



European Union

EUROPEAN UNION'S ACTION PLAN FOR POWER SECTOR DECARBONISATION

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Delivered for the 14th Clean Energy Ministerial (CEM14)

July 2023





BACKGROUND

A collaborative report from the Clean Energy Ministerial (CEM) on [Lessons Learned for Rapid Decarbonization of Power Sectors](#) was delivered to energy ministers and presented at the 13th CEM (CEM13) in the United States in September 2022. In light of these lessons learned and discussed at CEM13, several jurisdictions signaled intent to develop Action Plans for power sector decarbonization, to be released at CEM14 in India in July 2023.

These Action Plans complement, but are differentiated from, other international power sector initiatives such as the Breakthrough Agenda (whose broad purpose is to raise collective ambition) and the Global Power System Transformation (G-PST) Consortium (whose goals are to convene power system operators to accelerate research innovations and foster peer learning). The Action Plans, supported by the [21st Century Power Partnership](#) and other CEM workstreams via direct technical assistance and capacity building, are intended to focus on select implementation actions given each country's existing power sector goals and activities, and are an opportunity for countries to display leadership in power sector decarbonization.

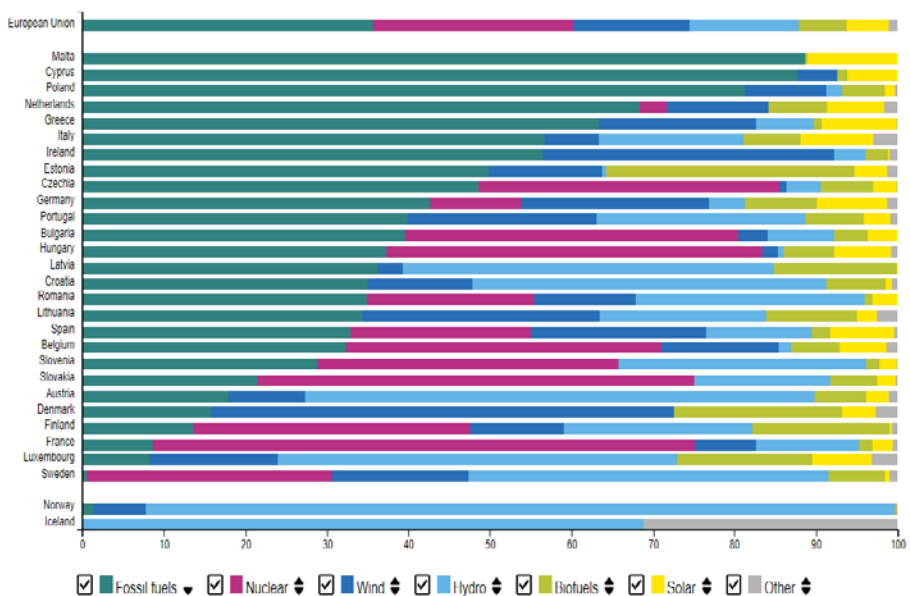
These Action Plans are voluntary, developed by each country individually, not comprehensive of all activities within the jurisdiction, and are living documents that are subject to change.



EU POWER GENERATION MIX

- Around 23% of the **final energy consumed in the EU** is **electricity** and it comes from different sources.
- **In 2020, renewable energy sources** accounted for 39% of the electricity supply in the EU, overtaking **fossil fuels** (36%) as the main power source for the first time. In addition, 25% of the electricity came from **nuclear** power plants.
- Among renewable sources, the highest share of electricity came from **wind turbines** (14%), **hydropower plants** (13%), **biofuels** (6%) and **solar power** (5%).
- The sources of electricity production vary among the Member States

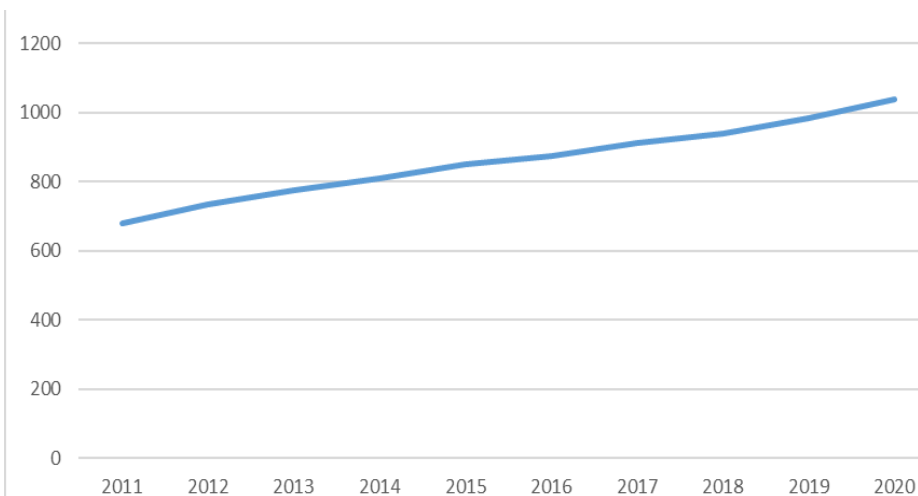
Production of electricity by source, EU27, 2020 (in %)



Hydro includes pumped hydro, which for certain Member States, in particular Lithuania and Luxembourg, leads to a higher share for this category. Other includes electricity from geothermal, non-renewable waste, heat from chemical sources and other sources.

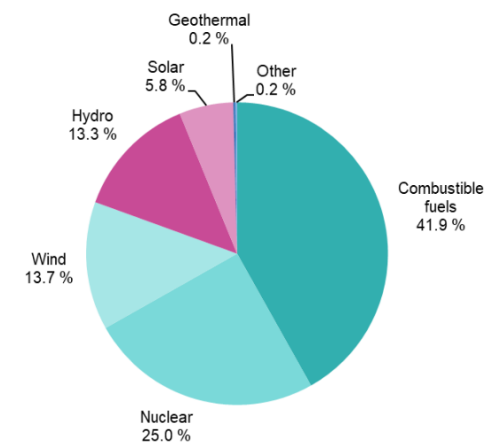
Source: Eurostat - [access to dataset](#)

Use of renewables for electricity in the EU (2011-2020, GWh)



Source : JRC analysis from Eurostat data

Net electricity generation, EU27, 2021 (% based on GWh)



Source : Eurostat



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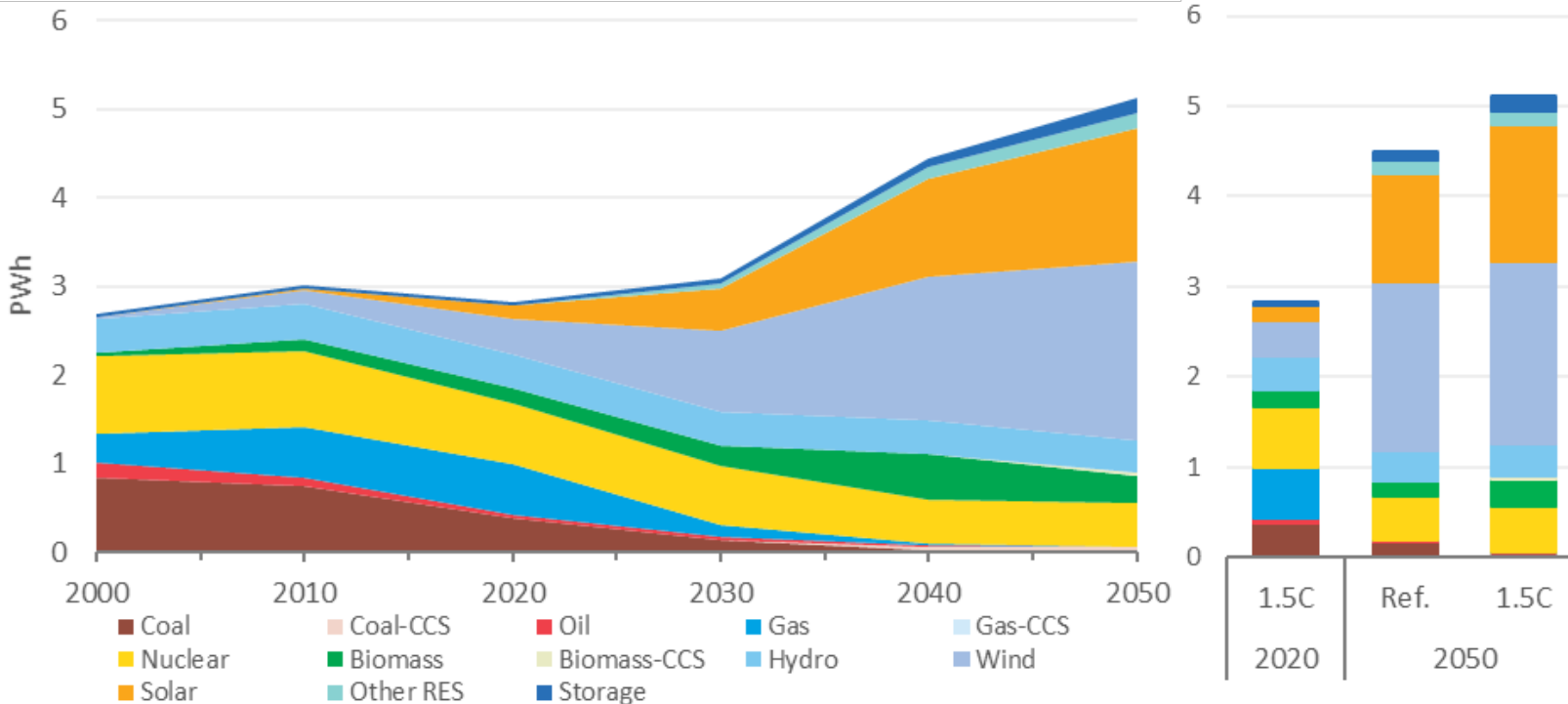
I. PLANNING

Action Plan for Rapid Power Sector Decarbonisation



EU POWER SECTOR DECARBONISATION: A PATHWAY TO 2050

EU power generation, by technology, for Reference and 1.5°C Scenarios



Source: POLES-JRC model

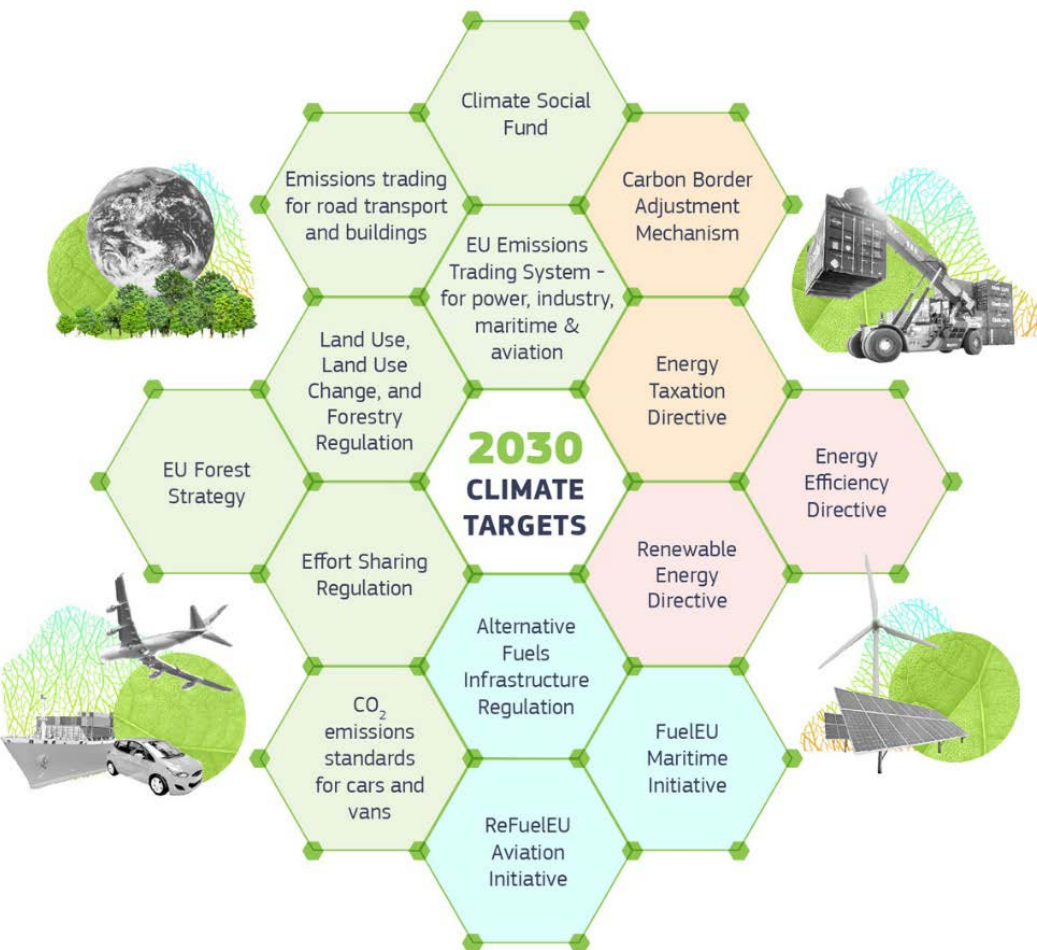
The Global Energy and Climate Outlook ([GECCO](#)) of the EU's Joint Research Centre (JRC) provides **long-term global and EU energy and emissions projections** under different scenarios.

In the 1.5°C Scenario, the EU power generation mix is **dominated by wind and solar**. Nuclear is the third largest source of generation.

Power plants fitted with carbon capture and storage (CCS) provide only 1.9% of generation in 2050.



EUROPEAN GREEN DEAL



The [European Green Deal](#) (2019) is the EU's long-term, whole-of-the-economy plan to make **Europe climate neutral by 2050**.

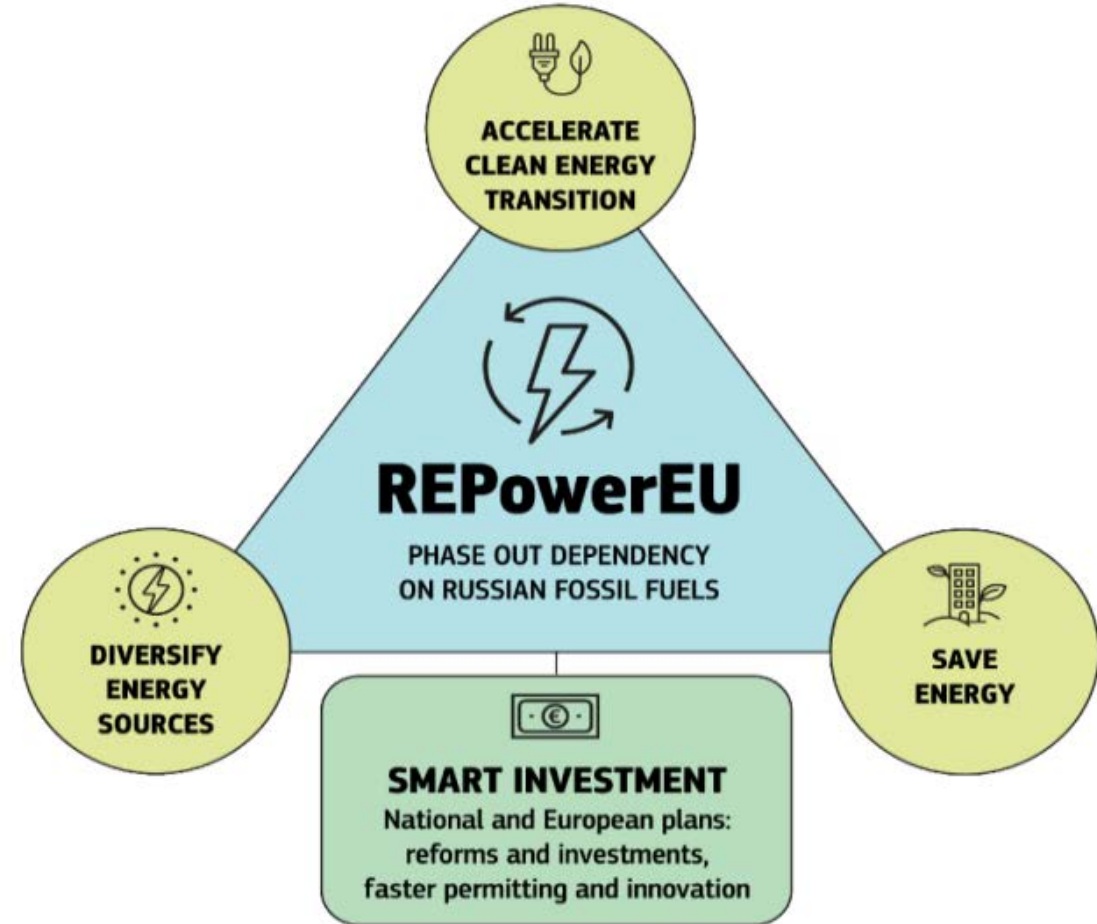
The [European Climate Law](#) (2021) made climate-neutrality a legally binding target for the block, along with **reducing greenhouse gas (GHG) emissions by at least 55% by 2030**, compared to 1990 levels.

In 2021, the Commission presented its [‘Fit for 55’](#) legislative package, outlining policy measures to reduce GHG emissions by 55% by 2030. The package included the revision of the renewable energy directive, **increasing the targeted share of renewable energy in the EU mix to “at least 40%” by 2030**, from the initial target value of 32%.

REPOWEREU

- The [REPowerEU](#) plan is the EU's response to global energy market disruption caused by Russia's invasion of Ukraine.
- It seeks to transform Europe's energy system by **ending the EU's dependence** on Russian oil and gas imports, and **tackling the climate crisis**.
- The measures in the REPowerEU Plan include **energy savings, diversification of energy supplies, and accelerated roll-out of renewable energy**.
- It aims to increase **the share of renewables in the EU energy mix to 42.5% by 2030**.

The REPowerEU package includes **Commission recommendations on speeding up permit-granting procedures for renewable energy** projects and facilitating Power Purchase Agreements (C/2022/3219 final): Faster, shorter, and digitalized procedures; Better identification and planning of land and sea areas; Easier grid connection





EMISSIONS TRADING SYSTEM

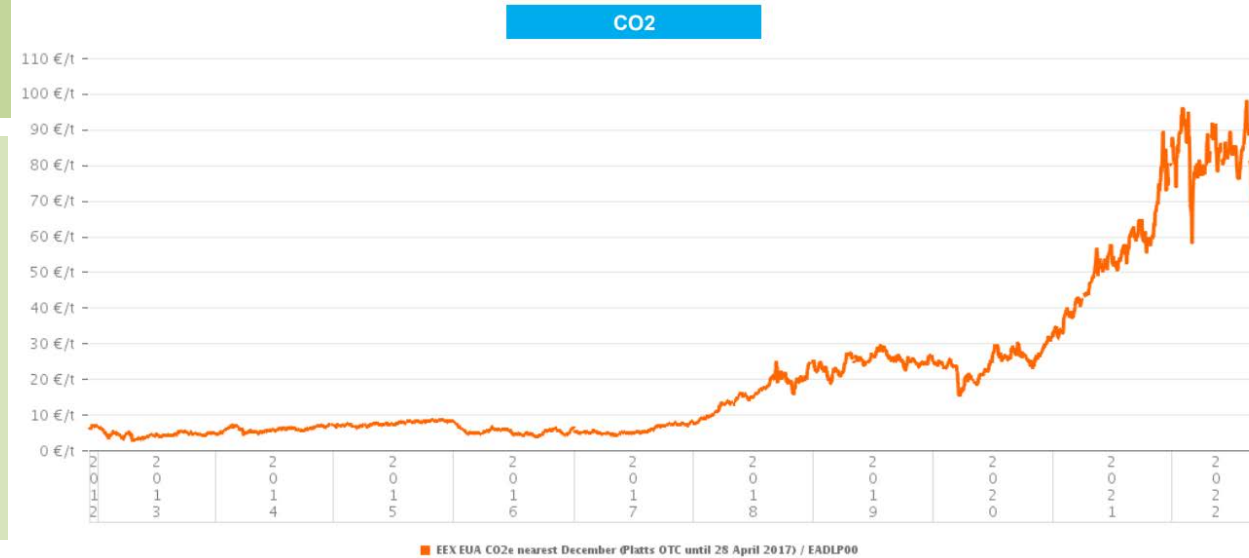
Since 2005, the [EU Emissions Trading System](#) (ETS) has successfully set a price for carbon and steered investments into cleaner, greener technologies in the participating industries such as **electricity generation** and energy intensive industries.

Emissions have been cut by 42.8% in the main sectors covered: power and heat generation and energy-intensive industrial installations.

As a market-based system, the ETS ensures that emission reductions take place where it is cheapest to do so. As a result, **most emission reductions until now have taken place in the power sector.**

The legislative framework of the EU ETS was revised in 2018 and in 2021 in line with the EU's 2030 emissions reduction target (55%). The **Commission proposed to increase the 2030 emission reduction targets for ETS sectors from -43% to -61%** (against 2005 levels), as well as annual emissions reductions of 4.2%.

EU ETS CO2 price, €/t (2012-2022)



Data Source: @S&P Global Platts, ECB



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II. BUILDING

Action Plan for Rapid Power Sector Decarbonisation



RENEWABLE ENERGY DIRECTIVES

Renewable Energy Directive (RED)

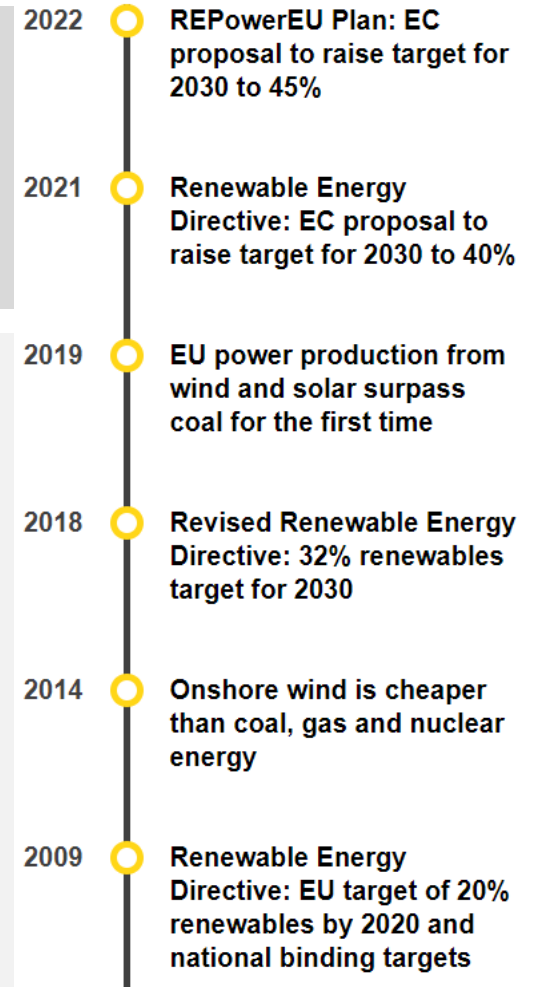
The Renewable Energy Directive (2009/28/EC) and its revisions provide the **legal framework** for the development of renewable energy across all sectors of the EU economy, and supports cooperation across EU countries. Since the introduction of the RED in 2009, the **share of renewable energy** in gross final energy consumption has kept growing, **reaching 22% in 2020**.

RED revision => 42.5% renewable energy by 2030

The ambition and measures in the directive have been reviewed several times (2018, 2021, 2023) in line with the evolution of EU energy and climate policies.

- In May 2022, as part of the **REPowerEU Plan**, the EC proposed to increase the share of renewables (COM/2022/230 final).
- In April 2023, EU co-legislators reached a provisional political agreement to raise the target **share of renewable energy in the EU total energy consumption to 42.5% by 2030**, with an additional 2.5% indicative top-up that would allow reaching 45%. *(Note: subject to formal adoption)*

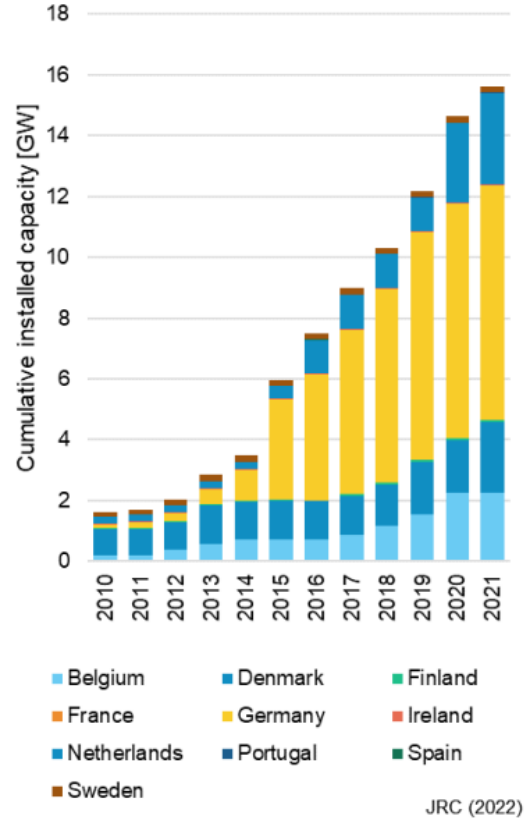
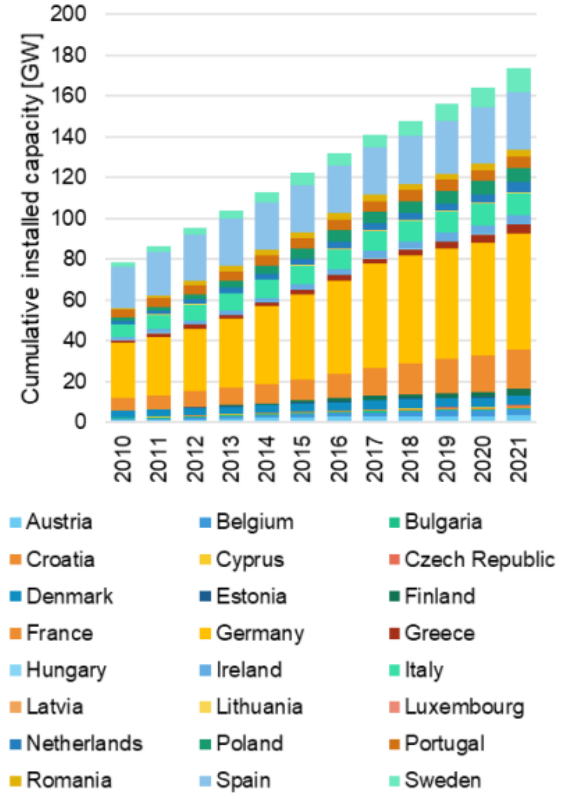
The revised RED will increase (int. al.) the share of renewables in various sectors (heating and cooling, transport, industry, buildings, etc.), boost investments, and strengthen criteria for sustainable bioenergy.





WIND AND OFFSHORE RENEWABLE ENERGY POLICY (2020)

Cumulative installed capacity of onshore (left) and offshore wind (right) in the EU (2010-2021)



JRC (2022)

JRC (2022)

Source: JRC based on GWEC (2022)

Wind accounted for **over one-third (37%)** of the total electricity generated from renewable sources in the EU in 2021 (source: [Eurostat](#)).

The wind sector is also a **significant contributor to the EU economy**: it provided between 240,000 and 300,000 jobs in 2020, of which about 62,000 were in the offshore wind industry (source: WindEurope).

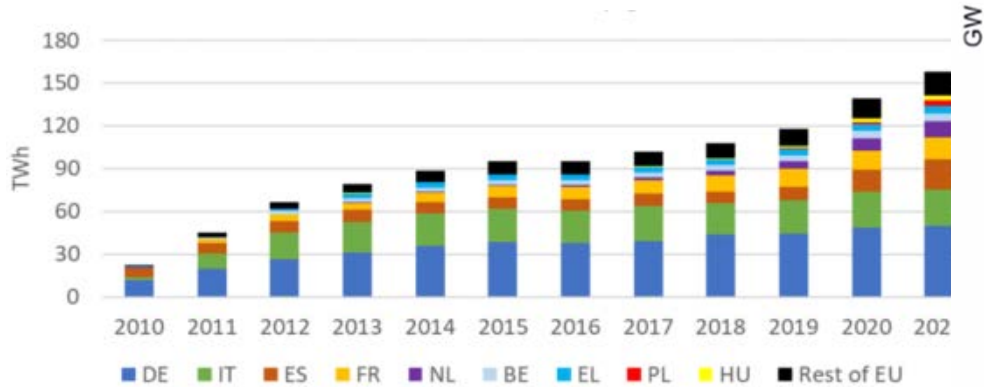
EU wind strategy & Offshore renewable energy ([COM\(2020\)741](#))

- Capacity needs (not targets), calculated against policy objectives.
- **By 2030**: to bring online at least **510 GW of wind capacity** (incl. **60 GW of offshore**, starting from 12 GW in 2020) and **1 GW of ocean energy capacity**.
- **By 2050**: **300 GW of offshore wind** capacity and **40 GW of ocean energy capacity**
=> a massive change of scale: 30x multiplication of offshore renewable capacity (at an estimated cost of EUR 800 billion)



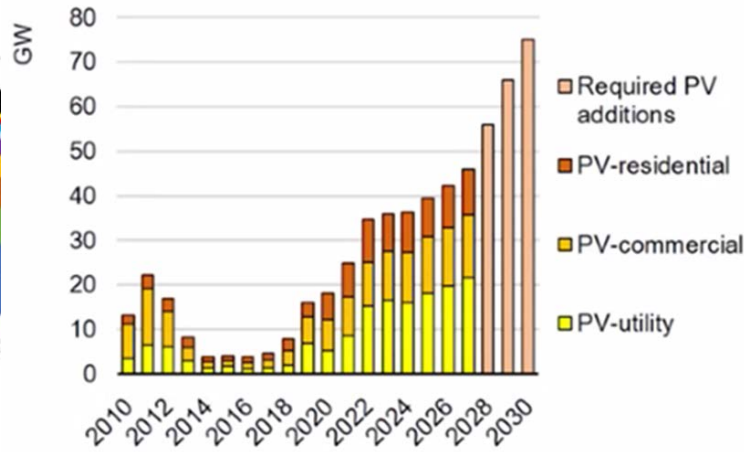
SOLAR PHOTOVOLTAIC POLICY (2022)

Cummulative EU solar PV generation per country (2010-2021)



Source: JRC analysis based on Eurostat

EU solar PV net capacity additions and forecast (2021-2027) vs. Required additions needed to reach REPowerEU targets



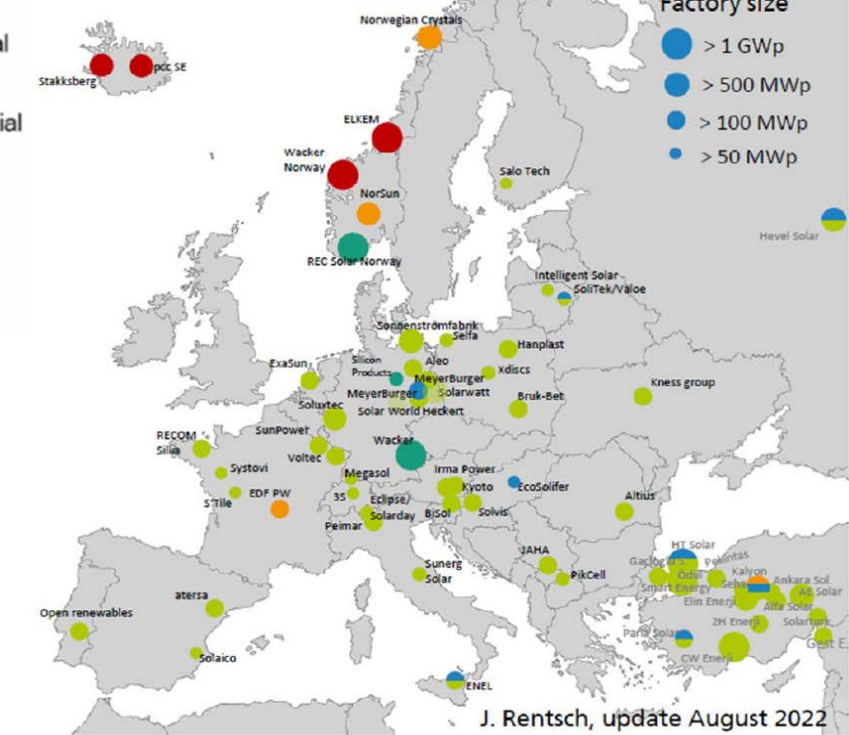
Source: IEA

Current European c-Si PV manufacturing landscape in August 2022.

Status Quo - PV Production

Overview of PV production along the value chain

Source: Map: kartoxjm (fotolia) / europakarte.org



Communication on EU solar energy strategy: [COM\(2022\)221](#)

- **By 2025:** to bring online over **320 GW** of solar photovoltaic capacity (in 2020, the EU had 136 GW of installed solar PV capacity)
- **By 2030:** to bring online almost **600 GW** of solar photovoltaic capacity
 - => average annual additions of 46 GW (from 2020 levels)

PROGRESS MADE: RENEWABLE CAPACITY ADDITIONS IN 2022

New installed capacity in 2022 for renewable energy sources in the EU was **57 GW**, including:



15 GW for **wind** power generation (+34% more than in 2021)



41 GW for **solar power** generation (+47% more than in 2021)



1 GW for **other renewables** power generation

For 2023, industries expect an **additional 69 GW of new renewable energy capacity**.

TRANS-EUROPEAN NETWORKS FOR ENERGY (TEN-E)



Energy infrastructure, the backbone of a secure and climate-neutral energy system

Interconnectors are the circulatory system of the EU allowing energy to flow seamlessly across borders, ensuring security of supply, the integration of renewable energy and keeping prices in check.

The EU's cross-border energy system has developed significantly since the 1990s and in particular through the modernised TEN-energy policy since 2013 and is more resilient and flexible than any system across the globe.

It is a true European success story of integration, cooperation and mutual support.

New regulation on guidelines for trans-European energy infrastructure (EU 2022/869)

New TEN-E infrastructure categories: offshore, hydrogen, electrolysers, smart gas grids, as well as (in addition to the electricity transmission) smart electricity grids, CO₂ networks and energy storage

Ten-Year Network Development Plan



TEN-YEAR NETWORK DEVELOPMENT PLAN (TYNDP)

TYNDP is the result of a collaborative effort

TYNDP

Every two years, the European Network of Transmission System Operators for Electricity (ENTSO-E) and gas (ENTSO-G) publishes **a non-binding EU-wide ten-year network development plan**.

The TYNDP builds on national and regional investment plans prepared by the **transmission system operators (TSOs)**.

The TYNDP is **consulted with stakeholders** who contribute to its elaboration via open workshops, public consultations, and meetings.

National System Operators and ENTSO-E

European Commission
Joint Research Centre
Agency for the Cooperation of Energy Regulators

National competent authorities and Regulators

Other stakeholders

[High-Level Report on TYNDP 2022](#) was published in January 2023.

- ENTSO-E TYNDP 2022 includes a scenario analysis, system needs analysis, and project assessment.
- Overall, the ENTSO-E TYNDP 2022 portfolio represents 43,000 km of lines or cables.
- ENTSO-E TYNDP will assess **141 transmission projects, of which 85 are cross-border projects, and 23 storage projects**.
- You can check how these projects respond to the 2030 and 2040 scenarios here: [TYNDP 2022 Project Collection](#)

VIDEO: <https://youtu.be/szlc6dcNWrc>



PROJECTS OF COMMON INTEREST (PCIs)

The PCIs are key infrastructure projects aimed at completing the European energy market, ensuring security of supply, and achieving the EU's 2030 and 2050 energy policy and climate objectives. Projects selected as PCIs can benefit from many advantages stemming from the Trans-European Network - Energy (TEN-E) Regulation, including:

- **accelerated permit granting;**
- **improved regulatory treatment;**
- the possibility to apply for **financial support** under the Connecting Europe Facility (CEF) for Energy: total budget of €5.84 billion (2021-2027);
- dedicated rules to facilitate the development of **offshore renewable grids;**
- strengthened **cross-sectoral** energy infrastructure planning.

In order to be eligible for inclusion in the PCI lists, electricity and hydrogen projects must be part of the latest available EU-wide ten-year network development plan (TYNDP).

CEF ENERGY 2023
CALL FOR PROPOSALS

EUR 750 MILLION

Funding for
PROJECTS OF COMMON INTEREST (PCIs)
- Works & Studies

DEADLINE
5 SEPTEMBER

 #CEFEnergyPCIs



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III. OPERATING

Action Plan for Rapid Power Sector Decarbonisation



EU ELECTRICITY MARKET DESIGN

The EU is a zonal market. Individual market areas or **Bidding Zones** are mostly coextensive with the EU Member States (formerly national networks). Each bidding zone is a **separate part of the European electricity market**.

Bidding Zones are defined by structural congestions:

- *Unlimited exchange allowed inside a Bidding Zone*
- *Capacity calculation occurs between Bidding Zones*

In each bidding zone, a separate forward, day-ahead, and intraday market etc. exist.

Bidding zones are **physically coupled by interconnectors**, and the electricity markets are coupled via **market coupling**.

Cross-border market foundations

Capacity calculation

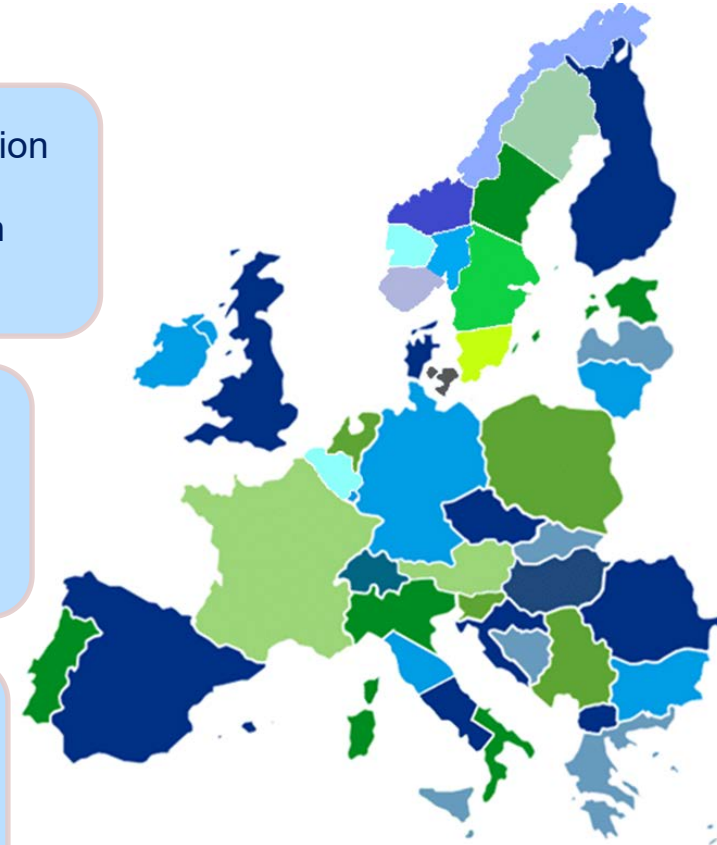
- Definition of Capacity Calculation Regions
- Flow based capacity approach
- Path for merging of regions

Capacity allocation

- Designation of NEMOs
- Rotating Market Coupling Operator function
- Obligation for an intraday platform (XBID)

Bidding zones review

- Social welfare analyses
- Model based and splitting / merging scenarios

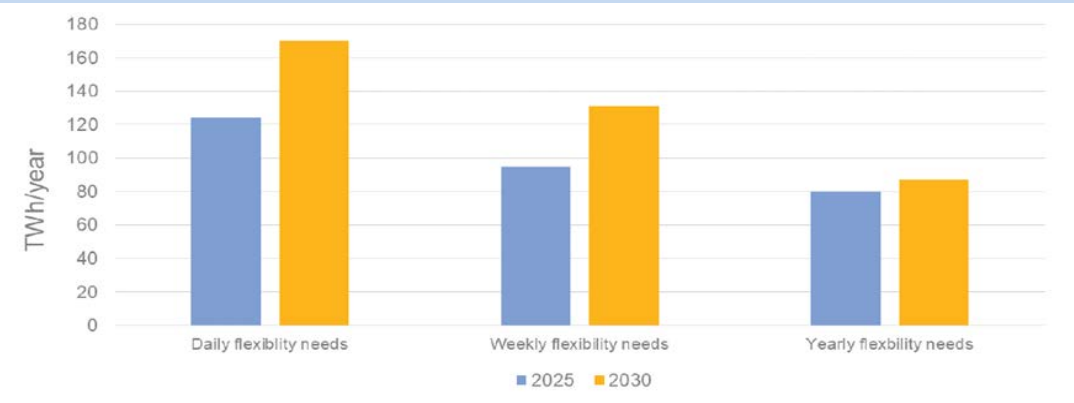


Bidding zones in the EU + UK



RENEWABLES INTEGRATION AND FLEXIBILITY DEVELOPMENT

- The **need for flexibility** solutions to integrate variable renewables is increasing (source: ACER).



- Challenge:** Increasing the share of renewables needs to be balanced with non-fossil flexibility.
- Gas is playing a dominant role in providing the required flexibility.
- Main fossil-free alternatives: demand response (DR) and storage (with **70 GW of available capacity today**).
- However, there is currently low participation of DR and storage in electricity markets.

EC proposals in revised Electricity Market Design (COM(2023) 148 final)

Enhance non-fossil flexibility sources (demand response and storage, etc.)

- NRAs shall issue a report on the **need for flexibility** in the electricity system every two years.
- Member States shall define an **indicative national objective** for demand side response and storage.

Clarify the role of system operators

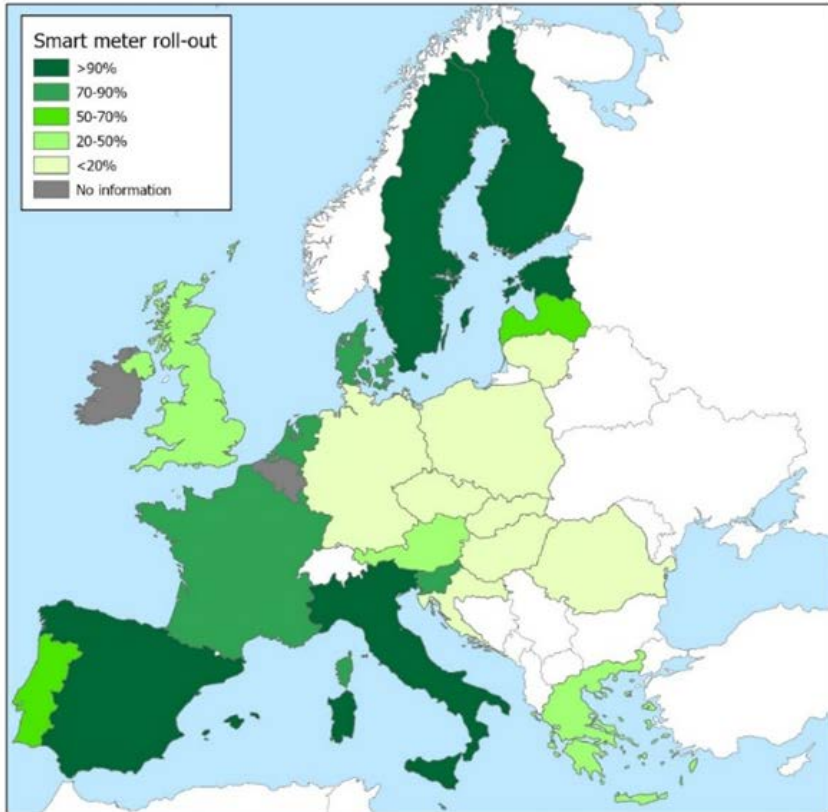
- Peak shaving product:** TSOs may procure a peak shaving product to reduce electricity demand during peak hours.
- Transparency:** TSOs and DSOs to provide information about the availability of grid connection capacity, and the status and treatment of the connection requests.
- Dedicated metering:** System operators can use the data from dedicated metering devices for the observability and settlement of DR and flexibility services.
- Network tariffs:** Take into account operational costs in network tariffs and TSOs/DSOs remuneration, to incentivize the use of flexibility services.

Create more opportunities for trading (of renewables and flexible sources)

- Allowing cross-border **intraday trading closer to real time (30 min)**.
- Mandatory **sharing of liquidity** in the intraday market, also within a bidding zone.



SMART METERING DEPLOYMENT



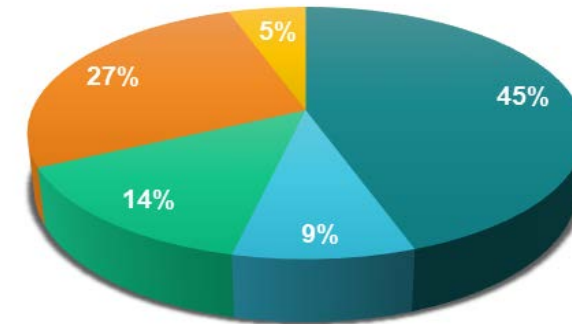
By 2020, smart meters have covered **43% of the electricity consumers**, with a total of 123 million installed smart meters.

Estimation of reaching **77% of European customers by 2024.**

Source: Vitiello, Andreadou, Ardelean, and Fulli (2022)*
 * Data has been retrieved from published reports until 31/12/2021

At the level of DSOs:

EU Directives (2009, 2019) have been a great stimulus to the deployment of smart metering systems: **95% of distribution system operators (DSOs) have started implementing a smart meter roll-out program** (JRC DSOs Observatory 2022).



Status of smart meter roll-out by DSOs.

- Completed roll-out
- About to complete a roll-out
- Roll-out in progress
- Early stage/pilot
- No roll-out

Source: JRC DSOs Observatory 2022



CITIZENS' ENGAGEMENT: ENERGY COMMUNITIES & ENERGY SHARING

The EU legal framework recognises **Energy Communities**, enabling citizen-driven action, contributing to the **decarbonisation of the power system**, and allowing for **direct benefits to citizens**.

Its reform (COM(2023) 148 final) will give **consumers the right to share renewable energy**:

- Consumers will have the **right to have injected electricity deducted from their total metered consumption**
- **System operators will need to collect, validate, and communicate relevant metering data**

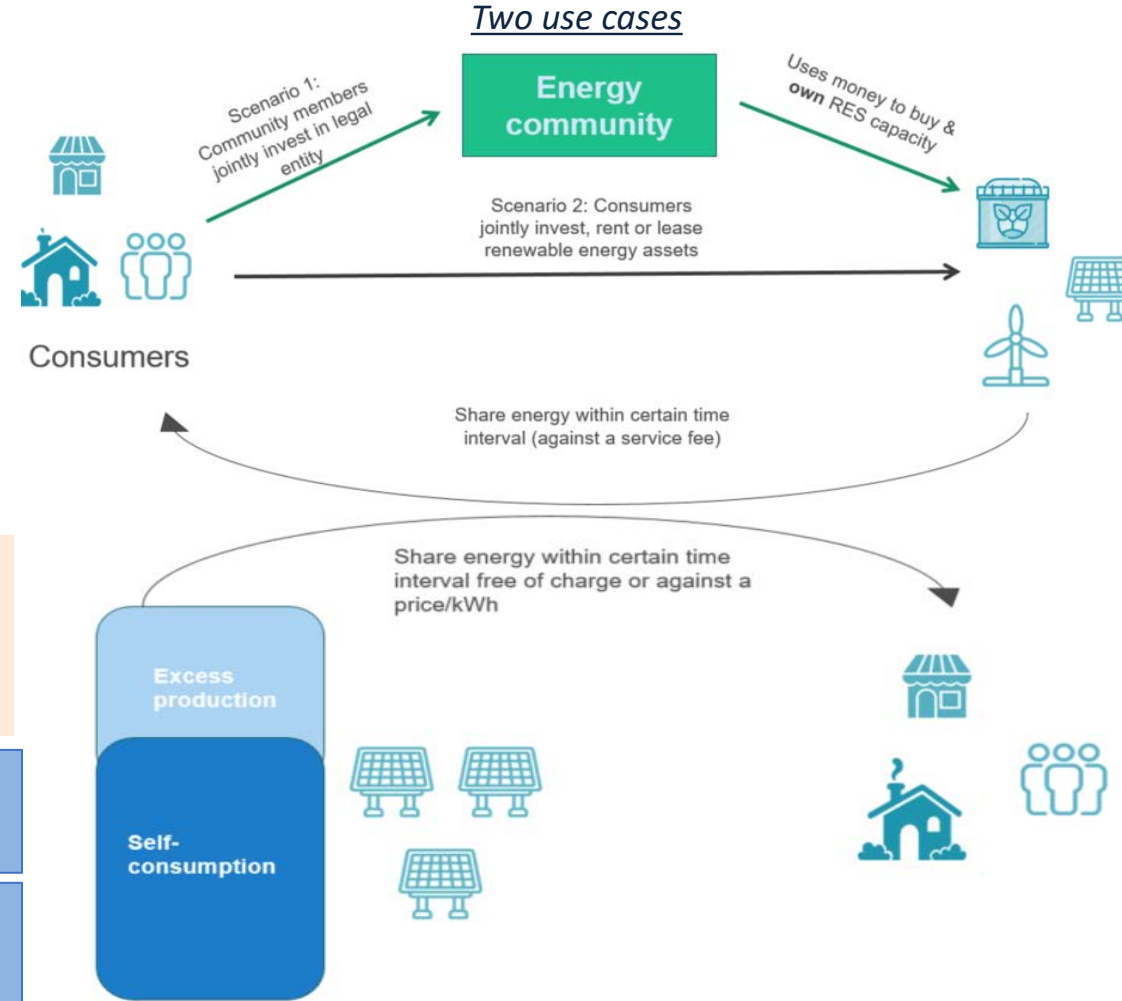
Renewable Energy Directive (2018) to empower Renewable Energy Communities

Directive on common rules for the internal market for electricity (2019) to enable active consumer participation

Revision of the Electricity Market Design (2023) to give the right to share renewable energy

Energy Communities Repository: supporting local actors in the creation and management of energy communities in urban areas.

Rural Energy Community Advisory Hub: technical and administrative advice for creation of energy communities in rural areas.



GREEN DEAL INDUSTRIAL PLAN

With the **Green Deal Industrial Plan** (GDIP), the Commission will promote the creation of a more supportive environment for deploying the clean technology manufacturing capacity required to meet Europe's ambitious green targets.

- ✓ The **productivity** in the clean energy sector is about **20% higher** on average across the economy
- ✓ The European economy counted **4.5 million green jobs in 2019**, up from 3.2 million in 2000

GLOBAL TRENDS

- ❖ The International Energy Agency estimates that the **global market for key mass-manufactured clean energy technologies** will be worth around USD 650 billion a year by 2030 – more than three times today's level. *(IEA, Energy Technology Perspectives 2023)*
- ❖ The related energy **manufacturing jobs could more than double** in the same time period.



The GDIP is based on four complementary pillars



A predictable and
simplified regulatory
environment

Faster
access to
funding

Enhanced
skills

Open trade for
resilient supply
chains



BIBLIOGRAPHY

- https://joint-research-centre.ec.europa.eu/geco_en
- https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en
- https://climate.ec.europa.eu/eu-action/european-green-deal/european-climate-law_en
- https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en
- https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en
- https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3542
- https://ec.europa.eu/commission/presscorner/detail/en/fs_22_3133
- <https://ec.europa.eu/eurostat/web/products-eurostat-news/w/DDN-20230119-1>
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- <https://eepublicdownloads.blob.core.windows.net/public-cdn-container/tyndp-documents/TYNDP2022/public/high-level-report.pdf>
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NREL/PR-5R00-86635

