framework Guidelines stipulating the key principles for development of the network codes. The European Commission requested ENTSO-E to draft the text of the network codes, which had to be in line with the relevant Framework Guideline developed by ACER. The drafts became a network code after their adoption was recommended to the European Commission by ACER and approved by a committee composed of national experts (Electricity Cross-Border Committee) using the comitology procedure.[112] At the end of the comitology procedure, the Commission adopted the network codes as implementing acts.[113]

Who do they apply to?

The network codes concern the operation of energy (electricity and gas) networks connecting two or more EU Member States and countries which constitute part of the European Economic Area. However, over the past few years some non-EU countries have opted for voluntary adoption of NCs, e.g. the Energy Community Contracting Parties (see section 1.2).

Similarities and differences between a network code and a guideline

We commonly refer to these eight regulations as 'network codes.' However, not all of them are legally defined as such. Just four of the eight are defined as network codes (ER NC, RfG NC, DC NC and HVDC NC). The other four are referred to as guidelines (CACM GL, FCA GL, EB GL and SO GL). Initially, all

112 Information on comitology is provided by the European Commission at <https://ec.europa.eu/info/law/law-making-process/adopting-eu-law/implementing-and-delegated-acts/comitology_en>.

113 A comprehensive overview of the legal perspective on network codes and guidelines is provided in Hancher et al. (2020).

eight were planned to be developed as network codes, yet some became guidelines in the development process. In theory, network codes and guidelines can cover the same topics. In practice, however, it is observed that some topics lend themselves better to guidelines than to network codes and others vice versa.

Network codes and guidelines are similar in that they carry the same legal weight (both are Commission regulations and are legally binding), are directly applicable (they do not need to be transposed into national law) and are subject to the same formal adoption procedure (the ‘old’ comitology procedure). Network codes and guidelines differ regarding their legal basis, stakeholder involvement, amendment processes, topics, scope and the adoption of further rules during the implementation phase (see also Meeus, 2020).

The main practical difference is the work to do during the implementation phase. In general, network codes are more detailed than guidelines. This is because guidelines shift a larger share of further development to the implementation phase, which can allow more flexibility but can also slow down or complicate the overall process. Guidelines include processes in which TSOs or Nominated Electricity Market Operators (NEMOs) must develop so-called ‘Terms and Conditions or Methodologies (TCMs).’ TCMs are comprehensive (legal) texts that are often referred to as ‘methodologies.’ In most cases, methodologies have to be jointly developed by all TSOs or all NEMOs at the pan-European level or by the relevant TSOs/NEMOs at the regional or national levels. Depending on the scope of methodologies, the Third Package foresaw them being approved either by all National Regulatory Authorities (NRAs) (pan-European methodologies) or the relevant subset of NRAs (regional and national methodologies). In certain cases, a decision is to be referred to ACER. The implementation of TCMs foreseen in the first generation of network codes and guidelines will continue until around 2025.[114]

Clean Energy Package: additional network codes and guideline areas

In its Clean Energy Package (CEP) issued in November 2016 and approved in late 2018, the European Commission proposed a recast of Regulation (EC) 714/2009. Adoption of the Clean Energy Package brought significant changes for both existing and future generations of EU network codes and guidelines.

First, the recast of Regulation (EC) 714/2009 includes provisions that modify the operation of a number of the network codes and guidelines. Moreover, additional areas for a ‘second generation of network codes and guidelines’ were identified. Examples are rules on demand response, including aggregation, energy storage and demand curtailment, and rules for non-discriminatory and transparent provision of non-frequency ancillary services.[115]

Second, the development process saw a shift in roles and responsibilities. The strong role of ENTSO-E in drafting the network codes was reduced. The CEP also mandated the establishment of an EU DSO entity to involve Distribution System Operators (DSOs) in the network code and guideline drafting process. The role of ACER in the development phase is expected to increase. Another change concerns the time interval in which the European Commission is required to compile a priority list for new network codes.

Third, changes were introduced in the adoption process for both TCMs and new network codes and guidelines. Regarding TCMs, ACER now directly decides on methodologies at a pan-European scale (the former ‘all NRA’ decisions). Regarding network codes and guidelines, the Clean Energy Package distinguishes between the adoption of network codes and guidelines as implementing or delegated acts. Depending on the type of act, the European institutions and stakeholders have different rights and possibilities to intervene in the adoption process.

114 More details on network codes versus guidelines are provided in a FSR blog post available at <https://fsr.eui.eu/network-codes-versus-guidelines/>.

115 More information on the second generation of network codes and guidelines is provided in Reif et al. (2021).

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4.2 Gas wholesale markets

Ilaria Conti and James Kneebone

In this section we break down the wholesale markets for natural gas and the associated supply chain. This includes the composition of 'natural gas' and its applications, the supply chain that brings it from production to consumption, the way the markets function and the future of natural gas markets in the EU. We also provide an overview of the existing EU Gas Network Codes.

What is 'natural gas'?

Natural gas is an odourless and colourless mixture of four gases, predominantly methane with smaller quantities of ethane, butane and propane. It serves a range of important functions, including heating, electricity generation, transportation and industrial applications. Natural gas currently constitutes roughly 22% of overall energy consumption in the EU (Eurostat, 2022).

The term 'natural gas' has historically referred to 'fossil methane,' a product of heat and pressure applied to organic matter in geological formations. The natural gas network as described in this section predominantly serves the extraction, transportation and use of this product. Nevertheless, to a much smaller (but growing) extent the same network now also serves 'biomethane,' another methane-based gas that can be used interchangeably and in combination with fossil methane. Like fossil methane, biomethane is also produced from decomposition of organic matter but it is not considered a fossil fuel. This is because biomethane is recovered from anaerobic digestion of organic matter (such as food and animal waste) above ground rather than extracted from fossil sources in geological formations underground. In this sense, there is a technical distinction between methane of fossil origin and methane of biogenic origin. Nevertheless, due to the similarities in their chemical composition the market is broadly unaffected by this distinction. In this section the term 'natural gas' will be used to describe the combination of fossil gas and biomethane that is used in the modern European gas network.

The natural gas value chain

What is the natural gas value chain?

The term 'value chain' or 'supply chain' in this context refers to the process, actors and infrastructure that bring natural gas from the point of production/generation to the end-user at the point of consumption. It is a complex series of interactions between actors and infrastructure that link together EU market actors across borders and connect the EU to the wider global natural gas value chain (Figure 29).

Figure 29: The EU natural gas infrastructure network, including entry points (ENTSOG, 2019)

Which are the actors in the value chain and what are their roles?

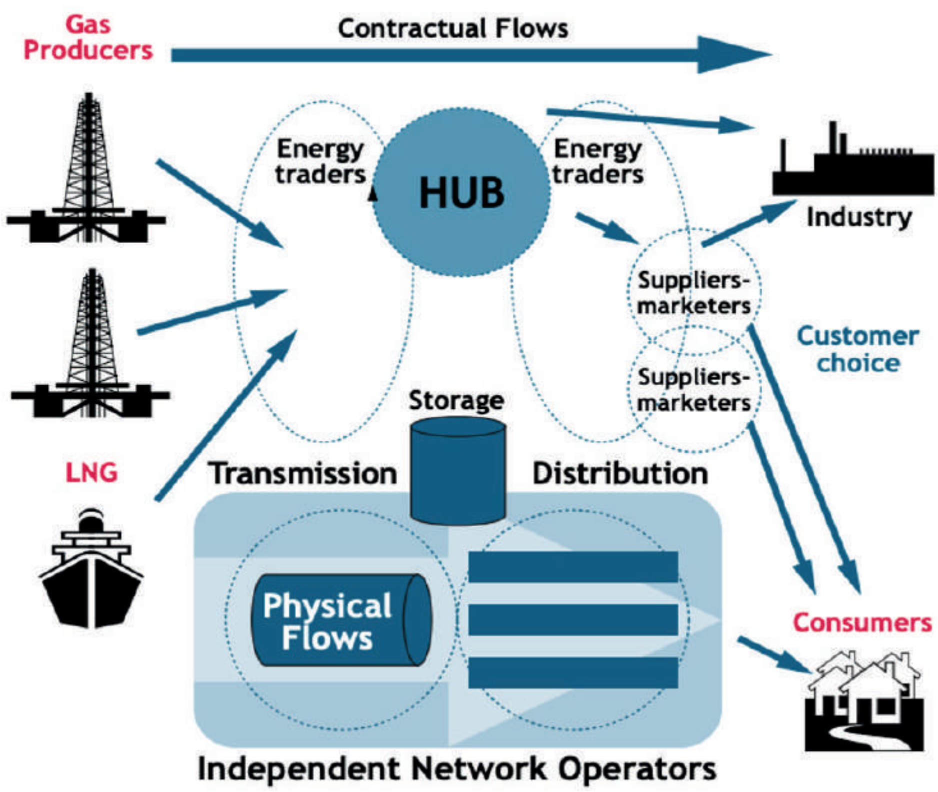
Actors in the natural gas value chain can be broadly categorised in three different segments:

- production/generation (upstream);
- transmission (midstream);
- distribution (downstream).

Generation or production includes exploration, drilling, collection, and processing of gas. Fossil gas extracted from the earth comes with impurities such as water, oil and trace gases. The upstream segment must therefore process these contaminants out of the product before it can be injected into the gas network. Similarly, biogas produced in anaerobic digesters must be further refined into biomethane before injection. These upstream operations are carried out by privately-owned or state-owned corporations that typically own the upstream assets.

Transmission is the process of transporting natural gas from the point of production to the distribution network, perhaps storing it along the way. The EU gas Transmission System Operators (TSOs) coordinate the flows of gas in the transmission network to keep it in balance (Figure 30).

Figure 30: Overview of natural gas value chain actors (EFET, 2005)



The gas being transported is owned and shipped by energy traders and shippers through a complex and extensive system. Natural gas can either be transported through large pipelines or converted into liquid natural gas (LNG) and transported on ships (or by rail or on trucks). Where the gas is not immediately required for use in the distribution network or where traders would rather store it for resale later, it is injected into a storage facility along the transmission network. Unlike electricity, natural gas can be stored cost-effectively for long periods of time, typically in underground reservoirs, such as salt caverns. The stability and cost-effectiveness of storing natural gas makes it a flexible energy vector, useful in balancing the electricity grid through combustion in gas fired power plants. Moreover, natural gas storage helps to account for seasonal variations in overall supply and demand and protects against security of supply concerns and price fluctuations (see section 3.1 for more details). Natural gas storage is managed at the operational level by Storage System Operators (SSOs).

Distribution is the final step in delivering natural gas to consumers. While some large industrial customers such as steel and chemical companies receive their natural gas directly from the transmission network, most users such as households and small businesses receive natural gas from a distribution company. These companies use local distribution networks of small pipelines to take natural gas from the transmission network and deliver it to the point of consumption. Before the natural gas reaches consumers it typically undergoes some further refining and the addition of an 'odour' to make it easier to identify leaks. The distribution network is coordinated by Distribution System Operators (DSOs).

How are the different components in the value chain organised and regulated?

Pipeline operation is considered a natural monopoly due to the scope and economies of scale associated with the infrastructure, for example it is far more efficient to have one large gas transportation pipeline than five small ones. The transmission segment used to be considered an operational branch of the incumbent company. However, liberalisation of the European gas market has brought many changes to the organisational characteristics of the network to increase competition and avoid market failures at the transmission and distribution levels. In its modern configuration, the different components of the supply chain must be owned and operated by separate companies to ensure owners of monopoly infrastructure such as pipelines do not distort the market. Producers, shippers and distribution companies must have contracts with the TSOs and DSOs to transport gas through the network. This process of disaggregating the supply chain is called 'unbundling.' It is a core pillar in EU energy policy as it promotes competition in the wholesale and retail energy markets with the ultimate scope of keeping prices for consumers low.[116]

Another important actor in the value chain is the energy regulator, which defines the rules applying to each segment of the supply chain. The scope of these interventions ranges from extraction techniques to consumer protection and ensures fairness and transparency for all the actors involved. In Europe, there is one national energy regulator for each member state.[117] These regulators are represented at the European level through ACER. There can be more than one national gas TSO and DSO in a member state. All the gas TSOs in Europe are represented by ENTSOG while there is currently no homologous association at the EU level for DSOs (see section 1.4 on EU agencies).

How does the natural gas market work?

Natural gas as a commodity

Natural gas is a commodity like electricity, oil or grain. Commodity markets are inherently volatile and natural gas is one of the most volatile commodities currently traded. The natural gas market has unique characteristics that differ from other commodity markets. This is primarily due to the physical characteristics of natural gas and the natural gas network. For example, the natural gas network is relatively centralised with a finite number of injection and offtake points. This creates a high level of dependence on certain pieces of infrastructure for the operation of the network. Certain natural gas infrastructure components require specific conditions to operate, for example pipelines operate at a given pressure which is directly related to the volume of gas flowing through them. The high variability of natural gas supply and demand can therefore put the proper functioning of the grid at risk. As a result, effective balancing in the network is crucial to avoid network failures.

Natural gas markets

There are two distinct markets for natural gas, the spot market and the futures market. The spot market is the daily market in which natural gas is bought and sold with immediate effect. This is the most accurate natural gas price at any given point. The futures market is used to purchase and sell natural gas with a contract between 1 and 36 months in advance. For example, in a simplified futures contract one could enter into an agreement today for physical delivery of gas in two months' time. Natural gas futures are traded on specific exchange platforms, for example the European Energy Exchange (EEX) and the New York Mercantile Exchange (NYMEX). Futures contracts are one of an increasing number of derivative contracts used in commodity markets. They can be quite complex and difficult to understand.[118]

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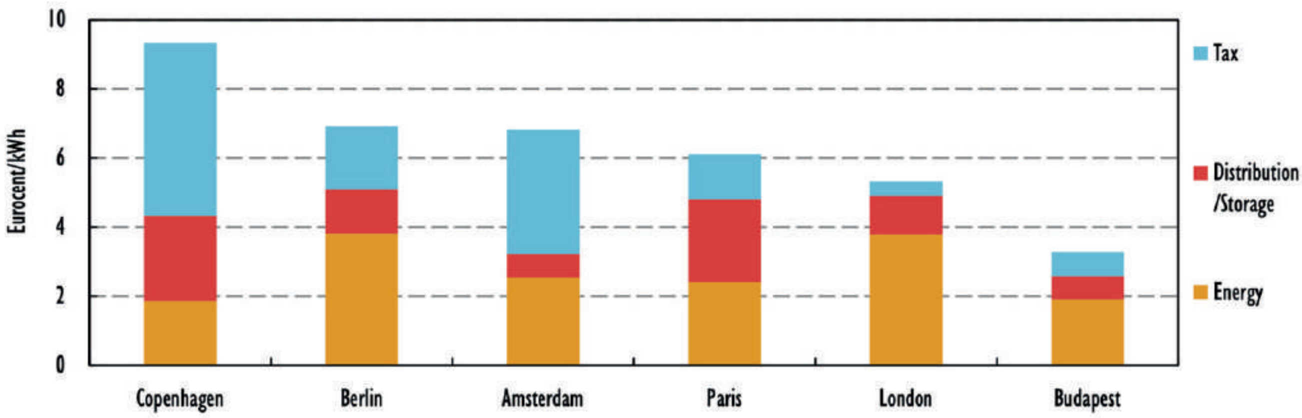
116 A comprehensive description of unbundling in the European gas and electricity sectors is provided in an FSR blog post available at <https://fsr.eui.eu/unbundling-in-the-european-electricity-and-gas-sectors/ >.

117 See the European Commission list available at https://ec.europa.eu/energy/topics/markets-and-consumers/energy-consumer-rights/protecting-energy-consumers/national-regulatory-authorities_en.

118 The European Securities and Markets Authority (ESMA) is an independent EU Authority in the field of securities regulation. It has the aim of improving the functioning of European financial markets and strengthening investor protection. See ESMA (2017, 2020) for information on the ESMA and derivative contracts.

Natural gas is priced and traded at different points around the world called 'market hubs.' These are either physical points located at the intersections of major pipeline systems or 'virtual hubs'[119] in the pipeline stocks of national transmission systems. The US hub ('Henry Hub') is located in Louisiana and futures contracts that are traded on the NYMEX are Henry Hub contracts, meaning they reflect the price of natural gas for physical delivery at this hub. An example of a virtual hub is the Italian Punto di Scambio Virtuale (Virtual Trading Point – PSV). The price at which natural gas trades differs among the major hubs (such as TTF, NBP, Henry Hub, Asean) depends on the supply and demand for natural gas at those particular points, e.g. Dutch Title Transfer Facility (TTF) versus Italian PSV. The difference between the price at one hub and another hub is called the 'location differential.' As is indicated in Figure 31, the traded price of natural gas often makes up the largest single component of its cost to consumers.

Figure 31: Composition of household retail natural gas prices in selected European cities (Euro-cent/kWh), (IEA 2016)



There are two primary types of natural gas trading: physical trading and financial trading. Physical natural gas trading involves buying and selling the physical commodity. This is the most common form of transaction. Financial trading involves derivatives and sophisticated financial instruments, with the buyer and seller never taking physical delivery of the natural gas. Physical long-term contracts have historically been the most common means of purchasing natural gas.

What are the rules that govern the operation of the natural gas market in the EU?

A number of key rules covering the functioning of the natural gas market are contained in the Third Energy Package, a series of five legislative acts introduced in 2009 aimed at further liberalising and integrating the EU energy market. It contained two directives, the Electricity Directive 2009/72/EC and the Gas Directive 2009/73/EC and three Regulations: (EC) 713/2009, (EC) 714/2009 and (EC) 715/2009.

The Third Energy Package included provisions requiring further unbundling of network operators, the establishment of ACER and strengthening the independence of National Regulatory Authorities (NRAs). ENTSO-E and ENTSOG were also established in the Third Energy Package as a means to enhance cross-border cooperation, in addition to rules for opening and improving competition in retail markets. Finally, the Third Energy Package also triggered the creation of electricity and gas 'network codes' (NCs).

The NCs are a set of technical rules enabling development of the internal energy market in Europe. They address the major barriers impeding the cross-border flow of electricity and gas, thus transforming

119 A virtual hub is a non-physical point in a natural gas market which represents all the entry and exit points in the given area.

a patchwork of national energy markets into a single European energy market. The NCs guide the integrated operation of cross-border energy networks to allow increased competitiveness, more cost-efficient integration of renewables and a secure supply of energy at affordable prices. Network codes address the market, system operation and grid connection rules. They represent the ‘software’ in the EU internal energy market.

So far, four gas NCs and a set of guidelines have been adopted:

- The interoperability and data exchange rule NC deals with technical, operational and communication-related barriers to cross-border gas flow.
- The gas balancing NC harmonises the rules in the gas balancing markets and distinguishes the responsibilities of TSOs and Network Users in this context.
- The capacity allocation mechanism NC introduces harmonised auctions and standardised capacity products to be traded according to the same rules and at the same time.
- The harmonised transmission tariff structure NC aims to harmonise the approaches to tariff setting for gas transmission services in the EU Member States.
- The congestion management procedure guidelines introduce two basic principles: (i) network users are required to use the contracted capacity, otherwise they risk losing it; and (ii) any unused capacity should be offered back on the market.

What is the future of the natural gas market?

Demand for natural gas in the EU is projected to remain stable in the short to medium term (IEA, 2020), with a requirement for flexible electricity production to balance growing variable renewable sources and coal users utilising gas-fired power plants in their transition to renewable energy. However, the origin and form of delivery of that gas is likely to change since the Russian invasion of Ukraine in February 2022. Prior to this, Russia was the EU’s main gas import partner, constituting ~45% of deliveries, the vast majority via pipeline. However, the EU has committed to eliminating Russian fossil fuel imports as soon as possible, including reducing Russian gas imports by 66% by the end of 2022. Furthermore, gas pipelines have increasingly become strategically important tools for geopolitical leverage, encouraging a transition to LNG deliveries which are inherently much more flexible. EU Member States are working towards receiving larger shares of gas deliveries in this form and are building the infrastructure to make it possible.

By 2050 natural gas is envisaged to have a considerably smaller role in the energy mix as it is replaced with renewable electricity and a mix of clean molecules, such as renewable hydrogen, biomethane and synthetic methane, in an effort to reach the EU climate goals (EC, 2016). As discussed earlier in the section, biomethane is already present in the existing natural gas network and is widely considered to be among the most commercially viable alternatives to replace at least part of current natural gas consumption due to its compatibility with existing infrastructure. Hydrogen is also likely to play a role in the EU energy mix by 2050, with the EU aiming to install 80 GW of electrolyser capacity in the EU and neighbouring region by 2030 (EC, 2020). The viability of satisfying meaningful portions of natural gas demand with renewable hydrogen requires a number of key developments, including significant sustained demand for renewable hydrogen, an increase in the availability of renewable energy, a further drop in the cost of renewable electricity and a drop in the cost of electrolyser manufacturing and the supply chain. The existing natural gas network may have a role to play in the future energy market as the European Commission and other stakeholders are considering the possibility of repurposing existing infrastructure such as pipelines and underground storage for hydrogen and other clean molecules (EC, 2021).

There are many unknowns surrounding the development of gas markets moving forward, but there are likely to be meaningful implications for the existing gas networks and their operators, with a requirement for policymakers to adapt their regulatory frameworks to keep pace with the sector's developments. In 2021 the EU presented a legislative package on hydrogen and gas markets decarbonisation (EC, 2021a, EC, 2021b, Kneebone, 2021). This legislation aims to evolve the current regulatory environment into a configuration that can incorporate a higher diversity of actors, a wider range of gases and a different role for gas in the energy mix (see section 5.4 on for further details).

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4.2 Retail markets and the new deal

Athir Nouicer and Leonardo Meeus

This section consists of two main parts. First, we present the current status of the EU retail energy markets and the existing barriers. Second, we introduce relevant provisions of the Clean Energy for all Europeans Package (CEP) on retail electricity markets and the proposals in the Hydrogen and Decarbonised Gas Package (Gas Package) on retail gas markets. Both packages aim to enhance consumer empowerment and protection.

EU retail markets

Energy retailing, or supply, is the final step in the traditional energy supply chain, following generation, transmission and distribution. Retailers or suppliers are the entities in charge of buying energy in wholesale markets and selling it to their contracted consumers. Retailers are often part of a company that also generates electricity, which provides them with a hedge against wholesale prices.

The first concrete EU-wide steps in the liberalisation of retail markets started with the Second Energy Package. The Electricity Directive 2003/54/EC and Gas Directive 2003/55/EC enabled industrial and domestic customers to freely choose their gas and electricity suppliers by July 2007. Six years later, the Electricity Directive 2009/72/EC and Gas Directive 2009/73/EC in the Third Energy Package established that the supplier switching process was to be effective within three weeks. Price regulation was only permitted under strict conditions. In addition, the Third Energy Package introduced rules to increase retail market transparency and reinforce consumer protection.

Several indexes are used to assess the functioning of retail markets. The ‘ACER Retail Competition Index’ (ARCI) uses a structure-conduct-performance framework. Market structure can be assessed with CR3106 and HHI107 indicators. Market conduct can be measured through the entry and exit activity of suppliers in the market, customer switching and the number of alternative offers per supplier. Market performance can be approximated with price dispersion and average mark-up (ACER and CEER, 2015). The use of ARCI was discontinued in the ACER and CEER Market Monitoring Reports (MMRs) in 2016, but some of the indicators continue to be reported.

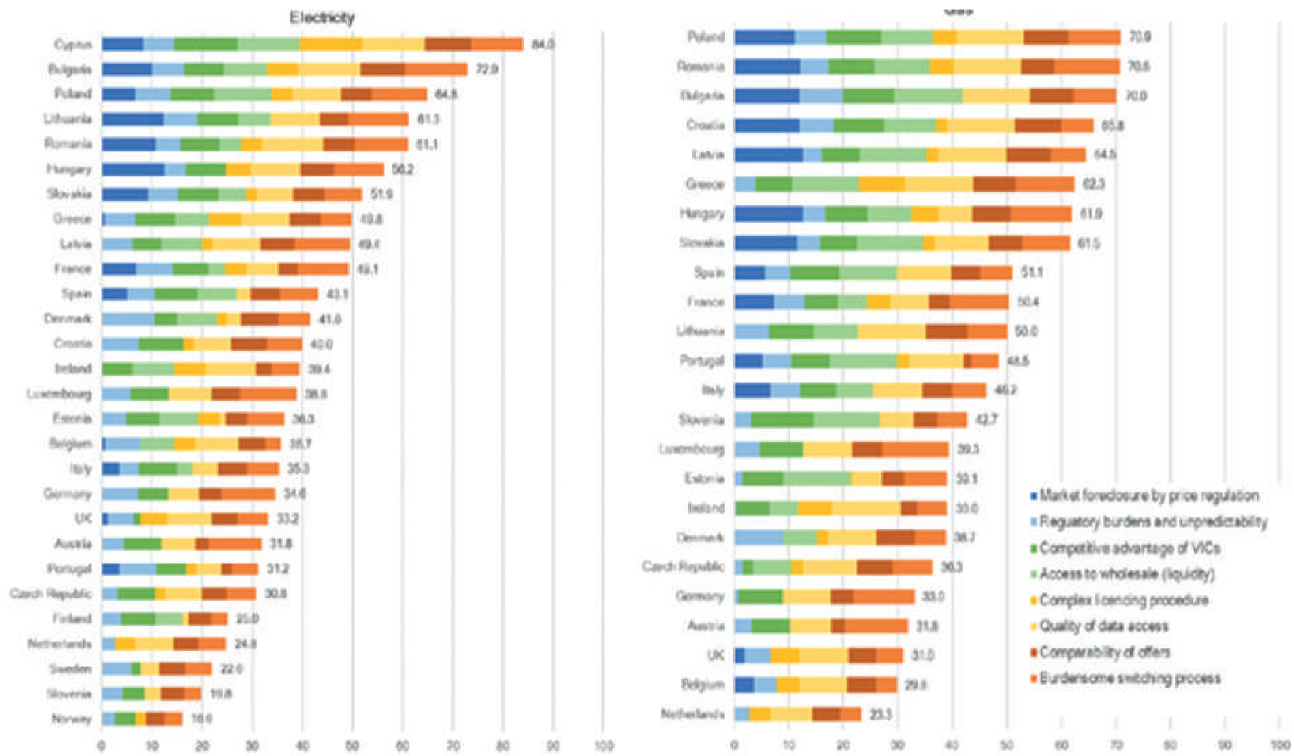
The Felsmann and Vékony (2021) report to the European Commission developed a Barriers Index, which builds on the ARCI. The five top barriers identified are:

- Advantage of vertically integrated market players;
- Low customer awareness or interest;
- Uncertainty around the regulatory future or digitalisation;
- Uncertainty around the current regulatory environment or its development;
- Strategic behaviour of incumbent or other market players.

Figure 32 shows the results of the Barriers Index for the electricity and gas markets. For electricity, the index indicates that in retail markets in Norway, followed by Slovenia, Sweden, the Netherlands and Finland, entrants face the fewest barriers. These markets stand out for having no regulated end-user prices, and no licencing obligation for new suppliers (except for the Netherlands). The countries where the report indicates the highest barriers are Cyprus Bulgaria and Poland, all of which have the specificities of extensive price regulation.

For gas markets, the Netherlands has the lowest barriers index, followed by Belgium, the UK, Austria and Germany, which are considered new entrant-friendly markets. On the other side, in Poland, Romania and Bulgaria, gas suppliers face significant barriers.

Figure 32: Barriers Index - Electricity and Gas, from (Felsmann and Vékony, 2021)



Empowering energy consumers

In 2015, the European Commission published the communication ‘Delivering a new deal for energy consumers,’ building on Third Energy Package provisions. For the electricity sector, consumer empowerment and protection provisions were enhanced by the CEP in 2019. The Gas Package proposals of December 2021 mirror the provisions in the Electricity Directive (EU) 2019/944 and aim to reduce the lag in gas consumer empowerment compared to electricity consumers. In what follows, we present the relevant provisions on: (i) self-consumption, (ii) smart metering systems, (iii) dynamic pricing, (iv) data access and management, (v) aggregators and (vi) energy communities.

Self-consumption

Directive (EU) 2019/944 provides a definition of self-consumers, or prosumers, which are referred to as active customers in the directive. The definition is quite broad and encompasses individual and jointly acting final customers that can consume, store and sell their self-generated electricity. Jointly acting renewable self-consumers are defined in RED II. They are referred to as a group of two or more renewable self-consumers that are located in the same building or multi-apartment block.[120]

120 In RED II, the possibility for Member States to allow production to take place at a location other than the consumer’s premises was also introduced

Commission Gas Directive proposal (EU) 2021/803 provides a similar definition of active customers of natural gas. As in the case of electricity, the definition also encompasses jointly acting final customers. An active customer can consume or store renewable gas that is located within a limited periphery, or when permitted by the national authority in other premises. It can also sell self-produced renewable gas using the natural gas system and participate in energy efficiency schemes as long as these activities do not constitute the active customer's primary commercial or professional activity.

Active customers with energy, including renewable gas, storage facilities have the right to a grid connection within a reasonable time after requesting it subject to fulfilling necessary conditions, e.g. balancing responsibility and adequate metering. They are not to be subject to any double charges, including network charges, for the renewable gas or electricity stored or when they provide flexibility services.

By 2026, consumers should be able to switch electricity and gas suppliers within 24 hours on a working day, and household customers and small enterprises should not be subject to any switching-related fees unless under specific conditions. At least one free-of-charge comparison tool for suppliers' offers is to be provided to households and microenterprises with an expected yearly consumption below 100,000 kWh for electricity microenterprises.

The Electricity and Gas Directives promote consumer-friendly billing, aiming to increase the readability and understandability of bills. Member States shall ensure that billing information is clear, accurate and easy to understand, facilitating comparison by consumers. Both directives include minimum requirements (Annex I) for billing and billing information that have to be met, such as the price and a breakdown of it where possible, information on the benefits of switching and a link to offer comparison tools.

Finally, electricity network tariff schemes that do not account separately for the electricity fed into and consumed from the grid, e.g. net metering, will not be granted new rights after 31 December 2023.

Smart metering systems

Directive (EU) 2019/944 and Gas Directive proposal (EU) 2021/803 highlight the role of electricity and gas smart meters as a prerequisite for consumers to benefit from innovative services and for DSOs to have better visibility of their networks. Member States are to conduct a cost-benefit analysis (CBA) for the roll-out of smart meters. If the CBA is positive, Member States are to ensure that 80% of final customers are equipped with these systems within seven years, or by 2024 for electricity smart meters. If the CBA is negative, Member States are to revise this assessment at least every four years and notify the Commission of the outcome. Member States with a negative CBA are to ensure that every final customer that wants to pay for a smart meter is entitled, on request, to have one installed or upgraded. This is to be carried out within a reasonable time and no later than four months following the request. Regarding smart meters that were installed before 4 July 2019 for electricity, and the future date of entry into force of the Gas Directive for gas smart meters, they may remain in operation if they meet the minimum requirements in Article 20 and Annex II of Directive (EU) 2019/944 and Article 18 and Annex II of the proposed Gas Directive. Otherwise, they shall be phased out by 5 July 2031 for electricity, and 12 years after the entry into force of the Gas Directive for gas.

For hydrogen, Article 17 of the Gas Directive proposal (EU) 2021/803 provides that Member States shall ensure deployment of smart metering systems and ensure their security and that of data communication and privacy. Interoperability requirements for hydrogen smart meters will be adopted by the Commission by means of implementing acts.

Dynamic pricing

Directive (EU) 2019/944 defines a dynamic electricity price contract as an "electricity supply contract between a supplier and a final customer that reflects the price variation in the spot markets, including in the day-ahead and intraday markets, at intervals at least equal to the market settlement frequency."

All customers with a smart meter installed are to have the right to conclude a dynamic electricity price contract with at least one supplier in their market and with every supplier that has more than 200,000 final customers. Customers shall be fully informed of the opportunities and risks involved in dynamic price contracts. In addition, suppliers need to get their consumers' consent before switching them into dynamic electricity price contracts.

Note that there are no provisions on dynamic gas pricing in the Gas Package due to the nature of natural gas (wholesale) pricing, which is typically less dynamic within a day.

Data access and management

Regarding data management models, Directive (EU) 2019/944 and the Gas Directive proposal (EU) 2021/803 do not specify a particular model for consumer energy data which include metering and consumption data and data needed for customer switching and other services. Member States or the competent authorities are to authorise and certify parties that are responsible for data management to ensure their compliance with the electricity and gas directives.

Eligible parties are to have non-discriminatory and simultaneous access to customers' final data. When consumers want to access their data on electricity or gas supplied or demand response, there should be no additional cost. The European Commission is also working on data interoperability rules that will be adopted by means of an implementing act (see section 5.3).

Aggregators

Directive (EU) 2019/944 defines aggregation as "a function performed by a natural or legal person who combines multiple customer loads or generated electricity for sale, purchase or auction in any electricity market." Member States are to develop regulatory frameworks for independent aggregators, which creates a level-playing field for the demand side with all consumers being entitled to conclude a contract with an aggregator without needing the consent of their electricity supplier. In addition, if a customer contracts with an aggregator, she/he is not to be treated in a discriminatory way by the electricity supplier. The rules on fees for terminating contracts with independent aggregators are similar to those on contracts with electricity suppliers. Aggregators must fully inform customers of the terms and conditions of aggregation contracts. On request, they must also communicate the relevant electricity and demand response data to their customers free of charge at least once in every billing period.

Regarding the aggregation implementation model, Directive (EU) 2019/944 leaves this open for Member States to decide as long as they respect the principles and rules in the Directive such as including perimeter correction and compensation for suppliers. Indeed, aggregators will be financially responsible for any system imbalances that they cause. They can be balance responsible or delegate the responsibility to a third party. Regarding compensation, e.g. of suppliers, Member States may require aggregators to pay financial compensation to other market participants or to their balance responsible parties (BRPs). The compensation is to be limited to covering costs incurred by customers' suppliers or their BRPs during activation of DR (Schittekatte et al., 2021).

Note also that there are no provisions on aggregators in the Gas Package. The European Commission's public consultation on the Hydrogen and Gas Market Decarbonisation Package, which was held in 2021, included "consumer participation in demand response through aggregation contracts" among the options for strengthening the rights of consumers and information available to them. However, this was not included among the provisions in the final package.

Energy Communities

Another new intermediary for customers introduced in the CEP and the Gas Package is energy communities. Two types of energy communities are introduced. An enabling framework for Citizen Energy Communities (CECs) is defined in Directive (EU) 2019/944 for electricity and the Gas Directive proposal (EU) 2021/803, while provisions on Renewable Energy Communities (RECs) were introduced in RED II.

Citizen Energy Communities (CECs)

Directive (EU) 2019/944 and the Gas Directive proposal (EU) 2021/803 define a CEC as a legal entity controlled by its members or shareholders, participation in which is open and voluntary. The members or shareholders can be natural persons, local authorities, including municipalities, or small enterprises. The primary purpose of a CEC is to provide them with environmental, economic or social community benefits. A CEC may engage in almost all energy system activities where applicable for electricity and renewable gas, e.g. generation, distribution, supply, consumption, aggregation, storage, energy efficiency services and charging services for electric vehicles for the electricity system, and energy efficiency services and maintenance services for the gas system.

Member States are required to adopt a legal framework for the establishment of CECs. The electricity and gas directives provide a broad guide with a catalogue of applicable rights and obligations. This includes rules regarding membership of CECs and their access to all electricity markets. CECs must not be subject to any discriminatory or disproportionate treatment in relation to their activities, rights and obligations. In turn, they should have balance responsibility for any imbalances they cause or delegate this responsibility. Nevertheless, Member States are free to decide on rules relating to cross-border participation by CECs, their ownership and the establishment, purchase and lease of distribution networks in their area.

Renewable Energy Communities (RECs)

RED II defines a REC as a legal entity based on open and voluntary participation. The definition includes proximity requirements for owned and developed renewable energy projects for the shareholders and members controlling the REC. They can be natural persons, small or medium-sized enterprises or local authorities, including municipalities. The primary purpose of a REC is to provide its shareholders, members or the local area where it operates with environmental, economic or social community benefits. REC generation activities cover only renewable energy but are not limited to electricity. REC members can produce, consume, store and sell renewable energy, including through renewable power purchase agreements (PPAs). They can share the renewable energy produced within the community. RECs are also entitled to access all suitable energy markets either directly or through aggregation.

RED II requires the Member States to assess existing barriers to REC development and the potential for RECs in their territories. They have to provide an enabling framework that removes unjustified regulatory and administrative barriers. In addition, the relevant DSOs must facilitate energy transfers among RECs. The communities are to be subject to fair, transparent and proportionate procedures, including for registration and licensing, and cost-reflective network charges. Furthermore, they should be able to participate in available support schemes on an equal footing with other participants. Indeed, their specificities are to be taken into account when designing support schemes without prejudice to Articles 107 and 108 TFEU (Almeida et al., 2021).

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4.4 Just energy transition and energy poverty

Daniele Stampatori

This section introduces the topic of energy poverty and the financial instruments that the EU is implementing to alleviate the negative effects of the energy transition. First, we explain what energy poverty is. Second, we give an overview of the financial instruments implemented in the European Green Deal to address energy poverty and the most recent measures adopted to face the recent price hikes.

What is energy poverty and what is the status quo in Europe?

Even though energy poverty is a widespread problem across the EU, an official definition does not exist. According to the Covenant of Mayors (see section 5.1), energy poverty can be defined as "a situation where a household or an individual is unable to afford basic energy services (heating, cooling, lighting, mobility and power) to guarantee a decent standard of living due to a combination of low income, high energy expenditure and low energy efficiency of their homes." In practice, consumers face energy poverty situations when energy bills represent a high percentage of their income and limit their capacity to afford other expenditure.[121] In the worst cases, households even need to reduce their energy consumption for economic reasons.

Due to its multi-dimensional nature, energy poverty is a hard phenomenon to detect. Various indicators have been developed in order to make it measurable and quantifiable. These fall in four groups (EC 2020e):

- indicators comparing energy expenditure and income;
- indicators based on self-assessments;
- indicators based on direct measurements, for example of physical variables (e.g. temperature);
- indirect indicators, such as arrears on utility bills, numbers of disconnections and housing quality.

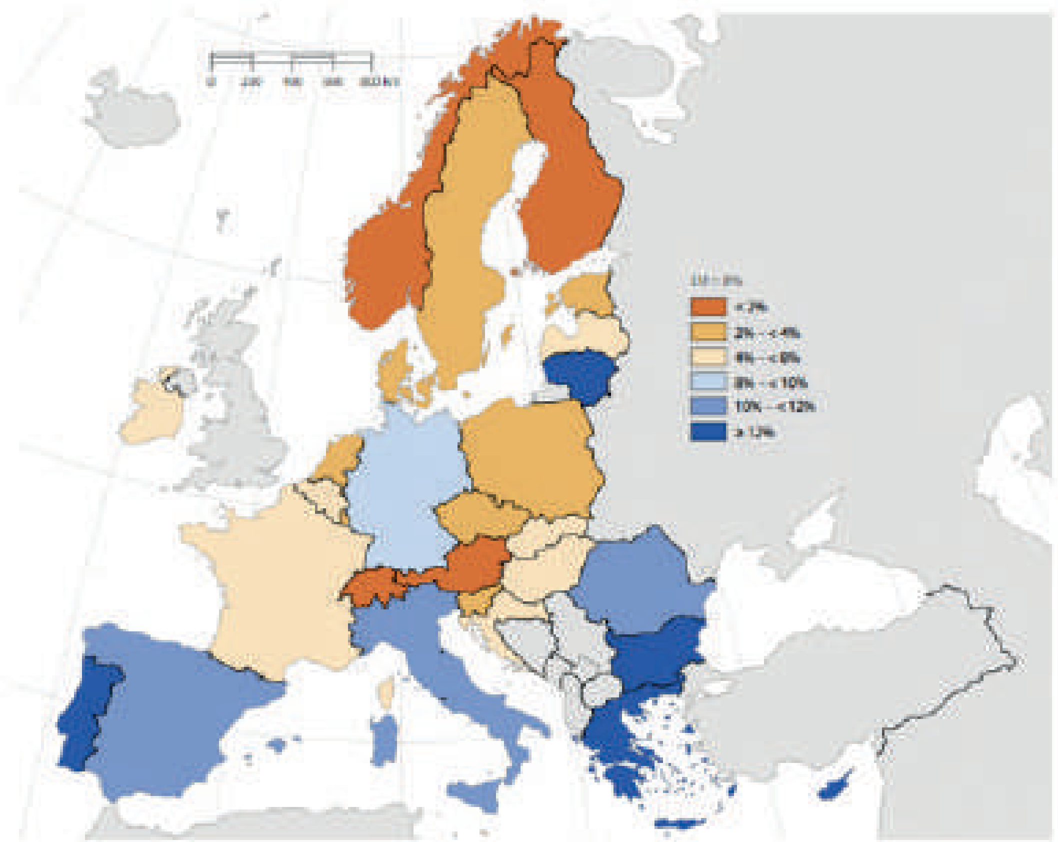
The EC estimates that in 2020[122] about 8% of the EU population, equivalent to 31 million people, were unable to keep their homes adequately warm, with significant differences among Member States, as is shown in Figure 33.[123] The Member State with the largest share of people saying that they were unable to keep their home adequately warm in 2020 was Bulgaria (27%), followed by Lithuania (23%), Cyprus (21%) and Portugal and Greece (both with 17%).

121 A 10% income threshold is widely used in the literature to identify energy poverty.

122 This situation has been exacerbated by the Covid-19 pandemic, as is pointed out in https://fsr.eui.eu/measures-to-tackle-the-covid-19-outbreak-impact-on-energy-poverty/.

123 See https://energy.ec.europa.eu/topics/markets-and-consumers/energy-consumer-rights/energy-poverty_en (accessed 30 March 2022).

Figure 33: Inability to keep the home adequately warm (% of populations) in 2020 (Source: Eurostat, 2021)



What is the EU legislative framework to tackle energy poverty?

The first mentions (at the Community level) of energy poverty are present in the Electricity Directive 2003/54/EC and Gas Directive 2003/55/EC in the Second Energy Package, which pointed out that actions needed to be taken to protect citizens against electricity disconnection and inability to pay bills (Pey et al., 2017). In addition to provisions in the subsequent directives in the Third Energy Package, several initiatives have been put in place to specifically tackle the problem such as the Vulnerable Consumers Working Group[124] and the Energy Poverty Observatory.[125]

Energy poverty is also a primary element in the Clean Energy Package, which includes measures to tackle the problem, for example in:

- The Electricity Directive (EU) 2019/944, which requires Member States to adopt appropriate measures to address energy poverty. A significant new element in the Directive is that it requires the number of households in energy poverty to be quantified and specific strategies to be included in the National Energy and Climate Plans (NECPs) of the countries in which the number of households in energy poverty is significant;

124 In 2011 in the 4th Citizens' Energy Forum, the European Commission launched a working group on vulnerable consumers with the aims of establishing qualitative and quantitative mapping of various aspects of vulnerability and measures which can contribute to addressing the issue, providing recommendations on defining vulnerable consumers in the energy sector based on the current state of play in the Member States and highlighting good (national) practices and appropriate non-policy solutions with a long-term potential to better target vulnerability.

125 The EU Energy Poverty Observatory (EPOV) was a 40-month project that commenced in December 2016. It was established with the aim of fostering transformational change in knowledge about the extent of energy poverty in Europe and innovative policies and practices to combat it. At the end of 2020 with the end of the EPOV approaching, the European Commission launched the Energy Poverty Advisory Hub, a 4-year initiative with the objective of assisting municipalities in the fight against energy poverty.

- The Energy Efficiency Directive, which requires Member States to take into account the need to reduce energy poverty in the context of their energy efficiency obligations;
- The Energy Performance of Buildings Directive (EU) 2018/844, according to which Member States must outline relevant national measures to help alleviate energy poverty as part of their long-term renovation strategies.

The Energy Poverty Advisory Hub (EPAH) is an EU-wide initiative aiming to eradicate energy poverty and accelerate the just energy transition of European local governments. Building on the EU Energy Poverty Observatory legacy, the EPAH adapts an action-based approach by creating a space for collaboration and exchange for local and regional authorities planning a variety of measures to tackle energy poverty in the pursuit of a just and fair transition.[126]

How does the Green Deal address the issue of energy poverty?

While the benefits of the energy transition will be more evident in the medium-long term, its costs will have to be addressed in the coming years. The switch toward more sustainable sources and uses of energy will come with a loss of jobs in fossil-based sectors and an increase in energy prices.[127] Moreover, the energy transition policies will have a mix of progressive and regressive effects. Significant social and distributional impacts may disproportionally affect vulnerable households, vulnerable micro-enterprises and vulnerable transport users, who spend a large part of their incomes on energy and transport and who in certain regions do not have access to alternative affordable mobility and transport solutions.[128]

In order to tackle these issues, the European Commission is planning to allocate a large amount of financial resources to sustain the most vulnerable citizens: a Just Transition Fund has already been set up as part of the Green Deal and a new Social Climate Fund is going to be created.

It is worth noting that measures to tackle energy poverty are also present in some proposals in the Fit For 55 Package, such as the recast of the Energy Efficiency Directive and the Energy Taxation Directive. These proposed directives attempt to safeguard vulnerable consumers by respectively prioritising energy efficiency measures aimed at alleviating energy poverty and by recommending tax reductions or (temporary) exemptions for fuels.

The Just Transition Fund

In January 2020 the EC (2020a) published a legislative proposal for a Just Transition Fund (JTF), which aims to help regions relying on fossil fuels and carbon-intensive industries to succeed in their energy transition. In the latest amendment, the JTF budget was increased from €7.5 to €17.5 billion [129] (CR 2021a/b; EC 2020b). The JTF together with the InvestEU 'Just Transition' scheme[130] and the Public Sector Loan

126 https://www.housingeurope.eu/section-110/energy-poverty-advisory-hub. Additional information about PAH can be found on the portal on energy poverty of the European Commission (https://energy-poverty.ec.europa.eu/index_en).

127 For a consumer perspective, see the recording of the FSR online 'Focus on energy consumers' event, available at https://fsr.eui.eu/fostering-consumer-empowerment-towards-a-decarbonised-energy-sector-in-europe/ (accessed 12 April 2022).

128 For an international perspective, see the recording of the FSR online 'Just Transition – What and How to go about it?' event, available at https://fsr.eui.eu/energy-transition-not-just-a-transition-it-must-be-just/ (accessed 12 April 2022).

129 €7.5 billion in the MFF and €10 billion in NGEU, in 2018 prices.

130 The InvestEU 'Just Transition' scheme will provide a budgetary guarantee under the InvestEU programme. It would provide a scheme to generate some €10 to €15 billion of (mainly private) investments.

Facility[131] (Council and Parliament 2021a/b) constitute the Just Transition Mechanism (EC 2020c), which is expected to mobilise up to a total of €75 billion in investments (see also section 1.1).

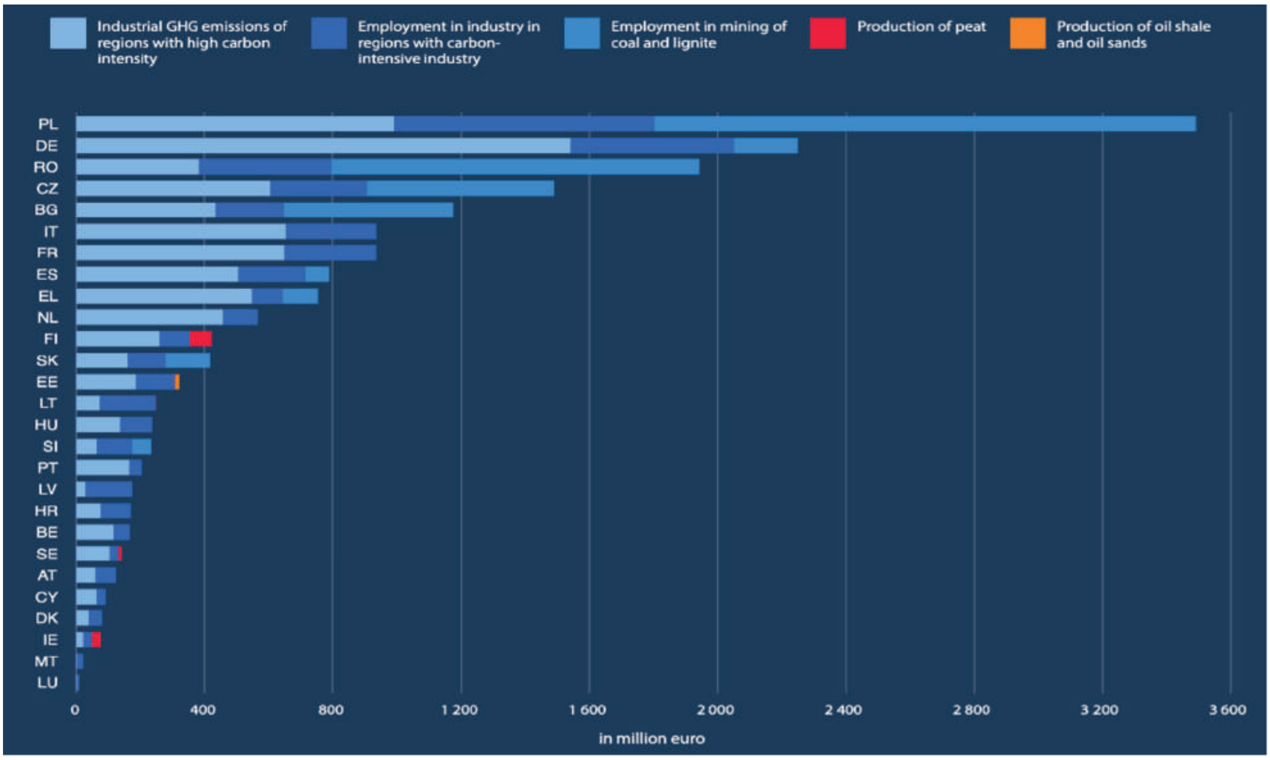
The funding provided by the JTF will be complemented by national co-funding according to the category of the regions in which the areas identified are located (more developed regions, transition regions and less developed regions). The budget for the JTF may be further supplemented with resources from the European Regional Development Fund (ERDF) and the European Social Fund Plus (ESF+). Such transfers from other cohesion policy funds are made on a voluntary basis and may not exceed three times the JTF allocation in the Multiannual Financial Framework (MFF). The JTF includes a green reward mechanism linked to reductions of greenhouse gas emissions in regions benefiting from JTF support and makes access to 50% of JTF resources conditional on adoption of the EU target of climate neutrality by 2050.

The allocation method used by the Commission is based on five socio-economic criteria, each of which has a different weighting factor: half the allocation is based on economic criteria (greenhouse gas emissions, production of peat, oil shale and oil sands) and the other half is based on social criteria (employment data).

After calculating the allocation based on these weightings, a May 2020 Commission proposal (EC 2020d) applied further capping and adjustment: an upper limit for each Member State was applied to prevent a Member State receiving an excessive share of the overall Just Transition Fund resources (which in practice only applies to Poland) and an adjustment according to gross national income per capita was factored in to ensure that resources are concentrated on assisting less developed Member States.

The final result of this allocation method across the Member States is depicted in Figure 34. Poland and Germany are the largest beneficiaries of the fund, accounting for almost a third of total resources.

Figure 34: Allocations of the JTF budget across Member States after capping and adjustments (Source: European Parliament 2021)



131 The Public Sector Loan Facility is a new public sector loan facility, consisting of a grant component worth €1.5 billion from the EU budget and a loan component of up to €10 billion from the European Investment Bank's resources. It is expected to mobilise around €18.5 billion of public investments.

The Social Climate Fund

The main purpose of the Social Climate Fund (SCF) is to compensate vulnerable households, micro-businesses and transport users for the future costs of the EU's green energy transition in the buildings and road transport sectors, to which the Commission is proposing to extend the emissions trading system (EC 2021a). The SCF will be funded primarily by the EU's own resources[132] as a proportion (25%) of ETS revenue accrued by the EU from these two new sectors and equivalent funding is required from Member States. In December 2021 the Commission proposed establishing the next generation of EU own resources by putting forward three new sources of revenue: the aforementioned revenue from the ETS; the resources generated by the proposed EU carbon border adjustment mechanism; and the share of residual profits from multinationals that will be re-allocated to EU Member States under the recent OECD/G20 agreement[133] on re-allocation of taxing rights ('Pillar One').

The Commission is proposing that the SCF should receive €72.2 billion of EU funding in the period of its operation (2025-2032). €23.7 billion of funding will fall under the 2021-2027 MFF (for 2025, 2026 and 2027) and €48.5 billion will fall under the next MFF (for 2028-2032).

The SCF proposal (EC 2021b) requires the Member States to submit social climate plans (SCPs) to the Commission as part of the scheduled updates to their national energy and climate plans (NECPs). The Fund should provide Member States with funding to support measures and investments in increased building energy efficiency, decarbonisation of building heating and cooling including integration of energy from renewable sources, and granting improved access to zero- and low-emission mobility and transport. Member States will be required to deliver their final SCPs by 30 June 2024 at the latest.

The report adopted by the Parliament in June 2022 stipulates that the national climate action plans prioritise investments and incentives for clean mobility over temporary direct income support measures, with the latter limited to 40% of fund expenditure and eliminated altogether by 2032 (EP, 2022). The Council adopted a general approach in June 2022. The general approach agrees that the fund should be part of the EU budget, but decided not to maintain the national contribution (co-financing) foreseen in the Commission proposal. The fund would be established in the period 2027-2032, coinciding with the entry into force of the ETS for the building and road transport sectors (Council, 2022).

What are the most recent developments?

Currently the EU is facing a sharp increase in energy prices. This upward trend was initially driven by increased global energy demand due to the post-pandemic recovery, but it is currently exacerbated by the Russo-Ukrainian war.

In response to the hikes in energy prices, in October 2021 the EC (2021c) published a 'toolbox' of measures that can be implemented by Member States to safeguard vulnerable consumers. Immediate measures include caps on energy prices and tax breaks and reductions for vulnerable consumers. In addition,

132 According to the EC, the current three main sources of revenue for the EU budget are customs duties, contributions based on Value Added Tax and direct contributions by EU countries, also known as Gross National Income-based contributions. Since 1 January 2021, a new revenue source for the EU budget has been a contribution based on non-recycled plastic packaging waste.

133 In 2021, the members of the OECD/G20 Inclusive Framework on BEPS (the Inclusive Framework) agreed on a 'Statement on the Two-Pillar Solution to Address the Tax Challenges Arising from the Digitalisation of the Economy.' The Two-Pillar Solution will ensure that multinational enterprises (MNEs) will be subject to a minimum tax rate of 15% and will re-allocate profits from the largest and most profitable MNEs to countries worldwide. Pillar One aims to ensure a fairer distribution of profits and taxing rights among countries with respect to the largest MNEs which are the winners from globalisation. Pillar Two puts a floor on tax competition regarding corporate income tax by introducing a global minimum corporate tax at a rate of 15%, which countries can use to protect their tax bases (OECD/G20 2021).

Member States can plan specific social payments such as lump-sum payments and time-limited compensation measures and direct support for energy-poor end users to cover part of their energy bills. At the same time, they can put in place (or maintain) safeguard mechanisms to avoid disconnections from the energy grid.

Bruegel (2022) offers a broad overview of such measures that have been implemented by 23 EU countries, Norway and the UK since September 2021. Six main strategies are identified, of which 'transfers to vulnerable groups' and 'reduced energy tax/VAT' are the most widespread among the Member States. Moreover, some countries have directly intervened in the market imposing caps on energy prices at the retail or wholesale level. Other measures concern support schemes for business activities and introducing special taxes on windfall profits of energy companies due to price hikes.

In March 2022, the EC (2022a) published the REPowerEU strategy, which boosts and moves up some of the Fit For 55 objectives with the primary aim of phasing out the EU's dependence on fossil fuels from Russia by 2030. The strategy consists of two main 'pillars':

- Diversifying gas supplies through higher LNG imports and pipeline imports from non- Russian suppliers, and higher levels of biomethane and hydrogen;
- Reducing dependence on fossil fuels at the level of homes, buildings and industry, and at the level of the power system by boosting energy efficiency gains, increasing the share of renewables and addressing infrastructure bottlenecks.

In the strategy the EC confirms that price regulation can be used to mitigate the effect of higher energy prices on consumers' bills but reducing the energy prices facing consumers could distort the market in a negative way. In fact, this type of measure weakens the incentives to save energy and therefore runs counter to the more general energy policy objectives of sustainability and security of supply. In this regard, Pototschnig et al. (2022) suggest that lump-sum rebate payments can safeguard vulnerable consumers from unaffordable energy bills without weakening incentives to save energy.

In a further Communication (2022b), the EC emphasizes again benefits of social payments, supports for energy efficiency improvements and reductions on taxes and levies to face the current crisis. Reductions in environmental taxes are considered as well: in case these reductions respect the minimum levels of taxation and the rules set out in the Energy Taxation Directive (see section 1.5) they can be implemented without notifying the Commission.

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5. EU energy innovation

In this chapter, we focus on energy innovation in five sections. First, we describe the EU initiatives that are relevant for smart cities. Second, we present the Strategic Energy Technology Plan. Third, we explain how digitalisation is impacting the energy sector and explore some of the challenges that come with it. Fourth and fifth, we provide insights on how clean molecules, and in particular hydrogen, will impact the energy sector and discuss the potential for their large-scale roll-out.

5.1 Smart city initiatives

Valerie Reif

In this section, we breakdown smart city initiatives into three parts. We start by explaining why cities are important for climate policy. We then describe what smart cities are, which main pillars they build on and how the concept of smart cities is evolving. Finally, we look at some of the most relevant European instruments to foster smart city projects and initiatives.

Why are cities important for climate policy?

Cities represent both a challenge and an opportunity for climate policy. More than 70% of the EU population lives in cities today.[134] Urban areas are important contributors to the EU's energy consumption and greenhouse gas (GHG) emissions and therefore have a significant impact on efforts to reach the EU's climate targets. At the same time, cities are the main drivers of the EU's economy.

Worldwide, more than half the population resides in urban areas today. Cities are often seen as centres of economic growth that provide opportunities for study and employment and improved quality of life. In 2050, nearly 7 in 10 people worldwide are expected to live in urban areas.[135] This will increase the demand for services related to energy, water, waste and mobility and others that are essential for the prosperity of cities, and the pressure on related resources and infrastructure.

Both the European Green Deal and global efforts to tackle climate change require solutions that are 'smart.' They need to be highly efficient and sustainable on the one hand and keep generating economic prosperity and social wellbeing on the other. Smart solutions rely on mobilisation of all a city's resources, active participation by all its citizens and workers, coordination of all relevant actors using new technologies, and development of adequate and forward-looking policies at multiple levels, including the local and city levels.

What are smart cities and how is the concept of smart cities evolving?

The term 'smart city' has been widely used in academic research and marketing by companies and cities, but a common definition does not seem to exist (Caragliu et al., 2009). The concept of smartness is often used in combination with other terms, for example smart governance, smart people, smart living, smart mobility, smart economy and smart environment (Manville et al., 2014), all of which can be part of the smart city concept. Fernandes et al. (2011) identify three main characteristics that are typically connected to the

134 According to Eurostat, in 2018 39.3% of the EU population lived in cities, 31.6% lived in towns and suburbs, and 29.1% lived in rural areas. Source: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/EDN-20200207-1 (accessed 18 March 2022).

135 According to estimates by the World Bank, available at https://www.worldbank.org/en/topic/urbandevelopment/overview (accessed 8 April 2021).

smart city concept, namely “i) friendliness towards the environment; ii) use of information and communication technologies as tools of (smart) management and iii) an ultimate goal of sustainable development.” Smart cities tend to integrate concepts of sustainability in every policy decision taken at the local level with the aim of significantly accelerating deployment of sustainable measures in pursuit of a low-carbon future, including in energy networks, buildings and transport.

Smart City Pillars

Cities are very different from one another, not only in terms of their physical and human geography but also in the supply and use of energy, the available means of transport and the ways they are managed etc. Each city has specific characteristics, which means that the most appropriate set of measures to improve a city’s performance also differs.

At the time of the SET Plan (see below) in the late 2000s, the European perspective on smart cities focused on sustainability issues, in particular on energy efficiency, low carbon technologies and smart management of supply and demand in the areas of buildings, local energy networks and transport (EC, 2009).

In the areas of energy and buildings, two types of measures can be broadly distinguished. First, improving energy efficiency of buildings, which covers construction of new buildings and renovation of existing ones with the aim of having a nearly zero-energy building stock, including using energy from renewable sources, smart readiness and building automation and control systems. Second, integrating energy systems with the aim of developing large-scale solutions regarding for example district heating and cooling, photovoltaics, geothermal energy and waste management. Together, these measures aim to improve energy efficiency, generate low-carbon energy, modernise infrastructure and create a high-quality living environment for citizens.

In the area of transport and mobility, measures aim, for example, to improve infrastructure, promote use of electric vehicles and clean fuels, increase inter-modality between different transport types and raise the attractiveness of public transport, collective transport and cycling. Such measures not only help increase the attractiveness and competitiveness of cities but also tackle congestion and improve air quality.

Digital and information and communication technologies are considered an integral part of the smart city concept as they allow the integration of different urban systems and their operational processes and enable innovative approaches to enhance citizen engagement. Some of the most widely used ICT solutions are energy management systems, traffic control systems, smart grids, urban data platforms and mobile applications.

From ‘smart’ cities to ‘climate-neutral and smart’ cities

With the increased climate ambitions in the European Green Deal, the concept of smart cities seems to evolve into a concept of ‘climate neutral and smart cities.’ The more traditional pillars of buildings, local energy networks and transport are increasingly integrated in a wider ‘system innovation’ approach to the entire value chain of city investment, which also includes governance, construction, and recycling, and even looks towards industry and agriculture, all supported by powerful digital technology.

An important initiative in this regard is the creation of a Common European Green Deal Data Space (EC, 2020a) to use the great potential of data to support Green Deal priorities on climate change, a circular economy, zero pollution, biodiversity, deforestation and compliance assurance. As part of this data space, the European Commission aims to create a data ecosystem for climate-neutral and smart communities, which will facilitate access to, sharing and re-use of locally relevant data, including in areas such as mobility, energy, climate and zero pollution (EC, 2020b). In a recently published Staff Working Document, the EC (2022a) specifies that funding for this data ecosystem is provided under the DIGITAL Work Programme, with the aim of first creating a blueprint that connects existing national, regional and local data ecosystems and enables public and private stakeholders to access relevant data, followed by validation and refinement of the blueprint in pilot projects, followed by deployment of the data space and a network of Local Digital Twins.

European instruments to foster smart city projects and initiatives

In the following we describe a few of the main EU instruments to foster smart city initiatives, namely the Covenant of Mayors, the Strategic Energy Technology Plan, the European Smart Cities Initiative, the European Innovation Partnership, the Smart Cities Marketplace and the new Horizon Europe programme. Note that this description is not exhaustive as a multitude of initiatives relevant to urban development exist in the EU.

Covenant of Mayors

The Covenant of Mayors initiative was launched by the European Commission in 2008. It brings together thousands of local and regional authorities which voluntarily commit to increasing energy efficiency and the use of renewable energy sources in their territories, thereby helping to achieve and exceed the EU climate and energy targets. The initiative has proven successful way beyond expectations and has been attracting local and regional authorities in Europe and beyond. It now operates in the EU's Eastern Partnership countries and has been extended, among other places, to the European Neighbourhood South Region. In 2016, the initiative officially reached a global dimension with the creation of the 'Global Covenant of Mayors for Climate and Energy.' At the time of writing, the Covenant community counts 10,565 signatories, 210 supporters, 226 coordinators, 61 countries and covers 334,638,792 inhabitants.

Originally, Covenant signatories aimed to meet and exceed the EU's 20% CO_2 reduction objective by 2020. Later, signatory cities pledged action to actively support achieving the EU's 40% GHG emissions reduction target by 2030 and agreed to adopt a joint approach to tackling mitigation and adaptation to climate change and to ensure access to secure, sustainable and affordable energy for all. More recently, signatory cities have pledged action to support achievement of the EU 55% GHG emissions reduction target by 2030 and adoption of a joint approach to tackling mitigation and adaptation to climate change. Signatories have also endorsed a shared vision for 2050.

To translate their political commitment into practice, Covenant signatories commit to submitting a Sustainable Energy and Climate Action Plan (SECAP) that describes the steps towards their 2020 or 2030 targets within two years of joining. Every two years thereafter, signatory cities are expected to report on progress in implementing the SECAP. Signatories also share their key actions as a source of inspiration for others.[136]

The Strategic Energy Technology Plan and the European Smart Cities Initiative

In its 2009 Strategic Energy Technology Plan (SET Plan), the EC recognised energy efficiency as the simplest and cheapest way to ensure CO_2 reduction and announced a new European Smart Cities Initiative that would aim to create the conditions to trigger mass market take-up of energy efficiency technologies

136 The action plans, progress reports and good practice database are available on the website of the Covenant of Mayors at https://www.covenantofmayors.eu/plans-and-actions/action-plans.html (accessed 18 March 2022).

(EC, 2009). The initiative aimed to support 25 to 30 ambitious pioneer cities that would transform their buildings, energy networks and transport systems into those of the future.[137] Importantly, these cities were expected to test and demonstrate the feasibility of transition concepts and strategies towards a low-carbon economy that went beyond the 2020 EU climate and energy targets, instead targeting 40% GHG emissions reduction by 2020.

The initiative built on existing EU and national policies, measures and initiatives and aimed to mobilise local authorities involved in the Covenant of Mayors to multiply its impact. It focused on three main areas. The first was buildings, with net-zero energy or net-zero carbon emission requirements for new buildings and refurbishment requirements to lower consumption and increase building standards for existing buildings. The second was energy networks, with the aim of fostering innovative and cost-effective applications and heating and cooling systems based on renewable sources, co- or tri-generation and district heating and cooling together with smart electricity grids, smart metering and energy management systems, smart appliances and local renewables-based electricity production. The third was transport, with testing and deployment programmes for low-carbon public transport and individual transport systems, and sustainable mobility. The cost of this initiative was estimated at €10-12 billion over the following ten-year period.

The European Innovation Partnership and the Smart Cities Marketplace

In 2010, the EU launched its ten-year growth and jobs strategy entitled 'Europe 2020' (EC, 2010). The strategy covered three mutually reinforcing priorities for growth (smart, sustainable and inclusive growth), five EU headline targets to be met by 2020 (e.g. the 20-20-20 energy and climate targets) and seven related flagship initiatives. Relevant to smart cities was the smart growth priority (i.e. growth in terms of effective investments in education, research and innovation) and the connected flagship 'Innovation Union' initiative to improve the framework conditions and access to finance for research and innovation. The Innovation Union initiative also aimed to re-focus research, development and innovation (RD&I) policy on societal challenges such as climate change and energy and resource efficiency. To develop the initiative, two types of stakeholder platforms were created, namely industry-led European Technology Platforms (ETPs) and European Innovation Partnerships (EIPs) between the EU and national levels to bring together public and private stakeholders and speed up development and deployment of the technologies needed to meet the challenges identified.

The European Innovation Partnership on Smart Cities and Communities (EIP SCC) was launched in 2012 (EC, 2012). It was set up as a partnership across the areas of urban energy production and use, urban transport and mobility and urban information and communication technology and constituted the next step to scale up the efforts undertaken by the Smart Cities Initiative under the SET Plan. The EIP SCC did not provide direct funding but set up a governance structure that, based on strategic and operational implementation plans, guided implementation projects, some of which were large-scale demonstrations partly financed under the research and innovation funding framework Horizon 2020.

The EIP SCC was later wound up together with the Smart Cities Information System in a new platform called the 'Smart Cities Marketplace.' The Marketplace is an initiative supported by the European Commission that brings together cities, industries, SMEs, investors, researchers and other smart city actors and aims to deliver practical knowledge, capacity-building opportunities and access to finance and more to establish a European smart city market and make European cities the most liveable places in the world. At the time of writing, the Marketplace community consists of six action clusters and 23 initiatives.

137 In their policy brief on the Smart City initiative, Meeus et al. (2011) identify three levels of smartness that ambitious pioneer cities can adopt, and recommended that cities are given institutional flexibility in terms of human and financial resources for their implementation. Moreover, the establishment of strict performance reporting methodologies was recommended to ensure the success of the initiative.

Horizon Europe

Under Horizon Europe, the funding programme for research and innovation for the period 2021-2027, the European Commission created so-called 'missions,' which are a set of measures to achieve bold inspirational measurable goals within a set timeframe. There are five main missions under Horizon Europe, one of which is that on 'Climate neutral and smart cities,' which aims to support cities in becoming more resilient and smarter.

The aim of the mission is to deliver 100 climate-neutral smart cities by 2030, and to ensure that these cities act as experimentation and innovation hubs to enable all European cities to follow their example by 2050 (EC, 2020b). The mission aims to boost existing efforts under the Covenant of Mayors framework in two ways. First, by setting the GHG emissions reduction target by 2030 at 100%. The cities should deliver a credible climate strategy and action plan for reaching carbon neutrality for each area. Second, by promoting a systemic change and transformation of cities that builds on a 'by and for the citizens' approach.

The mission is based on three principles, namely a holistic approach to foster innovation and deployment, integrated and multi-level governance, and deep and continual collaboration among all stakeholders. The cities will sign a 'Climate City Contract' as a new mechanism to deliver EU support for cities in the form of more innovation, better regulation and integrated financing. These contracts will be adjusted to reflect the realities of each city and developed in a co-creation process with local stakeholders and citizens to ensure that the voices of the people who live and work in the cities are heard. The signatory cities are expected to develop and implement system innovation in governance, transport, energy, construction and recycling, supported by digital technologies.

So far, expressions of interest have been submitted by 337 cities in all the EU member states and nine associated countries and countries negotiating association. After an evaluation of the submissions, the Commission announced in April 2022 the 100 cities that will participate in the Cities Mission (EC, 2022b). The 100 cities come from all 27 Member States, with 12 additional cities coming from countries associated or in the process of being associated to Horizon Europe.

Other relevant initiatives

Many other initiatives related to urban development and climate (including buildings, mobility, transport and energy) exist, descriptions of which would go beyond the scope of this section. To name a few, they include CIVITAS, the Green Digital Charter, the Green City Accord, European Green Capital Cities, the European Energy Award, BUILD UP, Energy Cities, the European Energy Research Alliance (EERA) Joint Programme Smart Cities, ManagEnergy, the European Urban Knowledge Network and the Urban Agenda for the EU.

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5.2 The European Strategic Energy Technology Plan

Athir Nouicer and Ronnie Belmans

The European Strategic Energy Technology Plan (SET Plan) represents the technology pillar in European energy and climate policy. In this section, we start by introducing the establishment of the SET Plan. We then present the next generation of renewable generation technologies to illustrate one of the priorities of the SET Plan. Finally, we discuss the way forward in the framework of the Green Deal.

Establishment of the SET Plan

The European Commission proposed the creation of the SET Plan following two communications in 2007: An Energy Policy for Europe (see section 1.1) and Towards a European Strategic Energy Technology Plan. The SET Plan that was agreed on with the Council in 2008 had two major timelines: 2020, as it provided a framework for the implementation of low-carbon technologies to contribute to the 2020 targets; and 2050, as it aims to mitigate climate change by maintaining the global temperature rise below 2° C. The European Commission's (2015b) Roadmap for the Energy Union, which is an Annex to the Energy Union Strategy Communication, established the Integrated SET Plan that defined the new European Research and Innovation (R&I) energy-related agenda that covers the EU energy system as a whole.

The SET Plan consists of four elements: the SET Plan Steering Group, the European Energy Research Alliance (EERA), the European Technology and Innovation Platforms (ETIPs) and the SET Plan Information System (SETIS).

- The SET Plan Steering Group is composed of high-level representatives from EU Member States and Iceland, Norway, Switzerland and Turkey. It had its first meeting in 2008. The group aims to ensure alignment between the SET Plan priorities and different R&I programmes at the EU and national levels, and commitments by the member countries. The Steering Group promotes cooperation between national programmes to find synergy and avoid duplication in research and development (R&D), demonstration and deployment efforts (European Commission, 2017).
- The European Energy Research Alliance (EERA) was established in 2008 in parallel with the launch of the SET Plan. It constitutes its public research pillar. EERA brings together more than 250 organisations from 30 countries (EERA, 2021). The alliance seeks to accelerate new energy technology development by aligning the R&D activities of research organisations with the SET Plan priorities. To date, EERA has 18 distinct Joint Programmes. The topics of the programmes are aligned with the SET Plan priorities (see Figure 35). In addition, many of these programmes are closely linked to the SET Plan Implementation Working Groups and the European Technology and Innovation Platforms (ETIPs).
- The European Technology and Innovation Platforms (ETIPs), which are the SET Plan's industrial pillar, were established in 2014. There are nine distinct ETIPs, which resulted from merging eight pre-existing European Technological Platforms[138] together with six European Industrial Initiatives[139] ETIPs aim to bring together EU Member States, industry and researchers in key action areas. The nine ETIPs promote the uptake of key energy technologies: wind, PV, ocean energy, bioenergy, geothermal energy,

138 European Technology Platforms (ETP) are a type of public-private partnership (PPP) established in the research field at the EU level (European Parliament, 2017).

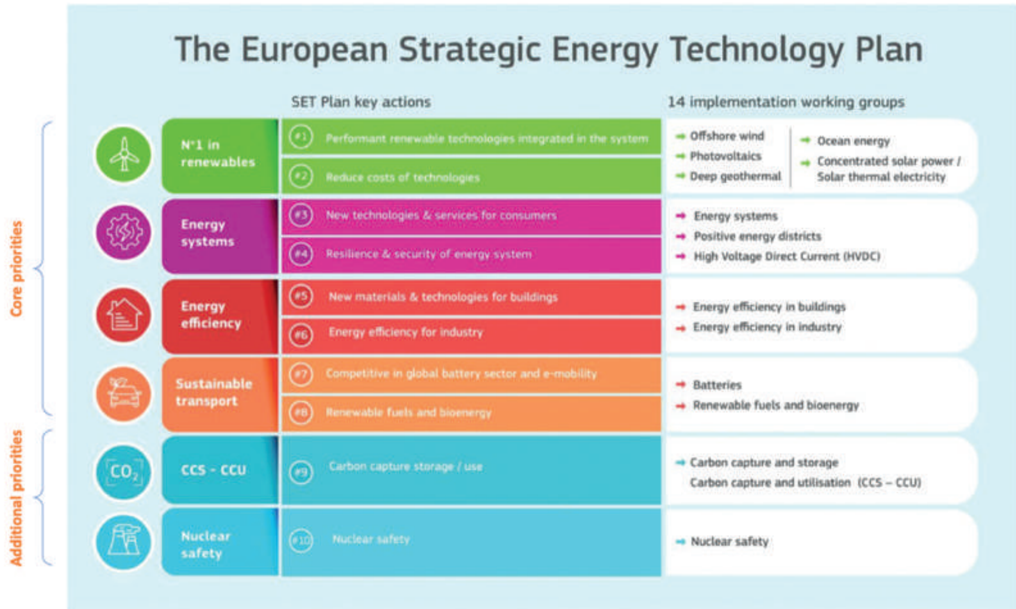
The six European Industrial Initiatives (EIIs) were launched by the Commission in 2008. They cover wind, solar (both photovoltaic and concentrated solar), electricity grids, carbon capture and storage, bioenergy and nuclear fission. 139

renewable heating and cooling, smart networks, carbon capture and storage (CCS), and sustainable nuclear energy technology. These platforms seek to pool funding, skills and research facilities for the different areas (European Commission, 2017).

- The EU's SET Plan Information System (SETIS) provides information related to implementation of the Plan. The platform, which the European Commission leads through its Joint Research Centre (JRC), gathers SET Plan-related documents in a dedicated platform. It includes, for instance, information on the different implementation plans. There are 14 implementation plans clustered by sector or technology that identify the required R&I activities and demonstration projects to achieve the SET Plan strategic targets (see Figure 35). The implementation plans are executed by 14 different Implementation Working Groups, which report to the Steering Group. Examples of targets included in implementation plans are cost reduction for a certain technology for a defined horizon and the development of cost-competitive integrated wind energy systems that can be used in deep waters. Achievement of targets is measured with dedicated Key Performance Indicators (KPIs).

In line with the 2015 Energy Union strategy R&I dimension (see section 1.1), the integrated SET Plan identifies ten actions, which are linked to 14 Implementation Plans (see Figure 35). The countries involved in the SET Plan and relevant stakeholders have also formed Implementation Working Groups (IWG).

Figure 35: SET Plan Key actions and Implementation Plans, adapted from European Commission (2021)



An example of a SET Plan priority: Be a world leader in developing the next generation of renewable energy technologies

In this subsection, we investigate one of the core SET Plan priorities, which is world leadership in the next generation of renewable energy. This priority comprises two key actions: (i) being active in renewable technologies and their system integration; and (ii) cost-efficient technologies. For this core priority there are five implementation plans: offshore wind, photovoltaics, ocean energy, deep geothermal and concentrated solar power/solar thermal electricity. For each of the two actions different implementation plans apply, as is shown in Figure 35. Below, we give some examples of how the actions are planned to be performed in the related implementation plans.

For the first action, being active in renewable technologies and their system integration, the EU has an opportunity to revitalise strategies and regain global leadership in the next generation of renewable energy technologies. The EU can scale up competitive manufacturing of next generation high performing PV. The EU is currently a world leader in some renewable technologies, such as offshore wind (European Commission, 2020a) and ocean energy (SETIS, 2021). This leadership is to be maintained by supporting the next generation of these technologies and improving their performance.

- The SET Plan PV Implementation Plan, which was approved in 2017, describes the technological and non-technological R&I activities that should be implemented to achieve the SET Plan strategic targets for PV performance. It aimed to increase PV module efficiency by at least 20% by 2020 compared to 2015 levels and by at least 35% by 2030, and include novel PV technologies (SETIS, 2017). The PV Implementation Plan also includes targets for the enhancement of PV system lifetime and building-integrated PV.
- The Offshore Wind Implementation Plan, which was approved in 2018, aims to reduce offshore wind technology costs and increase its performance and reliability. It also highlights the need to develop bottom-fixed offshore wind and floating offshore substructures and integrated floating wind energy systems used in deeper water (SETIS, 2018).
- The Ocean Energy Implementation Plan, which was approved in 2018, aims to bring ocean energy to commercial deployment. It also targets maintaining and reinforcing Europe's leading position in ocean energy and strengthening its industrial technology base to compete on the global stage (SETIS, 2021).

The second action on technology cost reduction can be achieved with a large stable market combined with coordinated R&I and increased manufacturing. Furthermore, regional cooperation, especially in areas with common renewable energy potential, could allow further cost reductions. For instance, the North and Baltic Seas have potential for offshore wind energy. In addition, the Atlantic seaboard has potential for ocean energy, while southern Europe has potential for photovoltaic and solar thermal systems, algae and biomass residues. In addition, northern, central and eastern Europe have potential for regional cooperation on bioenergy and biofuels (European Commission, 2015a).

The SET Plan PV Implementation Plan aimed to reduce turnkey PV system costs by at least 20% by 2020 compared to 2015 levels and by at least 50% by 2030 with the introduction of novel and high-efficiency PV technologies (SETIS, 2017).

- For offshore wind, the implementation plan set a target to reduce fixed offshore wind's levelised cost of energy (LCOE) in the final investment decision to less than 10ct€/kWh by 2020 and to less than 7ct€/kWh by 2030. Regarding floating offshore wind used in deeper waters (>50m) at a maximum distance of 50 km from shore, the implementation pPlan set a target of a LCOE of less than 12 €ct/kWh by 2025 and less than 9 €ct/kWh by 2030 (SETIS, 2018).
- The Ocean Energy Implementation Plan also aims to drive down the LCOE of ocean energy. Quantitative targets are set for the LCOE of tidal stream and wave energy. 100 MW are to be deployed as demonstration farms by 2025. In addition, there will be a reduction of LCOE for tidal and wave energy to 15 €ct/kWh by 2030 and 2035 respectively (SETIS, 2021).

Aligning R&I and EU energy policies: the SET Plan serving the EU Green Deal

The SET Plan objectives aim to boost the development and deployment of new generation renewable energy technologies across Europe. With the adoption of the European Green Deal, the EU climate and energy targets were updated inter alia with the Fit for 55 Package. Therefore, the SET Plan can provide substantial support for the transition to net-zero by 2050, with the update of its objectives and targets, and investigation of new technologies and issues.

At the national level more efforts are required to align R&I with European and national energy policies. Indeed, in its EU-wide assessment of the NECPs the European Commission pointed out that most Member States did not mention how the SET Plan areas they are involved in are linked to their national energy and climate objectives or how their national funds are allocated. This leaves considerable potential for synergies to be investigated to maximise complementarities and avoid duplication of efforts (Shtjefni et al., 2021).

Four Green Deal strategies for which cooperation between the Member States' R&I efforts is needed are particularly relevant to the SET Plan: hydrogen, offshore renewables, energy system integration, and the renovation wave. These strategies overlap with some of the SET Plan implementation plans and key actions, in which some targets are being updated. For instance, the Hydrogen Strategy foresees steering the development of key pilot projects supporting hydrogen value chains in coordination with the SET Plan from 2020 onwards (European Commission, 2020b). The Offshore Strategy states that the European Commission will review SET Plan targets regarding ocean energy and offshore wind and their implementation agendas. The strategy also indicates the launch of an additional SET Plan group on HVDC (European Commission, 2020a).

An outcome of the SET plan working group meetings in 2020-2021 has been an update of the implementation plans. About a third of the plans kept their original formulation (see Figure 36) while others were revised in 2020 or are still under revision, as is indicated in the SET Plan Progress Report 2021 (Shtjefni et al., 2021).

Figure 36: Status of the SET Plan implementation plans, source: Shtjefni et al. (2021)

Original Formulation	***Revised***
EE in buildings (2018)	Batteries (2020)
Positive energy districts (2018)	CCS – CCU (2020)
Nuclear safety (2019)	Deep geothermal (2020)
New	EE in industry (2021)
HVDC (2021)	CSP / STE (2021)
Under Revision	Energy systems (2021)
Offshore wind energy (2021/2022)	Ocean energy (2021)
Renewable fuels and bioenergy (2021/2022)	
Solar photovoltaics (2022)	

More than 150 R&I targets are included in the 13 existing implementation plans, with HVDC being new. About 29% of these targets were updated in recent years, while the others were considered suitable for upcoming challenges. For example, regarding offshore wind energy, for which the implementation plan is under revision, the working group agreed in November 2020 on new SET Plan targets:

- 8.7 GW annual installed capacity by 2030;
- 21.4 GW annual installed grid capacity by 2030;
- an average LCOE of between 35 and 45 €/MWh by 2030 for bottom-fixed offshore wind; and
- an average LCOE of between 62 and 106 €/MWh by 2030 for floating offshore wind.

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5.3 Digital transformation of the energy sector

Valerie Reif

In this section we give an overview of the ongoing digitalisation of the energy sector with a focus on measures to enhance consumer empowerment. The section focuses on the electricity sector but makes some references to the gas sector. First, we explain more generally the implications digitalisation has for the electricity sector. Second, we look at how digitalisation has been supporting the implementation of new consumer rights. Third, we give an overview of the EU policy and regulatory framework for smart metering systems and access to consumer data. Finally, we provide insights into current policy and legislative developments regarding digitalisation of the energy sector.

How is digitalisation transforming the electricity sector?

The ongoing digitalisation of electricity infrastructure is transforming the power industry while at the same time enabling its decarbonisation and decentralisation. Digitalisation is not a new phenomenon in the electricity sector. It is a process that has come in successive waves and has had widespread implications for the industry, ranging from technological to organisational, legal and behavioural change.

Rossetto and Reif (2021) show that the increasing deployment of technologies to generate, transmit, analyse and use data have had a considerable impact on:

- the way physical assets are planned, maintained and operated;
- coordination of the various autonomous actors operating in the interconnected electricity system;
- the emergence of new products that empower final customers and open the door to the entry of new players;
- the traditional managers of the electricity infrastructure; and
- the organisation and regulation of the sector.

They explain that the first wave of digitalisation covered transmission networks and large generation assets. Useable data on the status of the electricity network were increasingly available, which enabled more efficient and secure operation of the electricity system. Another wave brought the creation of competitive wholesale markets and their regional integration of them. A more recent development is digitalisation of distribution networks and final energy consumers, which allows both reduced costs of service and improved quality of service. It has enabled the establishment of innovative retail markets with increasing participation by empowered final consumers and new entrants. At the same time, digitalisation has challenged not only the traditional ways of managing electricity infrastructure but also existing approaches to sector regulation.

How is digitalisation supporting the implementation of new consumer rights?

Digitalised electricity infrastructure enables new forms of interactions and exchanges among the actors involved in the electricity sector (Glachant and Rossetto, 2018). It allows the creation of new innovative products, pricing models and business models, and the emergence of new markets, notably also at the level of distribution grids and retail-size assets owned by households or small businesses. Beyond the traditional supply of a kWh at a predefined price and grid connection point, a whole new set of energy services and tailor-made products are emerging that address the specific needs and preferences of customers (Rossetto and Reif, 2021). For example, new services can be related to energy efficiency, the concept of energy as a service, provision of ancillary services or energy with specific attributes such as energy generated locally or exclusively from RES. Another type of service is provision of new platforms for direct exchange of energy among peers (peer to peer), either individually or as part of larger communities of consumers.

The EU regulatory framework for smart meter roll-out and data access and management

As was described in section 4.3 on retail markets and the new deal, the Clean Energy Package and more recently the Hydrogen and Decarbonised Gas Markets Package have brought a new deal for energy consumers that enhances consumer empowerment and protection. New consumer rights regarding inter alia self-consumption, dynamic pricing and the use of intermediaries such as aggregators and energy communities go hand in hand with the need for a widespread roll-out of smart metering systems and proper data access and management policies.

Smart meter roll-out

The Third Energy Package included provisions with the aims of fostering the roll-out of smart meters and targeting active participation by consumers in the energy supply market through:

- transparency provided by the meter (timely and accurate information on consumption to increase predictability of costs and customer awareness);
- third-party access to data and interoperability (to facilitate competitive offers at the customer end, facilitate system integration and lower costs); and
- due regard to best practices (e.g. installation of in-home displays, connection to home automation, self-consumption).

However, under the electricity (2009/72/EC) and gas (2009/73/EC) directives, Member States were left with considerable discretion as to the extent to which they rolled out smart meters based on national cost-benefit analyses (CBAs). Provisions in the Electricity Directive were stricter than in the Gas Directive. Where the roll-out of smart meters for electricity was assessed positively in the national CBA, the Member States were required to roll-out smart meters to at least 80% of consumers by 2020. The Gas Directive also included a requirement to conduct a national CBA but did not foresee a specific timeline for the implementation of smart meters.

The most recent benchmarking report on smart meter deployment by Tractebel (2020) states that “[a]s of July 2018, all but two Member States have conducted at least one CBA for a large-scale rollout of electricity smart meters to at least 80% by 2020, with the results for most of these being positive. […] Regarding gas smart meters, the majority of Member States either did not conduct a CBA or did not specify whether the CBA conducted was for gas as well as electricity. But for those Member States that did perform a CBA for the roll-out of gas smart meters, the results were most of the time positive.” The report also provides the numbers of metering points equipped with smart meters and shows that the actual deployment rate fell short of expectations:

- As of 2018, 34% of all electricity metering points and 14% of all gas metering points were equipped with a smart meter in the EU28, with national deployment rates varying widely across Member States.
- At the time of writing the report, the authors expected that by 2020 only 43% of all electricity metering points and 27% of all gas metering points would be equipped with a smart meter.

Although the Third Energy Package contributed to the deployment of smart metering systems in some Member States, the fact that deployment rates vary widely across EU countries creates significant differences in the availability and accessibility of data. Therefore, both the CEP and the Hydrogen and Decarbonised Gas Markets Package push for increased deployment of smart meters in the EU.

The Electricity Directive (EU) 2019/94 foresees that Member States with a positive CBA shall equip at least 80% of final electricity consumers with smart meters either within seven years of the date of the positive assessment or by 2024 for the Member States that initiated the systematic deployment of smart metering systems before 4 July 2019. The proposal for a gas directive as part of the Hydrogen and Decarbonised Gas Markets Package (EC, 2021a) foresees that Member States with a positive CBA should equip at least 80% of final customers with smart meters within seven years of the date of the positive assessment. Member States with a negative CBA outcome for either electricity or gas are required to revise the assessment at least every four years. Note that the proposal for a gas markets directive also requires Member States to deploy smart metering systems in the hydrogen system.

Data access and management

Provisions on data access were already included in the electricity (2009/72/EC) and gas (2009/73/EC) directives in the Third Energy Package, which state in their respective Annexes I that consumers should "have at their disposal their consumption data, and shall be able to, by explicit agreement and free of charge, give any registered supply undertaking access to its metering data. The party responsible for data management shall be obliged to give those data to the undertaking. Member States shall define a format for the data and a procedure for suppliers and consumers to have access to the data. No additional costs shall be charged to the consumer for that service."

During the implementation phase of the Third Energy Package (which is still ongoing) and in the lead-up to the Clean Energy Package, discussions emerged on how to organise consumer data management across the Member States. In line with the EC's 'better regulation' agenda a report evaluating the Third Energy Package was published in 2016 (EC, 2016a).[140] It concluded that the package had achieved its main purpose (e.g. more supplier competition) but that some areas of increasing importance were not addressed or not in the necessary detail. More concretely, the report found that the Third Package had not been designed to address emerging challenges in managing large commercially valuable consumption data flows and that further progress was required in the areas of billing information, comparison tools and consumer ability to easily switch suppliers. It also highlighted the importance of the smart meter roll-out, a proper definition of DSO functions when it comes to consumer data management and a need for regulatory oversight.

The same year, the EC (2016b) published an impact assessment for the Market Design Initiative in the CEP. It underlined the needs to set up a non-discriminatory data management framework and to fill gaps in the EU regulatory framework regarding the role of DSOs in data management. The impact assessment looked at different ways to organise data management and concluded that the introduction of a single EU data management model (a data hub) would have high implementation costs, thus reducing the efficiency of the option. The preferred option was a 'flexible legislation' scenario that would lead to the introduction of further specific requirements on data handling responsibilities based on the principles of transparency and non-discrimination. EU consumer data management rules that are independent of the national data management model would be put in place aiming to ensure impartiality of the market actors involved in

140 In 2015 the Juncker Commission made 'better regulation' one of its top priorities, which means making sure that legislation is based on solid facts, is cost-efficient and benefits from input from citizens by involving them in the law-making process. It also means making use of evaluations, impact assessments and stakeholder engagement.

data handling, eliminate barriers to entry associated with data access and help all market actors provide a higher level of service to consumers.

In the EU today data management models differ from country to country.[141] They typically consist of a set of different roles, responsibilities, legal frameworks, technical standards and informal rules. Schittekatte et al. (2020) explain that these models can be categorised in terms of many different dimensions (e.g. ownership and operation, scope or set of metering points, data types, functionalities, rights of customers, access by third parties) with 'level of centralisation' (i.e. centralised, partially centralised or decentralised) being the most commonly used.[142]

Electricity Directive (EU) 2019/944 in the CEP eventually included more detailed provisions on data management independently of the data management model chosen at the national level. Member States are required to specify rules for access to consumer data by eligible parties and to authorise and certify (or supervise) the parties responsible for data management. Other provisions cover costs for accessing data, interoperability requirements and procedures for access to data, as is described in the following subsection.

The proposal for a gas directive as part of the Hydrogen and Decarbonised Gas Markets Package (EC, 2021a) mirrors the relevant provisions in the Electricity Directive. It also requires adoption of interoperability requirements and procedures for access to data in hydrogen systems.

Recent EU policy and legislative developments related to digitalisation of the energy sector

In the following we briefly introduce three ongoing initiatives at the EU level that are relevant in the digitalisation of the energy sector: the implementing acts on interoperability requirements and data access; the energy data space; and the Digitalisation of Energy Action Plan.

Implementing acts on interoperability requirements and data access

The Electricity Directive (EU) 2019/944 in the CEP entitles the European Commission to adopt implementing acts specifying interoperability requirements and non-discriminatory and transparent procedures for access to metering and consumption data, and data on customer switching, demand response and other services. The overall aim of the implementing acts is to facilitate full interoperability of energy services in the EU to promote competition in the retail market and avoid excessive administrative costs for eligible parties.

The EC has tasked the European Smart Grids Task Force (ESGTF) with the preparation of these acts (see ESGTF, 2019). The starting point is the diversity of existing solutions across Member States when it comes to handling consumer data. Over the last few years, a consensus has emerged at the EU level that efforts should focus on making the existing solutions interoperable instead of trying to create a common solution for all countries. Adoption of different implementing acts is foreseen, namely a generic implementing act that lays the common foundation for several other implementing acts on specific use case families (data access, demand response and traditional processes like billing and supplier switching). A contribution to the discussion on the implementing acts can be found in Reif and Meeus (2020), and a contribution to the wider debate on interoperability in the energy system in Reif and Meeus (2022). In 2022, the European Commission consulted on the draft of the first implementing act on metering and consumption data (EC, 2022a).

141 Some of the main (stakeholder) reports on data management models are CEER (2016), ENTSO-E et al. (2016), ESGTF (2016), Eurelectric (2016), NordREG (2018), TemaNord (2017), THEMA (2017) and Tractebel (2018).

142 Descriptions of the different types of data management models are provided in CEER (2016).

In the context of the Green Deal, the interoperability debate has gained further momentum and has been extended to the gas and buildings sectors. As was mentioned above, the proposal for a gas directive (EC, 2021a) requires adoption of interoperability requirements and procedures for access to data both for natural gas smart meters and in hydrogen systems. Moreover, a proposal for a recast of the Energy Performance of Buildings Directive (EC, 2021b) requires the European Commission to lay down implementing acts regarding interoperability and access to building systems data (i.e. all data related to the energy performance of building elements, the energy performance of building services, building automation and control systems, and meters and charging points for e-mobility).

The Energy Data Space and Digitalisation of the Energy Action Plan

A broader digitalisation initiative at the EU level is related to creating a single European data space (a single market for data) for personal and non-personal data as set out in the European Data Strategy (EC, 2020a). A common European data space is expected to bring together relevant data infrastructure and governance frameworks to facilitate data pooling and sharing. The aim is to overcome legal and technical barriers to data sharing by combining the necessary tools and infrastructure and addressing issues of trust by means of common rules. The Data Strategy indicated that it would initially support ten data spaces in different sectors, among them the energy sector.

The European Commission (EC, 2022b) specified that the first steps towards a common European energy data space include:

- energy-sector legislation (under the CEP and Fit for 55 Package) and cross-sectoral data space building blocks (as, e.g., provided by the Data Governance Act (EC, 2020b)) that define the main elements to enable future-proof data exchange among multiple parties in the energy sector and beyond; and
- various innovative national and EU-wide initiatives, including EU R&I projects that explore the potential for data sharing among companies and develop new use-cases for the benefit of the energy transition.

The EC sees a need to connect all these initiatives so that they can be scaled up for the benefit of a strengthened energy market and integrated energy system that make use of innovative and data-driven energy and cross-sectoral services.

In 2022, the European Commission published the Action Plan on the Digitalisation of the Energy Sector (DoEAP) (EC, 2022c). It states that the deployment of the common European energy data space, including a solid governance for it, will start no later than 2024. The DoEAP also specifies that a ‘Data for Energy’ working group will be formally established to, among others, support the Commission in developing and rolling out the data space. The group will bring together the Commission, the Member States and the relevant public and private stakeholders.

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5.4 Clean molecules

Ilaria Conti and James Kneebone

In this section we break down the subject of 'clean molecules,' an umbrella term we are using to cover abated fossil gases, decarbonised gases, renewable gases, and even emission-negative gases. We cover definitions of clean molecules, what sets them apart from fossil gas and from each other, and some of the associated opportunities and limitations. We also look at the role foreseen for clean molecules as outlined in EU strategies, recent legislation, and the European Gas Regulatory Forum (Madrid Forum), in addition to some possible ways to stimulate their strategic deployment.

Gas, gaz, plynu, plin…

Natural (fossil) gas

When we talk about 'gas' in the energy sector, we are typically referring to 'natural gas.' This is an odourless and colourless mixture of four gases, ~80% methane, with smaller quantities of ethane, butane, and propane. Natural gas is of fossil origin, the result of heat and pressure applied to organic matter in geological formations for prolonged periods of time. Following extraction, this fossil gas undergoes processing before being transported along a complex supply chain to consumers (API, 2021). Natural gas constitutes roughly 20% of final energy consumption in the European Union (Eurostat, 2021). In an effort to move away from natural gas to cleaner alternatives, a range of abated fossil, low-carbon, renewable and emission-negative gases are emerging as substitutes.

So-called 'clean molecules'

The most prevalent clean molecule in the EU at the moment is 'biogas,' a methane-based gas that when upgraded to 'biomethane' can be used interchangeably and in combination with fossil methane. Like fossil methane, biomethane is also produced from decomposition of organic matter. However, it is not considered a fossil fuel. This is because biomethane is produced from anaerobic digestion[143] of organic matter (such as food and animal waste) above ground rather than being extracted from fossil sources in geological formations underground.

Key emerging but still relatively uncommon clean molecules include: low-carbon, renewable and emission-negative hydrogen, ammonia and renewably produced syngases such as e-methanol, e-methane, and e-kerosene (El-Nagar, 2018). This is a complicated and nuanced area, in particular due to the many ways hydrogen and hydrogen-derived gases can be produced. For this reason, we have an entire section dedicated to exploring the hydrogen economy (see section 5.5). In short, hydrogen and its derivates can fall into any of the loose categories of unabated, low-carbon, renewable, and even emission-negative gases.

Conceptual versus legal definitions

As a starting point, it is important to have a fundamental understanding of the difference between conceptual and legal definitions of different gases and the metrics used to distinguish them.

143 Biogas can also be produced through other processes, such as thermos-gasification.

Conceptual definitions

In a conceptual sense, ‘clean molecules’ is a non-prescriptive and general term we are using to refer to all abated fossil, low-carbon, renewable and emission-negative gases. These are gases that in some way and to varying extents attempt to provide cleaner alternatives to unabated natural gas or their fossil equivalents, for example renewable versus fossil hydrogen. The following can be considered a descriptive classification.

- Abated fossil gases: gases derived from fossil fuels with the addition of carbon capture and storage (CCS) technology to reduce the emissions associated with end use, and offsets corresponding to lifecycle emissions or transformation of hydrocarbon-based gases into non-emitting or lower emitting derivatives. *Examples*: liquid natural gas (LNG) cargoes participating in an accredited emission offset scheme; ‘green LNG;’ fossil gas combusted in an electricity plant where CCS infrastructure is installed and operating; syngases (depending on the production process and end use).
- Low-carbon hydrogen: hydrogen derived from fossil fuels with the addition of carbon capture and storage (CCS) technology to reduce emissions associated with conversion from methane to hydrogen. *Examples: hydrogen produced through steam methane reforming (SMR) of natural gas with the addition of CCS; hydrogen produced from gasification of coal with the addition of CCS*.
- Renewable gases: Gases of non-fossil origin with no associated process emissions and no emissions released at the point of consumption. *Examples: biomethane; hydrogen produced from electrolysis driven by renewable electricity*.
- Emission-negative gases: gases of non-fossil origin which actively sequester or recycle carbon dioxide or other emissions through their production, including the full lifecycle of associated supply chain emissions. *Examples*: hyd*rogen produced through pyrolysis of biomethane feedstock; hydrogen produced through photocatalysis of biomethane feedstock.*

Different parties have different perspectives on how to categorise gases and there is a range of general terminology used to refer to them. You may have heard ‘green gas,’ ‘renewable gas,’ ‘decarbonised gas’, and ‘low-carbon gas’ used interchangeably, for example. These terms have a place, but they are non-scientific and can be misleading or create confusion if not well understood or contextualised. For example, the term ‘decarbonised gas’ is commonly also used to refer to clean molecules with carbon as a core component, such as syngases. In a technical sense, these gases are not ‘decarbonised’ at all.

In order to create conceptual taxonomies of gases, each party makes value judgments on what metrics should be used to classify them, such as origin, production process, final emission intensity, chemical composition, environmental and land-use considerations, etc. At the Florence School of Regulation (FSR) we proposed a taxonomy (Conti, 2020), as have energy companies like Iberdrola (2019) and non-governmental organisations (NGOs) like Bellona (2021a). These are useful lenses to frame the concept, but they are not legal classifications, although inevitably many are developed with the intention of influencing legal classifications.

Legal definitions: EU

It is up to policymakers to set formal metrics, thresholds and parameters for these gases and other forms of energy as a basis for differentiating their treatment in regulatory frameworks. The EU is the primary actor here in the context of European energy policy. For example, the definitions in the EU Sustainable Finance Taxonomy guide investment in energy infrastructure, while classifications in the Renewable Energy Directives (RED) and Energy Taxation Directive (ETD) stipulate the market conditions under which different gases will operate. These formal classifications and frameworks make it possible to incentivise certain products over others, and they go a long way to shaping the sector. Currently there are several existing reference points for the definition of clean molecules in the EU, and this remains an evolving unfinished landscape.

Renewable Energy Directive (EU) 2018/2001 (Red II) and its proposed revision (EC, 2018a; EC, 2021d).

The RED II is the core legal framework for development of renewable energy in the EU, covering relevant rules, objectives and principles to remove barriers, stimulate investment and drive cost reduction in renewable energy technologies. RED II defines renewable energy as "*energy from renewable non-fossil sources, namely wind, solar (solar thermal and solar photovoltaic) and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogas*." No specific methodology is provided to make statistical comparisons between the efficiency or emission intensity of different sources.

The RED II also creates a number of specific incentives for Renewable Fuels of Non-Biological Origin (RFNBOs), i.e. renewably produced hydrogen or hydrogen-derived fuels, by explicitly including them as a possible category for achieving the 14% renewable fuels target for transport applications in 2030, next to biofuels and recycled carbon fuels. However, a number of administrative requirements are imposed on the origin of the electricity used for the production of these RFNBOs. These requirements, for which a methodology was proposed in a Delegated Act (Art. 27.3) in May 2022, stem from the desire to ensure the renewable electricity used to produce RFNBOs is 'additional' to that already installed for direct electrification and therefore does not cannibalise the use of this already scarce resource. Although this so called 'additionality principle' is supported by many as a necessary precondition to ensure these RFNBOs are truly low emission, the specifics of its implementation in practice have been criticised extensively, with the original Commission proposal recently rejected in Parliament. Critics argue that the rules in their original form were too strict and would have hamstrung the scale up of RFNBO production, jeopardising the EU decarbonisation targets and the wider viability of this nascent sector. The Commission is currently preparing a revised version of the additionality rules.

Although the Delegated Act on RFNBOs was presented in sequence to the second Renewable Energy Directive in order to define which fuels could count towards the transport target of that Directive, it is not yet clear whether the same rules will apply for the reinforced transport and new industry targets proposed under the third Renewable Energy Directive (RED III).

The proposed revision of the Gas Directive (2009/73) (EC, 2021c).

Articles 2 and 8 of the proposed revision of the Gas Directive offer definitions of 'low-carbon hydrogen' and 'low-carbon gases' more widely, indicating a "greenhouse gas emission reduction threshold of 70%." The GHG in question is not specified and neither is the benchmark against which the 70% reduction applies.[144] The Directive also refers to Article 2 of the RED for classifications of 'renewable-gas,' 'low-carbon gas,' 'low-carbon fuel' and 'renewable fuels of non-biological origin'. A specific methodology for calculating and defining the thresholds for renewable and low-carbon hydrogen will only be provided in a delegated act at some point before the end of 2024.

What are the opportunities for and limitations of green gases?

Clean molecules in the context of EU climate and energy objectives

The EU 2050 long-term strategy outlines a vision to bring the bloc in line with the Paris Climate targets of keeping the global temperature increase well below 2°C and as close to 1.5°C as possible. This over-arching framework comes as part of the EU's own climate commitments: (i) climate neutrality by 2050 as outlined in the EU Green Deal; and (ii) an increased ambition of a 55% reduction in emissions by 2030 specified in the 2020 Communication on Stepping up Europe's 2030 Climate Ambition (EC, 2022d).

In line with the above-mentioned strategies, the more recent Energy System Integration (ESI) (EC, 2020b) strategy envisages a meaningful role for clean molecules in the future decarbonised energy system. Subsequent to energy efficiency and electrification (the two main pillars of the strategy), clean molecules are considered a suitable energy vector in hard-to-abate sectors, where electrification is not efficient or effective with current technology.

In 2021, the 35th meeting of the European Gas Regulatory Forum ('Madrid Forum', see also section 1.4) addressed the subject of clean molecules in detail, concluding that efforts should be made to facilitate the certification of renewable and low-carbon gases and the growth of a dedicated market and corresponding rules and regulations.[145] Building on these outcomes and the ambitions of the Fit for 55 Package that followed in the summer, the European Commission released its Hydrogen and Decarbonised Gas Market Package (HGMDP) in December 2021 (EC, 2021b).[146] More details on the Fit for 55 and HGMDP can be found in Kneebone (2021a, 2021b).

Opportunities for clean molecules

Clean molecules are likely to directly substitute fossil gas in some cases and carve out a market share in new applications previously served by other non-gaseous energy vectors. In 2019, residential and commercial heating represented the largest share of natural gas use in the EU, at roughly 35% of overall consumption. Electricity generation accounts for ~32%, and industry a further ~23% (Eurostat, 2021).

A significant amount of this demand is likely to be electrified in the future as it is typically more efficient in the context of a renewable-dominated energy mix. Within this context, projections for the gas sector broadly envisage a diminished overall role for molecules, as is shown in Figure 37 and Figure 38.

144 However, we might assume that it is benchmarked against the unabated fossil alternatives, i.e. unabated grey hydrogen (steam methane reforming of natural gas) and unabated natural gas.

145 The conclusions of the 35th meeting of the European Gas Regulatory Forum on 29-30 April 2021 are available at https://ec.europa.eu/info/sites/default/files/energy_climate_change_environment/events/documents/35th_mf_final_conclusions.pdf.

146 See also recordings of the following FSR online events: "The Commission's new Gas and Hydrogen Package," available at https://www.youtube.com/watch?v=ZrBNmqKyKCU, and "Decarbonised Gas Markets – What should be in the future Hydrogen Legislative Package?" available at https://www.youtube.com/watch?v=jgro5p6u6DE.

Figure 37: EU demand for gaseous fuel scenarios (Frontier Economics, 2019)

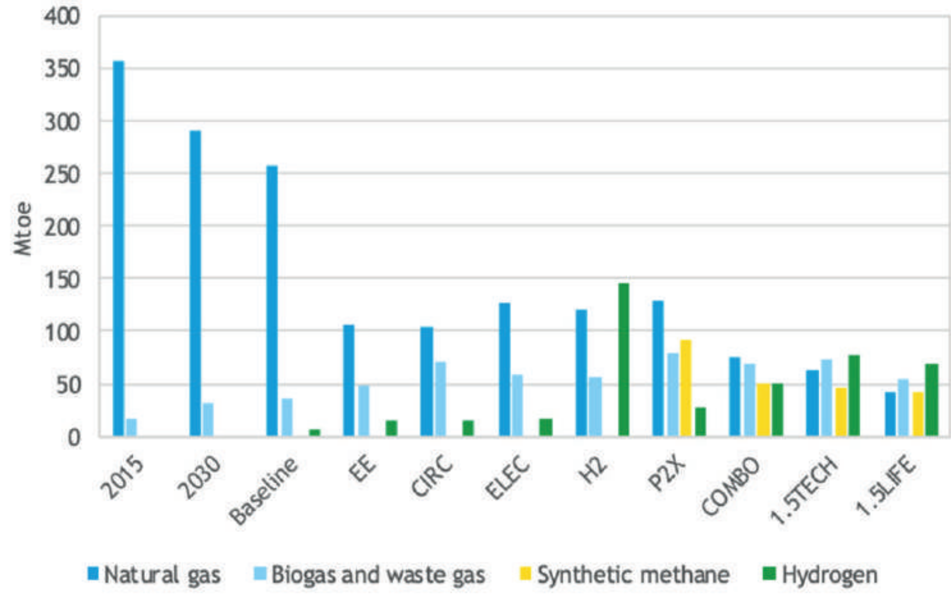
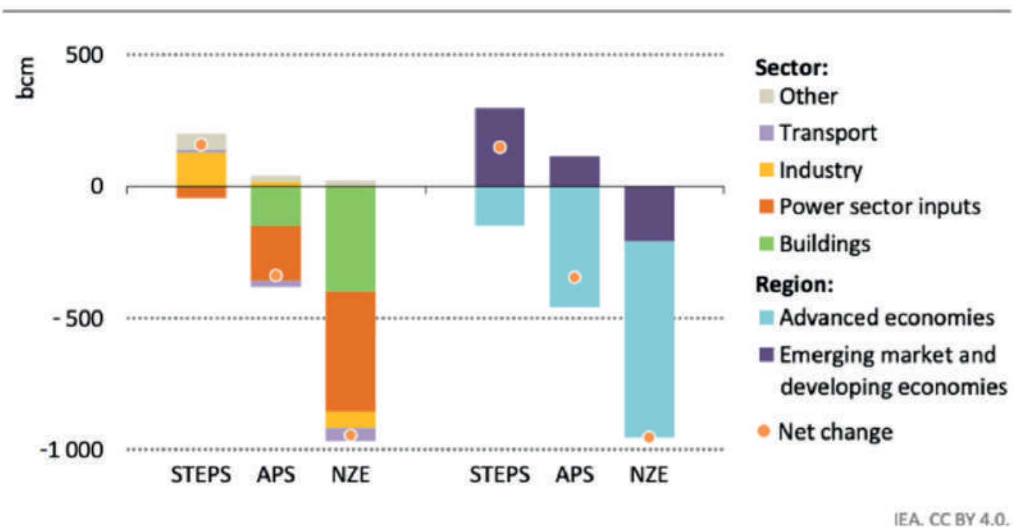


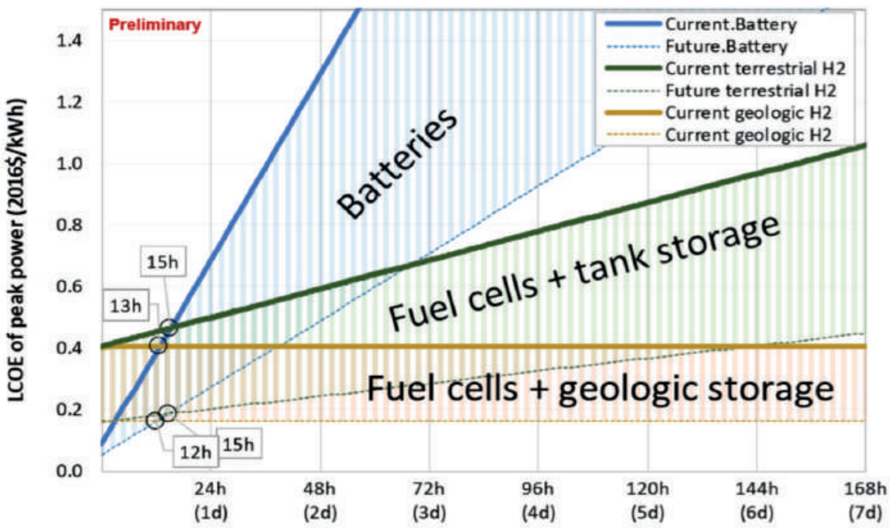
Figure 38: Change in global annual gas demand by sector in three scenarios: the Stated Policies Scenario (STEPS), Announced Policies Scenario (APS) and the Net Zero Emissions by 2050 scenario (NZE) (IEA, 2022)



However, there is likely to still be a requirement for significant volumes of molecular energy. This is due in part to the physical properties of energy in this form. Two key advantages of molecular energy over electrical energy can be identified that make it an important component in future energy systems.

First, gases such as methane and hydrogen are more effective than electrical energy in certain applications where high temperatures are required such as steel production. This is because with current technology molecular energy can often be delivered more quickly (in terms of ramp-up speed) and has higher stability (in terms of maintaining the temperature) compared to electricity. The second key advantage of molecular energy is that it can be stored for extended periods of time at very low marginal cost relative to electricity. Figure 39 gives an illustration of the price competitiveness of storing electricity in batteries versus hydrogen gas storage coupled with fuel cells. The Levelised Cost of Electricity (LCOE) for each technology indicates that at current prices hydrogen technologies are more economical than batteries for any storage duration beyond 15 hours.

Figure 39: Economic performance benchmarks for current & future hydrogen and batteries (NREL, 2019)



For this reason, clean molecules can have a role in sector coupling as an energy vector, helping to balance the electricity and gas grids by providing medium to long-term storage and dispatchable power, for example through power to gas facilities. This balancing component is likely to grow in importance as the EU electricity mix becomes increasingly characterised by variable renewable sources. Furthermore, much of the storage and transport infrastructure that currently exists in the natural gas network can be cost-effectively repurposed for clean molecules, thus reducing the requirement for infrastructure investment and easing pressure on the electricity grid.[147]

Clean molecules also have an increasingly important role in achieving greater energy independence and overall security of energy supply in Europe. Currently the EU is roughly 90% dependent on imports for its gas supply, 45% of which come from Russia (EC, 2022c). The EU has been attempting to ameliorate this dependence and improve security and competitiveness in the gas sector since the early 2000s by diversifying suppliers, liberalising the internal market and providing solidarity requirements between Member States (EC, 2017). Although many of these initiatives have been successful, particularly regarding the development of an internal market within the EU, overall dependency on Russian gas has never been higher. In the context of Russia's invasion of Ukraine in February 2022, the EU has proposed measures to aggressively divest from Russian gas imports, and also oil and coal, for which the EU is also heavily dependent on Russia (EC, 2022d). Clean molecules can play a central role in these efforts as they are typically produced locally or at least can be supplied by a large number of parties. This is a localisation and a democratisation of the sector as compared to the current system, which is controlled by those endowed with deposits of natural resources and with whom the EU is connected by means of rigid infrastructure (IRENA, 2022).

147 As of 2022, gas TSOs are required to include hydrogen infrastructure in their Ten-Year Network Development Plans (TYNDPs), see https://tyndp2020.entsog.eu/.

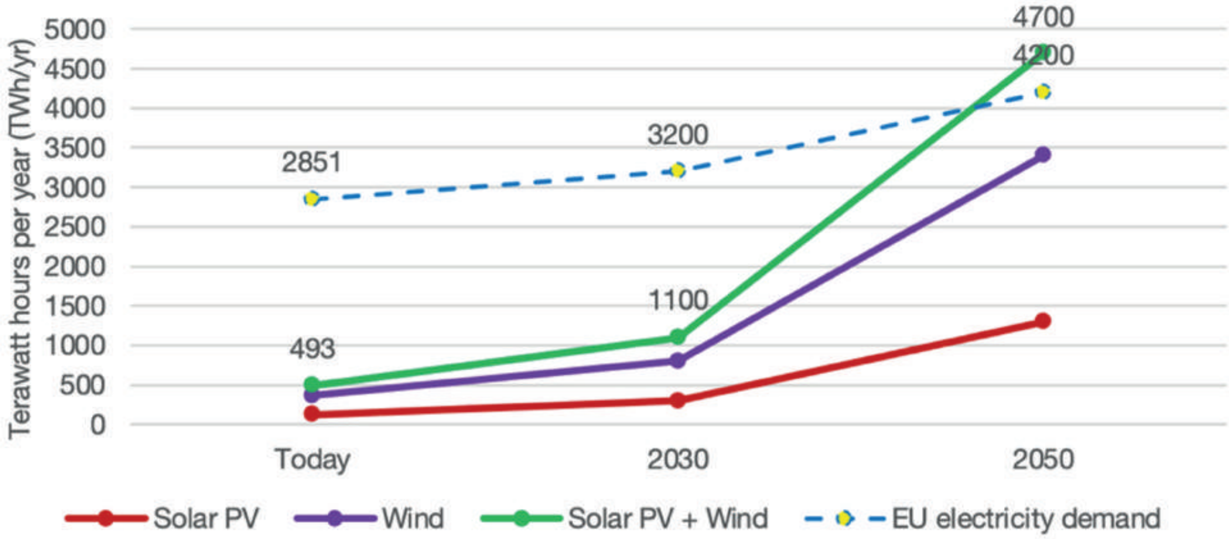
Limitations of clean molecules

Nevertheless, there are limitations and bottlenecks foreseen for the growth of clean molecules in the EU energy mix.

First, there is the issue of lifecycle emissions. One aspect of this is fugitive emissions, which unfortunately do not disappear with the departure of fossil gas. Clean molecules can also be climate forcers.[148] For example, biogas is not of fossil origin, but it is primarily composed of methane and therefore acts as a climate forcer when it escapes, just like fossil methane.[149] The EU is attempting to address this with measures outlined in its Methane Strategy (EC, 2020a). There have been several recent studies assessing the emission intensity of hydrogen produced with differing levels of fugitive methane emissions, including one comparing SMR with CCUS with unabated SMR, fossil gas and coal use. Similarly, in the event of a leak, hydrogen itself is an indirect greenhouse gas as it enhances the lifespan and warming potential of greenhouse gases already present in the atmosphere.[150]

Another aspect of lifecycle emissions is the opportunity cost in the allocation of scarce resources depending on the production process (SMR, pyrolysis, electrolysis, photocatalysis, etc.) and corresponding conditions. For example, green hydrogen is produced through electrolysis, a process of passing renewably produced electricity through water, splitting it into hydrogen and oxygen. Roughly 25% of the energetic value of the renewable electricity input is lost in the hydrogen production process, with a further ~25% energy loss if it is subsequently reconverted back into electricity. These losses are relatively unproblematic in a scenario of abundant renewable electrons, but while they remain scarce (see Figure 40 below) their allocation to one activity incurs an opportunity cost elsewhere.

Figure 40: Total estimated realistic energy potential for cumulative installed capacity of renewable electricity in the EU, present, 2030, 2050 (Belmans, Dos Reis, Vingerhoets, 2021. Electrification and sustainable fuels: competing for wind and sun, https://cadmus.eui.eu/handle/1814/71402 via Jones, Kneebone, Piebalgs, 2022)



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148 The University of Calgary (2020) defines climate forcing as "the physical process of affecting the climate on the Earth through a number of forcing factors. These factors are specifically known as forcings because they drive the climate to change, and it is important to note that these forcings exist outside of the existing climate system."

149 See United Nations Economic Commission for Europe (UNECE). The Challenge, https://unece.org/challenge.

150 https://onlinelibrary.wiley.com/doi/full/10.1002/ese3.956

ifferent EU initiatives aimed at decarbonisation may end up competing for the same renewable electricity, for example electrification of road transport and electrolyser capacity for hydrogen production. Where fossil electricity generation is required to cover renewable electricity diverted away from direct consumption in the electricity grid to serve electrolysers, the resulting green hydrogen will have considerably higher emissions than hydrogen produced with fossil fuels (Belmans et al, 2021). With this in mind, it will be important for the overall decarbonisation of the sector for clean molecules to be deployed strategically where they are the most effective, giving consideration to the overall decarbonisation approach outlined in the above section 'Clean molecules in the context of EU climate and energy objectives.'

Second, the scope of clean molecules to decarbonise existing energy demand will to a considerable extent be dictated by their cost-effectiveness compared to alternatives, and the speed at which they can be scaled. Figure gives an overview of some of the expected costs associated with hydrogen produced through different processes. Other than the most optimal scenarios (which are limited in scale) clean hydrogen alternatives are anticipated to remain considerably more expensive than grey hydrogen (which is typically produced for less than €1 /kg) for the foreseeable future.

Getting these costs down as quickly as possible is key to ramping up the uptake of clean molecules. Nevertheless, the exceptionally high prevailing electricity and gas prices in the second half of 2021 and the first three quarters of 2022 have completely rewritten the economics of this sector. Under these conditions, green hydrogen is already cheaper than fossil hydrogen or any methane-based hydrogen, provided the electricity is purchased on a long-term power purchase agreement (PPA) established prior to the energy crisis or provided through a dedicated supply (Collins, 2021). Similarly, at a price of ~70€/MWh biomethane has historically struggled to be cost-competitive with imported fossil methane, which has averaged roughly 20-30 €/MWh in recent years (IEA, 2020). However, under current market conditions, biomethane is comparatively very cheap, with fossil gas prices in the hundreds of euros per MWh.

Finally, it is also worth noting that not all clean molecules are created equally, and each have scalability challenges. Different gases each have unique properties and therefore need to be deployed in an optimal combination. For example, hydrogen has the highest energy density of any known substance by mass. However, by volume it has relatively low energy density. For context, substituting 5% volume of natural gas or biomethane with hydrogen would only cover 1.6% of the energy content, requiring higher overall volumes of gas for the same quantity of energy. It is therefore uneconomical and wasteful to use hydrogen as a direct substitute for methane in residential heating applications, for example. However, it can have a great value as a reducing agent in the production of iron and steel, for example, replacing coking coal (Bellona, 2021b).

Figure 41: Breakdown of average levelised cost assumptions of hydrogen for different timelines and different production methods (Jones, Kneebone, Piebalgs, 2022)

Scenario	Current Technological Maturity	Levelised cost assumption	EUR/kgH_2** **today**	EUR/kgH_2** **2030**	EUR/kgH_2** **2050**
Domestic green H_2: Utility scale solar	Commercial (established)	Minimum	2.6	1.3	0.9
		Average	6.9	3.6	2.7
Domestic green H_2: Offshore wind	Commercial (established)	Minimum	3.6	1.8	0.9
		Average	6.9	4.8	3.0
Domestic blue H_2	Commercial (established)	Minimum	0.9	0.9	1.0
		Average	1.8	2 [6.8***]	2.0
Domestic turquoise H_2	Commercial (early)	Minimum	-	0	0
		Average	-	3 [4.1***]	3 [4.1***]

KEY: Colour coding (only for illustrative purposes): High price — *low price*
NOTE:
** Data from reference list 1 [IEA (2021a). IEA (2021b). IRENA (2021). H Quest via Collins (2021). BNEF (2021). BASF, Monolith Materials, Argonne International Laboratory, Universidad Politécnica de Madrid, via Conti, et al. (2021). Zachmann, et al. (2021)]*
*** Euros per kilogram of hydrogen*
**** Including use of non-crop 'sustainable biomethane' for upper end estimations. A blend of natural gas and biomethane is also possible. Every 10% of biomethane blended would add roughly 10% to the overall feedstock cost by 2030, although this is not infinitely scalable. Biomethane prices vary enormously. Company reported data are included in these estimates.*

Biomethane is considered among the most viable substitutes for natural gas due to similarities in chemical composition and therefore compatibility with existing infrastructure. However, in 2020 the EU produced only 23 TWh (~2 billion cubic metres (BCM)) of biomethane (EBA, 2020), less than 1% of overall gas consumption (fossil gas and clean molecules combined). Although biomethane production is envisaged to increase massively in the coming years due to ambitious national initiatives,[151] sustainable biomethane is not an infinitely scalable energy vector and therefore is limited in its scope to displace fossil methane. Furthermore, there is a risk of creating perverse incentives in which significant support for biomethane can lead to more animal agriculture and therefore higher overall emissions (EC, 2020a).

How can the growth of clean molecules be stimulated in an effective and targeted way?

The following section outlines some different approaches available to policymakers to foster the growth of clean molecules, focusing predominantly on some of those already implemented or proposed.

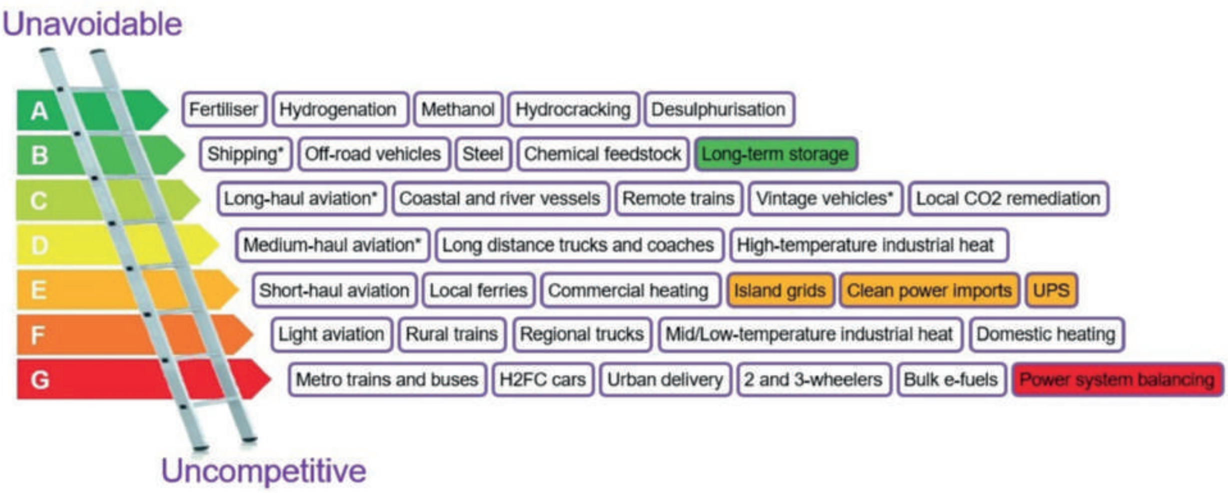
Establishing areas for 'no regret' implementation

There are significant uncertainties in the development of the clean molecule sector moving forward. Key variables include: (i) the price of renewable electricity, (ii) demand for clean molecules, (iii) which clean molecules to use where, (iv) technological development, and (v) infrastructure capacity and suitability. Due to the number and unpredictability of variables in this sector it is difficult to decide on objective technology preferences, for example. Nevertheless, to keep pace with EU climate targets and to move the EU away from fossil fuel dependence as quickly as possible, there is mounting pressure on policymakers to accelerate the transition of the gas sector.

151 See 'Support schemes' below for examples.

In the light of these conditions, policymakers may choose to compartmentalise the issue, intervening first in areas where a cost-benefit analysis (CBA) reveals a clear case for one specific technology or product, subsequently expanding and evolving the approach as the outlook becomes clearer. This can be characterised as a 'no-regret' strategy focusing on the clearest use cases, and it is often discussed as a means to stimulate the growth of the sector with a high-level of effectiveness and minimal risk of stranded assets.[152] Strategic build-out of expensive infrastructure can also be key to minimising the cost of the final product. Figure 42 below outlines one conceptual hierarchy for use cases of clean hydrogen, for example.

Figure 42: The Clean Hydrogen Ladder, Version 4.0, (Liebreich Associates, Adrien Hiel, Energy Cities, 2021); *via ammonia or e-fuel rather than H2 gas or liquid



Support schemes

Once a certain technology or product has been identified for a given application, there are a number of tools at the disposal of policymakers to support its competitiveness. We split them here into three overarching groups.

First, 'push factors' can be used to make established products and technologies less competitive or entirely uncompetitive, encouraging or forcing the market to react and adopt alternatives. The EU has attempted to do this through several means, including broadening the scope of the EU Emissions Trading System (ETS) while quickly reducing the availability of free credits and simultaneously introducing a Carbon Border Adjustment Mechanism (CBAM) to avoid carbon leakage. (Kneebone, 2021b). Under the proposed revision of the ETD, the Commission also adjusts the taxation rates for different gases, putting unabated fossil gas in the highest tax category, while advanced sustainable biofuels, biogas and RFNBOs such as renewable hydrogen are in the lowest tax category.[153]

A second approach is for regulators to loosen restrictions on market participants in a targeted way to help ensure the recovery of capital expenditure (CAPEX) and operational expenses (OPEX), thus lowering barriers to entry. This is a form of 'pull factor.' Measures can be permanent or temporary derogations and cover entire value chains or be strictly limited in scope. For example, exemptions to certain unbundling rules in the gas sector would allow network operators to own production facilities in the same value chain, thus

152 For example, Agora Energiewende and AFRY (2021) conduct a study assessing exactly this issue, specifically for hydrogen.

153 Low-carbon hydrogen and related fuels will also benefit from this treatment for a transition period of 10 years.

guaranteeing cost recovery for the gas produced.[154] Under the HDGMP, proposals are made to temporarily waive or adjust certain rules governing third party access (TPA), private hydrogen networks and unbundling to help guarantee returns for investors (Kneebone, 2021a). In parallel, low-carbon and renewable gases are given a 75% discount on entry and exit tariffs from the methane grid, and a 100% discount on transmission costs at interconnection points until 2031. This effectively functions as a cross-subsidisation mechanism from natural gas to clean molecules, narrowing the cost-competitiveness gap.

A third approach and another kind of pull factor is to directly incentivise a specific technology or product with financial support, narrowing the gap between the market rate and the CAPEX/OPEX costs of the replacement. This has been a common approach in the energy sector, for example direct subsidies and carbon contracts for difference (CCfD) for solar and wind power. So far, direct financing has not been introduced at the EU level for clean molecules. However, the Fit for 55 Package does propose measures to mandate their offtake. For example, the proposed ReFuel EU Aviation initiative mandates that from 2025 2% of aviation fuel should be sustainable aviation fuel (SAF), increasing to 5% by 2030, 32% by 2040, and 63% by 2050 (EC, 2021a). Moreover, there are examples of diverse initiatives at the Member State level. France, for example, has a binding mandate for 7% of gas transported in the national grid to be renewable by 2030.[155] Italy is investing €4.7 billion in supporting the transport and distribution of advanced biofuels for the transport sector (EC, 2018b). In Denmark subsidies for biomethane plants have historically covered as much as 40% of the CAPEX cost and Green Certificates (GCs) are provided upon injection of biomethane into the grid (Decorte et al., 2020).

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154 The possibility of applying this approach to power to gas facilities on a temporary basis was explored in a February 2021 FSR online event on "The Regulation of Power-to-Gas Facilities and Regulatory Sandboxes," available at https://fsr.eui.eu/electrolysers-in-the-eu-is-there-a-role-for-network-operators/.

155 See the French National Energy and Climate Plan, available at https://energy.ec.europa.eu/topics/energy-strategy/national-energy-and-climate-plans-necps_en#final-necps.

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5.5 Hydrogen in the EU Green Deal

James Kneebone

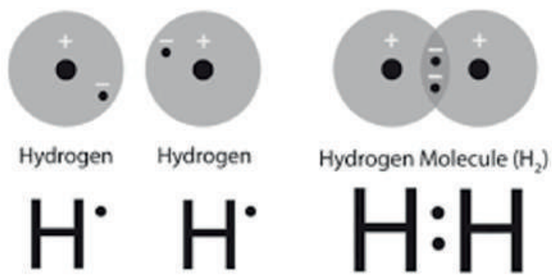
Achieving the ambitions of the EU Green Deal will require innovation and diversification across several key areas. One tool which is believed by many to be a bit of a 'Swiss Army Knife' to address tricky decarbonisation issues in multiple sectors is clean hydrogen.

In this section, we aim to map the contemporary hydrogen landscape by responding to five common questions. What is hydrogen? What are the current and potential uses of hydrogen? How is it produced? What do hydrogen supply chains look like? Which strategies and laws are aimed at supporting a clean hydrogen economy in the EU?

What is hydrogen?

Confusingly, we can talk about hydrogen in both its atomic and molecular forms (see Figure 43). The hydrogen atom is by a huge margin the most common atom in the known universe, making up roughly three quarters of its mass. However, hydrogen in molecular form, 'H2,' i.e. two hydrogen atoms bonded together, is scarce and on earth is only found in combination with other atoms, like oxygen in the case of water or carbon in the case of methane.

Figure 43: Hydrogen atom vs. hydrogen molecule



Hydrogen molecules are the focus of this section. At room temperature, hydrogen molecules are an odourless and colourless gas with the lowest density of any gas. As we cannot directly extract gaseous hydrogen as we can with some other energy vectors, we must liberate it from other products such as methane, water, coal and biomass. This can be done through a variety of processes, which we will explore later.

What current and potential uses are there for hydrogen?

We focus on two broad applications of hydrogen: (i) as an industrial feedstock and reductant,[156], [157], and as an (ii) energy vector in the power system.

156 Hydrogen works as a reducing agent in the production of certain metals (e.g. tungsten) and other chemical processes due in part to its ability to interact with oxygen molecules and compounds.

157 Luidold and Antrekowitsch (2007).

More than 90% of the existing demand for hydrogen in the EU,[158] is related to industrial processes, in which hydrogen is a feedstock and a reductant. In particular, hydrogen is used:

- for removing impurities during the crude oil refining process (the main one being sulphur) (~50% of total industrial use).
- As a feedstock (i.e. raw material) in chemical plants to produce a wide variety of products including ammonia (NH3), methanol (CH3OH), fertilisers, household products and industrial solvents (~40%).
- For steel production from direct reduced iron (DRI) and other industrial uses, e.g. as a blanketing gas and a coolant (~5%).
- Other uses (~5%)

In a decarbonised future we can imagine that demand for crude oil will drop considerably, reducing the demand for hydrogen in this sector, which is the biggest current consumer. What remains of current fossil hydrogen demand will need to be replaced with more sustainably produced hydrogen. However, in recent years hydrogen has also caught the attention of other sectors, most notably in applications as an energy vector. These uses remain very marginal in the EU today, constituting ~0.7 million tonnes (Mt) of the 8.4 Mt (IRENA, 2021) overall demand, with virtually all of this being of fossil origin. However, according to the International Renewable Energy Agency (IRENA, 2021) by 2050 hydrogen could represent as much as 12% of final global energy consumption.

Four categories of energy sector applications for hydrogen moving forward (EP, 2021):

- Buildings (e.g. space heating, water heating, cooking);
- Industry (e.g. high-temperature steam in the glass and cement industries);
- Mobility (e.g. for heavy duty vehicles, derivatives for aviation);
- Electricity generation and grid balancing (e.g. seasonal storage of electricity – stored as hydrogen – and electricity generation during peak loads from hydrogen-based gas turbines or fuel cells).

How is hydrogen produced?

Currently, hydrogen is produced either at dedicated production facilities or as a by-product of other production processes, such as chlorine production. According to the IEA (2019), ~60% of global hydrogen production is at dedicated facilities, with the remainder coming as a by-product. Virtually all dedicated global hydrogen is of fossil origin, and other chemical processes that produce hydrogen as a by-product are also typically quite energy intensive.

Here we explore how hydrogen is produced and how it can be made more sustainable (Table 7).

- **Black** - produced by gasification of 'black' coal.
- Brown – produced by gasification of 'brown' coal.
- Grey - produced by thermochemical conversion of fossil gas, either Auto-Thermal Reforming (ATR) or Steam Methane Reforming (SMR).
- Blue - produced by ATR or SMR of fossil gas, with the addition of carbon capture (use) and storage (CCUS).

158 Circa 7.7 Mt (or 257 TWh) of 8.4 Mt (Agora Energiewende, AFRY Management Consulting, 2021).

- Turquoise - produced by pyrolysis of methane (fossil or bio) driven by electricity (can be renewable) (see also Conti et al., 2021).
- Pink - produced by electrolysis of water, utilising electricity of nuclear origin.
- Green - produced via electrolysis of water, driven by renewable electricity.
- Yellow - produced by electrolysis of water, utilising grid electricity.

Table 7: Visual classification of ways of hydrogen production by emission profile, (Author, 2022).

<table>
<tr><th></th><th colspan="4">HYDROGEN PRODUCTION CODED BY 'COLOUR'</th></tr>
<tr><td>FOSSIL</td><td>BLACK HYDROGEN</td><td>BROWN HYDROGEN</td><td>GREY HYDROGEN</td><td rowspan="4">YELLOW HYDROGEN</td></tr>
<tr><td>ABATED FOSSIL</td><td colspan="2">BLUE HYDROGEN</td><td>TURQUOISE HYDROGEN (fossil methane feedstock)</td></tr>
<tr><td>DECARBONISED</td><td colspan="3">PINK HYDROGEN</td></tr>
<tr><td>RENEWABLE</td><td colspan="3">GREEN HYDROGEN</td></tr>
<tr><td>EMISSION NEGATIVE</td><td colspan="4">TURQUOISE HYDROGEN (biomethane feedstock)</td></tr>
</table>

As a reference, in 2018 the global production of grey hydrogen for industrial feedstock uses generated around 830 Mt of CO_2 emissions, 2.5% of global CO_2 emissions (IEA, 2019). In the same year, clean hydrogen production was negligible (IEA,2020). Projects of meaningful scale have only emerged since 2021.

It is important to keep in mind that lifecycle GHG emissions also depend on emissions associated with supply chains. For example, the GHG emissions of the natural gas supply chain can be significant and highly variable due to methane leaks in the chain. Although emissions from electricity supply chains can be negligible if the electricity is from renewable sources, there are still differences in the emissions from wind power infrastructure and solar, for example. This is one of the challenges in the certification of hydrogen.[159]

What do hydrogen supply chains look like?

The vast majority of hydrogen currently consumed is produced at the point of consumption or nearby, typically connected via a private network. However, different forms of clean hydrogen require various con-

159 For more information, see Piebalgs et al. (2020), a blog post by Dos Reis, P.C. (2021b) and a paper from IRENA (2022) on the certification of green hydrogen.

ditions, such as abundant renewable electricity and suitable geological conditions for storage of CO2. In these new value chains, there is a requirement for storage and transport infrastructure.

Hydrogen can be stored in different ways depending on its state (gaseous or liquid). For example, gaseous hydrogen can be stored in salt cavern storages or pressurised tanks. Geological storage is far cheaper than above ground storage in manmade infrastructure.

There are two overarching transportation options for hydrogen, with different implications:

- Pipelines: used to transport either pure gaseous hydrogen, hydrogen blended into the methane network or hydrogen converted into ammonia, methanol or a liquid organic hydrogen carrier (LOHC),[160]
- Shipping (maritime and land): either as a liquid following cooling to temperatures below -252°C, or in ammonia, methanol or an LOHC.

Transport costs can greatly vary according to the volume of hydrogen demand and the distance required for it to be transported. Newly built and repurposed gas pipelines are widely believed to be the cheapest methods of transporting hydrogen under most circumstances (Agora Energiewende and AFRY, 2021; Wang et al, 2020). This is largely due to the cost of transforming hydrogen into a LOHC and the energy penalty for getting hydrogen to a low enough temperature to liquify it (roughly 100°C lower than methane) compounded by equipment costs for handling such a cold and volatile product.

In some circumstances, blending relatively low volumes of hydrogen into the natural gas grid (<20%) is an option that is already possible with current infrastructure, and it has been supported in the recent 'Hydrogen and Decarbonised Gas Market Package' (HDGMP), which we will discuss shortly. This approach has the advantage of providing immediate offtake options for producers, and potentially making a very marginal decarbonisation impact on the emission intensity of gas in the network. Nevertheless, the resulting gas mix of methane and hydrogen will be of lower energy density than pure methane gas; for example, a 5% blend of hydrogen by volume delivers only 1.6% energy equivalent. This means you need to deliver more gas to provide an equivalent amount of energy. Moreover, blending creates equipment interoperability issues beyond very low hydrogen volumes, it is hugely energy inefficient in the case of renewable hydrogen and will create challenges at end use, such as 'de-blending.'[161] This market evolution will mark a clear departure from the current configuration of gas supply chains, which almost exclusively transport pure methane or pure hydrogen (see also Dos Reis, 2021b).

What strategies and laws are most relevant to clean hydrogen in the EU?

As part of the European Green Deal, the European Commission's complementary strategies 'A hydrogen strategy for a climate-neutral Europe' (Hydrogen Strategy) (EC, 2020a) and 'An EU Strategy for Energy System Integration' (ESI Strategy) (EC, 202b) both identify 'clean' hydrogen and other synthetic fuels as necessary to reach decarbonisation.

The Hydrogen Strategy identifies cumulative investment needs and policies to promote the development of value chains for low-carbon and renewable hydrogen. These aims are broken down into the following three phases:

- Phase 1 (from 2020 to 2024): installation of at least 6 gigawatts (GW) of electrolyser capacity in the EU

160 See UMICORE, LOHC technology: accelerating the deployment of hydrogen storage and fuel cell electric vehicles, https://www.umicore.com/en/newsroom/lohc-technology/.

161 For more information, see Jones, Kneebone, Piebalgs, (2022) and a blog post by Dos Reis, P.C. (2021).

by 2024, corresponding to production of up to 1 million tonnes of renewable hydrogen;

- Phase 2 (from 2025 to 2030): installation of at least 40 GW of electrolyser capacity in the EU by 2030, with a further 40 GW installed in the neighbourhood region (Ukraine and North Africa) – corresponding to 10 million tonnes of renewable hydrogen in the EU;
- Phase 3 (from 2030 onwards and towards 2050): renewable and low-carbon hydrogen technologies should reach maturity and be deployed on a large scale.

The 'REPowerEU' Communications released in March and May 2022 in response to the Russian invasion of Ukraine increased these targets considerably, with a view to leveraging hydrogen and other clean molecules to enhance energy security (EC, 2022). The total production and import target for renewable and low-carbon hydrogen rises to 20 million tonnes by 2030, in the hope that this can replace 25-50 billion cubic metres (BCM) of Russian gas. The Communication also emphasises the need to ramp up the development of corresponding infrastructure, including storage, and promised expedited assessment and processing of hydrogen projects, inlcuding the so-called 'hydrogen corridors', under the 'Important Projects of Common European Interest' (IPCEI) and state aid procedures. Against the backdrop of REPowerEU, the European Commission has also proposed to introduce carbon contracts for difference (CCfD) to support the uptake of green hydrogen by industry and provide specific financing under the Innovation Fund, potentially under the framework of the 'European Hydrogen Bank (Parkes, 2022).

The ESI Strategy describes the "use of renewable and low-carbon fuels, including hydrogen, for end-use applications where direct heating or electrification are not feasible, nor efficient or have higher costs" as some of the important uses of hydrogen in the context of energy system integration.[162] Moreover, electrolysers are one of the key tools for sector coupling between renewable electricity and renewable gas networks.

The 'Hydrogen and Decarbonised Gas Market Package' (HGMDP) (EC, 2021a) of December 2021 was perhaps the most important development since the ESI and Hydrogen Strategies, particularly in terms of setting the incentives and market conditions for uptake of hydrogen and other clean molecules. The HGMDP was the fourth iteration of comprehensive legislation in the sector, following most recently the 'Third Energy Package' in 2009.[163]

The two major components of the publication were a proposed recast of the Regulation (EC, 2021b) on conditions for access to natural gas transmission networks (715/2009) ('Gas Regulation') and a proposed recast of the Directive (EC, 2021c) on common rules for the internal market for natural gas (2009/73) ('Gas Directive'). The core aims of the updates are to: (i) establish the conditions for facilitating rapid and sustained uptake of renewable and low-carbon gases, (ii) improve market conditions and increase engagement of gas consumers, (iii) better account for contemporary security of supply concerns, (iv) address price and supply concerns at the Union level and (v) recalibrate the structure and composition of regulatory bodies.

The package covers many different issues, more complete explanations of which can be found in Kneebone (2021a). However, in terms of hydrogen the package attempted to: (i) define more clearly the different forms of clean hydrogen, (ii) provide incentives for the uptake of clean hydrogen, and (iii) propose a specific framework for the management and planning of a clean hydrogen sector.

162 The Strategy defines 'energy system integration' as referring to the planning and operating of the energy system 'as a whole' across multiple energy carriers, infrastructure and consumption sectors, by creating stronger links between them with the objective of delivering low-carbon, reliable and resource-efficient energy services at the least possible cost to society.

163 See also the recording of the FSR online event 'The Commission's new Gas and Hydrogen Package,' available at https://www.youtube.com/watch?v=ZrBNmqKyKCU.

i. Regarding definitions, Articles 2 and 8 of the proposed revision of the Gas Directive offer definitions of 'low-carbon hydrogen' and 'low-carbon gases' more widely, indicating a "greenhouse gas emission reduction threshold of 70%." The greenhouse gas in question is not specified and neither is the benchmark against which the 70% reduction applies, but we can assume it refers to the unabated fossil equivalent. The Directive also refers to Article 2 of RED II for classifications of 'renewable-gas,' 'low-carbon gas,' 'low-carbon fuel' and 'renewable fuels of non-biological origin' (RFNBOs). A specific methodology for calculating and defining the thresholds for renewable and low-carbon hydrogen will only be defined in a delegated act at some point before the end of 2024.

ii. Concerning incentives, there is no stipulation of a mandatory offtake for industry (demand side) or a direct financing mechanism (supply side). However, renewable and low-carbon hydrogen will receive a 75% discount from various entry and exit tariffs as per Article 16 of the Gas Regulation. Moreover, until 1 January 2031 tariffs will not be chargeable for transmission of these gases across interconnection points between Member States. Tariffs at interconnection points will also not apply to the pure hydrogen network once it is established. There are also proposals to temporarily waive or adjust certain rules governing third-party access (TPA), private hydrogen networks and unbundling to help guarantee returns for investors.

iii. For management and planning of the network, first an entity for European Distribution System Operators (DSOs) will be set up. Full details of the scope and role of the entity can be found in Articles 36 and 37 of the Gas Regulation. Second, a network association will be established for hydrogen network operators, 'The European Network for Network Operators of Hydrogen' (ENNOH). ENNOH's tasks include writing relevant network codes and Union-wide non-binding ten-year network development plans (TYNDPs) for the hydrogen sector. Third, and remaining with the TYNDP theme, hydrogen interconnection projects will now be eligible to apply for funding if they fall within the scope of the wider TYNDPs of the European Network of Transmission System Operators for Gas (ENTSOG) provided they are not already covered in IPCEIs.

In May 2020, the European Commission's recovery plan document 'Europe's moment: Repair and Prepare for the Next Generation' (EC, 2020c) already identified hydrogen as one of the key technologies for the clean energy transition, for which investments would be reserved in the 'Strategic Investment Facility.' Later that year it was agreed by EU leaders that technologies based on 'renewable' and 'low-carbon' hydrogen and other synthetic fuels would also be one of the main potential recipients of the EU's €750 billion recovery package.[164] The Commission has embarked on some industrial partnerships recently, including for electrolysers, where 20 CEOs recently signed a joint declaration to increase electrolyser manufacturing output tenfold by 2025 (EC, 2022b).

Finally, many of the Member States' National Energy and Climate Plans (NECPs) include hydrogen as a key component on the path to decarbonisation. Additionally, several EU Member States have adopted national hydrogen strategies with varying perspectives on their roles in a European and global clean hydrogen economy (technology, exports, imports, etc.).[165]

164 According to the Council of the EU, Video conference with the economic and finance minister, 6 October 2020, available at https://www.consilium.europa.eu/en/meetings/ecofin/2020/10/06/.

165 For more information, see Jones and Piebalgs (2020) and a blog post by Piebalgs and Jones (2021).

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