FUTURE OF ENERGY

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YES - Europe
Young leaders in Energy and Sustainability

The Future of Energy Report 2022-2023

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About YES-Europe

Who we are:

YES-Europe, created through an initiative of the EPFL University of Lausanne in Switzerland, brought together 50 students from nine European countries for the first annual conference organised in May 2016 to connect and find meaningful ways to make a difference in the energy field. Since then, YES-Europe grew internationally to have an impact at the European level.

What we do:

YES-Europe offers a platform to develop both international as well as national initiatives to shape the future of energy in Europe and give a space for youth to act within this fundamental transition. Believing in individual as well as collective creativity, we support each other in brainstorming, developing & implementing ideas. YES-Europe has the mission of catalyzing the energy transition by creating an environment where youth are given a space to develop ideas, take on responsibility, build their local community and act for change.

Disclaimer: *Several parts of this report were authored in 2022, and as such, do not reflect any developments or changes that may have occurred after that year. The information provided should be considered accurate only up to the end of 2022, and users are advised to verify the current status of any referenced data or events, as circumstances may have evolved since the report's creation.*

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Introduction

The European Green Deal is a proposed EU-wide climate change action plan and is aimed at **reducing EU CO2 emissions by at least 40% by 2030**, compared to 1990 levels and climate neutrality by the year of 2050. For the EU to reach their target of climate neutrality one of the most important goals is to decarbonise their energy system by aiming to achieve "net-zero greenhouse gas emissions by 2050." In this regard, the European Commission has adopted a set of proposals to make the EU's climate, energy, transport and taxation policies fit for reducing net greenhouse gas emissions which includes a range of other initiatives, such as the promotion of electric vehicles, photovoltaics, and energy efficiency.

Climate action is at the heart of the **European Green Deal** and the EU has created a binding target for reducing energy-related CO2 emissions. It is also pursuing efforts to increase energy storage energy efficiency and will improve the well-being and health of citizens and future generations by **prioritising energy efficiency** to develop a power sector based largely on renewable resources, securing an affordable EU energy supply and to have a fully integrated, interconnected digitised EU energy market. These activities fully comply with the Paris Agreement obligations, which sets out a global framework to avoid dangerous climate change by limiting global warming to well below 2°C and pursuing efforts to limit it to 1.5°C. Moreover, the EU is looking to **diversify its energy sources** and reduce its amount of reliance on Russia for natural gas. The European Union's ambitious renewable energy goal is sure to inspire other nations to follow suit. In fact, the International Renewable Energy Agency (IRENA) has said that the 2020s will be "the decade of renewable energy."

We think the future of energy in the EU is bright and likely to only grow brighter in the years to come. This report provides a comprehensive overview of the future of energy in the EU, with an emphasis on trends and the latest developments in the energy sector.

1. Sustainable Energy Development Framework

1.1 The Paris Agreement goals

The **2016 Paris Agreement** is a legally binding international treaty aimed at counteracting climate change primarily by reducing the rise in mean global temperature to well **below 2 °C** (preferably to 1.5 °C). The 193 parties to the Paris Agreement include world's top carbon dioxide emitters such as China, the United States and India. Every 5 years, state parties are required to prepare and submit their so-called Nationally Determined Contributions (NDCs) - more detailed climate action plans of individual countries. So far, although all 193 Parties have issued at least their first NDC, only 151 communicated an updated NDC as of 2 November 2021. The United Nations themselves note that not all of the plans are adequate and sufficient to ensure the fulfilment of the Paris Agreement climate goals.

Indeed, it seems that the United Nations are unlikely to ensure that the goal of reducing global warming to pre-industrial levels is reached on time. According to the Climate Action Tracker, the policies presently in place around the world [as of November 2021 - YES-Europe comment] are projected to result in about 2.7 °C warming above pre-industrial levels. The implementation of the NDCs is projected to limit warming only to 2.4 °C, which is significantly above even the less ambitious goal of 2 °C. In fact, even more optimistic research indicates that while it is technically possible to meet the climate targets, it will actually happen only if all conditional and unconditional pledges are implemented in full and on time. Considering that full and timely implementation of all pledges seems unlikely, we should be prepared to assume that the Paris Agreement goals will not be fulfilled on time.

Perhaps the most important recent development related to the Paris Agreement is the 2021 Conference of the Parties that took place in Glasgow (COP26) from 31 October to 13 November 2021. The Conference focused on the need to increase the current efforts in climate change mitigation. The highlight of COP26 is the adoption of the final version of the Paris Rulebook, which follows up on the 2018 Katowice climate package and establishes the main rules for the international transfers of emissions.

The 2018 Katowice climate package adopted at COP24 set out detailed rules on many aspects of the Paris Agreement, including what information should be provided by governments in their NDCs and how the Global Stocktake (the process of gathering information to find out how the implementation of the Paris Agreement is progressing) should be carried out. However, a few outstanding issues were left for consideration during subsequent negotiations. Notably, the particulars of voluntary cooperation and non-market approaches were not finalised. COP26 in Glasgow helped put into practice the so-called Article 6 Rules, which are often considered The key provisions of Article 6 of the Paris Agreement discussed during COP26 include Article 6.2 on the cooperative approaches of Parties and Article 6.8 on non-market approaches. Article 6.2 sets up an accounting framework for international emissions trading, which allows for international transfer of carbon credits between countries as well as for cooperation between systems from different countries and regions. One of the challenges related to the implementation of Article 6.2 in practice was the risk of double-counting, whereby one country could theoretically count emissions purchased from a different country towards its own NDC goal even if that different country already included them in their calculations. Another potential issue was that, since different countries use different metrics (e.g., renewable energy targets or hectares of land afforested), emission trading was more difficult. COP26 established that Parties must always use a standardised measure of tons of CO2 equivalent in their accounting, even if their original metrics are different. In addition, the updated Paris Rulebook implements measures that are likely to decrease the risk of double counting, such as the prohibition on carrying-over of carbon market units from one NDC period to another and limiting the number of accounting exemptions.

Article 6.8 creates a non-market system to implement Parties' NDCs. The non-market approaches "shall aim to: (a) promote mitigation and adaptation ambition; Enhance public and private sector participation in the implementation of nationally determined contributions; and (c) Enable opportunities for coordination across instruments and relevant institutional arrangements." The COP26 update to Article 6.8 establishes a treaty body - the Glasgow Committee on Non-Market Approaches - to oversee the implementation of non-market solutions and to introduce the framework and the work programme by providing opportunities for non-market-based cooperation to implement mitigation and adaptation actions in NDCs.

How the new measures will play out in reality remains to be seen. The next COP will be held soon in Sharm El Sheikh, Egypt. The conference will focus on implementation issues and Parties will be expected to demonstrate how their legislation, policies and programmes help achieve the climate goals in practice.

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1.2 Decarbonisation of the European energy

1.2.1 Introduction

In the light of the global energy crisis, a number of energy strategies might be labelled as “wrong” or “unsuccessful”. Governments and other national institutions should evaluate and acknowledge these failures, analyse them, and attempt to prevent a repeat of the same situations in the future. Every action or decision has a global impact and contributes to a greater picture, which is why it is crucial for state authorities to remember this while making a decision that may impact and shape our climate future. Multinational negotiations and joint agreements form the main core of climate justice, such as the Paris Agreement or Kyoto Protocol, both of which were supposed to present a global legal system on climate, where leaders from around the world made a concerted effort to strive for climate neutrality by 2050.

Among the big two, yet another example of a greener piece of legislation - the European Green Deal intends to make Europe the world’s first climate-neutral region by 2050. Although with tremendous responsibility comes an inevitable failure: a struggle to keep such arrangements in place, despite common endeavour and open dialogue.

A coalition of NGOs has been formed creating an alliance to highlight the greatest negligence: the world’s biggest banks allegedly investing trillions in the fossil fuel industries just a couple of years after the Paris Agreement was signed. It’s not only a blatant example of climate denialism, it also represents a significant failure of global ethics as well.

1.2.2 A road to become independent

Europe is attempting to restore the balance between human activity and environment as the region faces a major climate problem that will only worsen overtime. Changing the existing situation into a fully integrated and secure internal energy market is a demanding and extremely challenging endeavour.

This can only be realised if the goals outlined in climate policies for creating neutral targets are met within a specified timeframe. As the coronavirus crisis has shown, we are all vulnerable, and it is critical to restore the balance between human activity and the natural environment. Such techniques are critical components of the large-scale transformation we are pursuing.

To meet the European Union's goals, each Member State must align and modernise its national energy and climate policies. In order to make the transition to a climate-neutral economy, the European's strategy presents a vision of the profound economic and societal adjustments. It seeks to ensure that this change is socially just, leaving no individuals or regions behind through a couple of steps:

- fully decarbonising Europe's energy supply
- embracing clean and connected mobility
- maximising benefits from energy efficiency
- developing smart network infrastructure
- reaping the benefits of bio-economy
- putting industrial modernisation at the centre of a fully circular economy

There are certain immediate fixes we can aim for in addition to the longer-term objectives of lowering carbon emissions globally. About 12% of the GHG emissions in the EU originates from buildings, which is why we need to focus on the long term solution. Any house may be energy-efficient, regardless of when it was constructed. However, older homes should be updated to perform better in terms of energy efficiency with cutting edge technologies, since modern building regulations already demand higher efficiency.

1.2.3 Responsible use of fossil fuels

While there are still insufficient resources to accomplish the target stated above, the European Union is confronted with the task of developing a fully integrated and climate-neutral energy mix. To minimise GHG emissions, there are a number of specific policies and sources of funding to fight this battle. In fact, the initial step was the implementation of the EU ETS which is the world's first international emissions trading system that adheres to the "cap and trade" philosophy. It establishes an upper limit on the total amount of greenhouse gases that can be released by all participating entities. Allowances can be traded and are either sold at auction or given away for free.

Although many believe the European Union's carbon trade system has proven to be an effective tool in reducing GHG emissions, the system has also been severely criticised.

Since the European Union is committed to assisting coal areas in making a fair transition, it is crucial to highlight that about 20% of the EU's total electricity generation comes from coal. In addition, it offers employment for over 230,000 people in mines and power plants spread throughout 31 regions and 11 EU nations. What is encouraging, the system has seen an almost 30% decrease in overall coal power generation since 2012.

In a number of places around Europe, power stations have been decommissioned along with mine closures due to the diminishing demand for coal. However, there are still coal regions suffering with their own transition. In reality, coal accounts for over 70% of Poland's electrical generation. The country requires reliable power sources to supplement renewable production, and some modifications to existing units are required. Plants receive state assistance for supplying baseload power, however this is expected to change when the stricter EU emissions restrictions apply to power plants receiving such support, which has been the main topic of the ongoing debate.

While coal continues to be a major fuel in the European energy mix, the shift to cleaner energy sources and cutting-edge technologies, like carbon capture and storage, are essential to achieve European goals of reducing CO2 emissions by at least 55 percent from 1990 levels by 2030 and becoming the first climate-neutral region of the world by 2050. Coal is the most CO2-emitting fossil fuel and nations should remember the time to fight for a cleaner future starts now.

1.3 The EU taxonomy for sustainable activities

In order to accomplish the European Union's climate and energy targets, we must change our lifestyle and daily habits into more sustainable ones. The European Union paved the road for "greener" investments in sectors such as biodiversity, renewable energy, and the circular economy by passing the European Green Deal. As a result, the Taxonomy Regulation was enacted to promote fair competition and legal stability for all businesses operating in every Member State. It establishes six environmental objectives:

1. Climate change mitigation;
2. Climate change adaptation;
3. The sustainable use and protection of water and marine resources;
4. The transition to a circular economy;
5. Pollution prevention and control;
6. The protection and restoration of biodiversity and ecosystems;

Taxonomy is a method of classification that creates a list of economically viable environmental practices. A unified vocabulary and a precise explanation of what is meant by "sustainable" are necessary for this to happen. Investors can find advice on business ventures that qualify as ecologically friendly under those provisions. Article 8 of the Taxonomy Regulation (Taxonomy Regulation) aims to increase transparency in the market and help prevent greenwashing by providing information to investors about the environmental performance of assets and economic activities of financial and non-financial undertakings. This provision aims also to increase the space for green finance through transparency about companies' environmental performance. Additionally, it requires European businesses to disclose the extent of their taxonomy-aligned operations. Any activity left off the list risks losing access to sustainable financial instruments and running afoul of long-term EU policy goals. By precisely defining whether a business or industry is running sustainably or ecologically friendly, as opposed to instances of greenwashing, taxonomy establishes a foundation for the concept of sustainability. Therefore in a sense, the regulation seeks to reward and promote environmentally friendly and sustainable business methods.

In spite of the fact that there has been an enormous disagreement within the Member States on the inclusion of nuclear energy and gas as "sustainable" sources of energy, the scientific explanation is indisputable: they are both crucial to the battle against climate change. According to Article 10(2) of the Taxonomy Regulation, strict requirements must be met before certain nuclear and gas activities can be added to the list of those already covered by the first Delegated Act on climate mitigation and adaptation. These quality standards include:

1) that gas and nuclear power both help the world move toward climate neutrality

2) that nuclear power meets environmental and safety standards

3) that gas helps the world move away from coal and toward renewable energy sources.

Following the latest failure of an attempt to stall the legislation in the European Parliament at the beginning of July 2022, the planned inclusion of specific nuclear and gas activities into the European Union's list of widely recognised as „green" investments is expected to take effect at the beginning of 2023. There has been a consistent increase in the share of gaseous fuels to generate electricity, and for economies currently relying heavily on high-carbon energy sources, the use of gas appears to be the only solution on the road to net zero.

This trend, which is gradually gaining in popularity, may only lose steam when nuclear power units are sourced. And while investment in gas infrastructure is a half-measure on the road to full climate neutrality, it could be used in the future for the transmission and distribution of biogas or hydrogen.
Moreover, each gas-related activity must adhere to strict emission standards, replace any existing coal facilities that cannot be converted to renewable energy, reach predetermined emission reduction goals, and completely transition to renewable or low-carbon gases by the year 2035.

1. Electricity generation from fossil gaseous fuels;
2. High-efficiency co-generation of heat/cool and power from fossil gaseous fuels;
3. Production of heat/cool from fossil gaseous fuels in an efficient district heating and cooling system.

1.4 Diversification of Energy Resources

The foundation for constructing the energy security system of European nations is the process of diversification of their energy supply channels and routes, but more importantly, of their sources.
In the event of the Russian war the European Commission changed their tracks on the green transformation. For example, the Baltic Sea is a key region for varying the sources of energy supply, which shows that political conflicts can also affect supply routes. Based on many sources, European's dependency on Russian imports of oil, gas and coal is between 25%-45%, depending on which resource you're taking into account. As a result, the European Union is planning to swiftly make **Europe independent from Russian gas by 2030** by means of diversification of supplies and unlocking zero-emission energy sources such as hydrogen or biomethane, thus making countries more resilient in terms of being dependent on one large supplier. As a result of the discussed practice (REPowerEU), a fair redistribution of energy among Member States may be achieved.

The **International Energy Agency (IEA)** predicts that the EU's power demand would rise by 12-26% by 2040, despite the fact that the EU's overall energy consumption is expected to remain relatively stable. To fulfil this rising need for electricity, the EU will need to strengthen its reliance on natural gas, sustainable energy, and modern technology. As part of the energy transition, natural gas will improve energy security, availability, and affordability in Europe, especially as it replaces coal-fired power generation.

To maximise natural gas's impact on the European energy market, a number of obstacles must be resolved, such as lowering methane emissions from the natural gas industry but also challenges encountered by geopolitical rivalry. Despite great progress being made by the EU in the construction of LNG terminals, reverse flow infrastructure, and natural gas pipelines, there are still regions of Central and Eastern Europe (CEE) that lack a variety of natural gas supply choices.

In order to establish a Mediterranean gas hub in the southern part of Europe, which will contribute to the diversification of the EU's energy suppliers and routes overall, the EU is actively pursuing an energy discussion with its partners in the Eastern Mediterranean and North Africa. The Mediterranean region can serve as a major source and route for supplying gas to the EU, especially in the light of Algeria's enormous potential for both conventional and unconventional gas resources as well as related infrastructure development plans. Because of their considerable offshore gas reserves, Egypt, and Cyprus are considered to be vital partners.

2. Energy Efficiency Targets in EU Member States by 2030 and 2050

2.1 Overview

Energy efficiency has become a critical issue globally, especially in the European Union (EU) countries. The EU countries are facing a significant challenge to reduce energy consumption while maintaining their economic growth. To address this issue, the EU has set ambitious targets for energy efficiency in its member states, both in the short term and long term by 2030 and 2050.

The EU's energy efficiency target for 2030 is to reduce energy consumption by at least 32.5% compared to 2007 levels. This target is part of the EU's overall goal to reduce greenhouse gas emissions by 40% by 2030. The EU's energy efficiency target for 2050 is even more ambitious, aiming for a 60% reduction in greenhouse gas emissions compared to 1990 levels.

To achieve these targets, the EU has implemented several policies and measures to promote energy efficiency, such as the Energy Efficiency Directive (EED) and the Energy Performance of Buildings irective (EPBD). In addition to that, energy labelling and minimum energy performance standards for products, as well as financial incentives and regulations for building renovations are also implemented. The EU has also established the Energy Efficiency Directive, which sets binding targets for energy efficiency improvements in all sectors, including industry, buildings, and transport.
Each member state has its own national energy efficiency targets to reach by 2030, which are based on their individual energy consumption and economic performance. Member states are required to develop national energy efficiency plans every three years, which outline their strategies and measures to achieve their targets. The plans are then reviewed and monitored by the European Commission to ensure that they are effective.

Some member states have already made significant progress towards their energy efficiency targets. For example, Denmark, Finland, and Sweden have set some of the highest national targets for energy efficiency and have implemented policies to support the use of renewable energy sources. Germany has also made significant progress towards its energy efficiency goals, particularly in the building sector, where it has implemented strict energy performance standards for new and renovated buildings.

Despite these efforts, some member states are still struggling to meet their targets, particularly in the transport and industry sectors. The EU has recognized this challenge and is working to support member states in their efforts to achieve their energy efficiency goals. For example, the EU has established a funding program called the European Regional Development Fund, which provides financial support for energy efficiency projects in member states.

In conclusion, the EU's energy efficiency targets for 2030 and 2050 are ambitious, but achievable with the right policies and measures in place. Member states have a significant role to play in reaching these targets and must continue to implement effective energy efficiency policies and strategies. The EU will continue to support its member states in their efforts to reduce energy consumption and greenhouse gas emissions, promote sustainable development, and build a more energy-efficient future.

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3. The EU action to address the Energy Crisis

The past year experienced high fluctuations in electricity prices in Europeans reaching historical peaks. The recent IEA report shows elevated future prices and a tight winter ahead. This article highlights the workings of European electricity markets, the recent price cap mechanisms and what to expect in 2023.

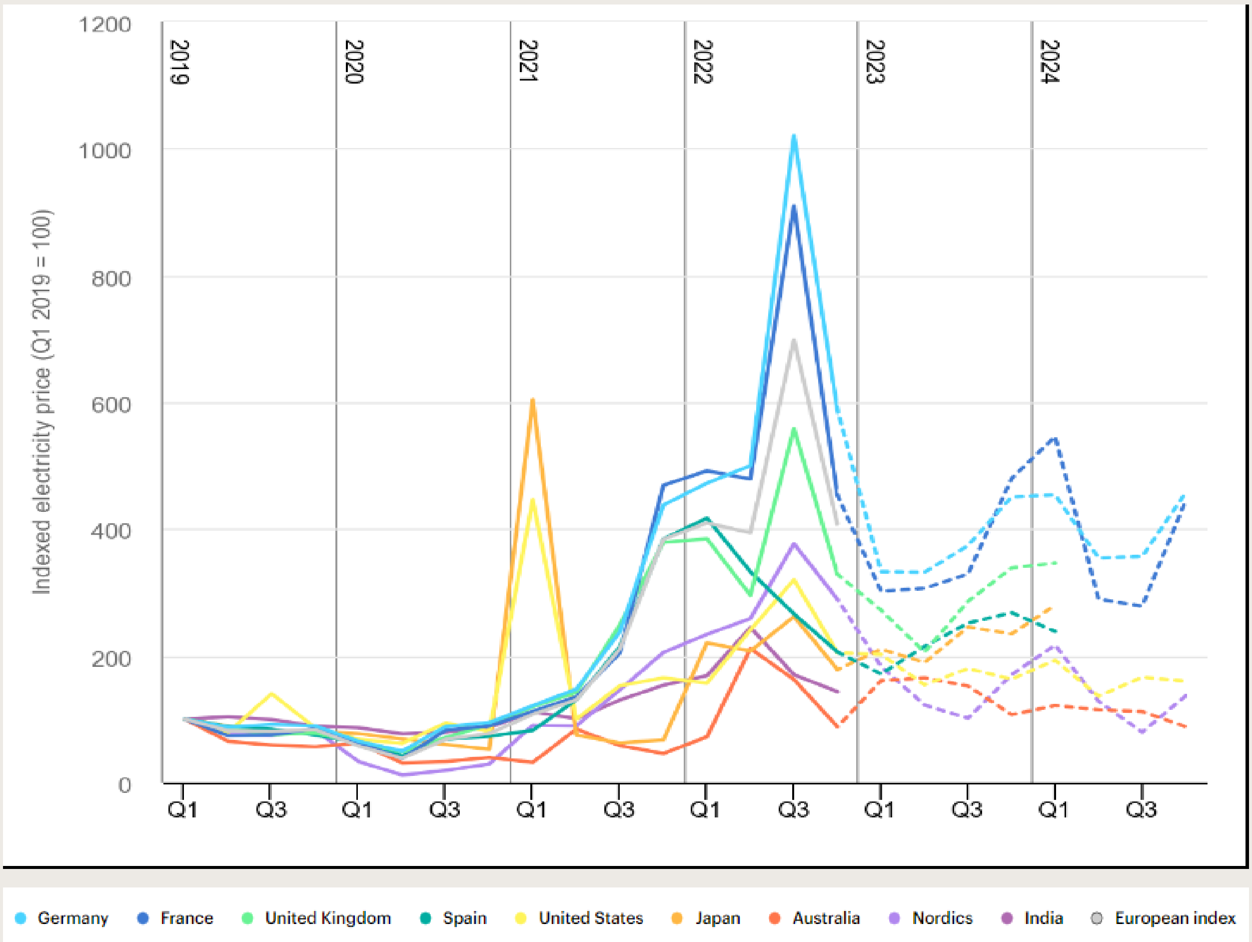
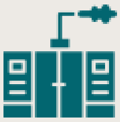


Figure 1 Indexed quarterly average wholesale prices for selected regions, 2019-2024.[1]

3.1 How does the EU electricity market work?

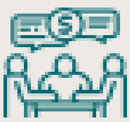
Since the liberalisation, the European Electricity market has operated on rules overseen by the **European Union's Agency for the Cooperation of Energy Regulators (ACER).** These rules promote competition and energy supply security and incentivise renewable investment.

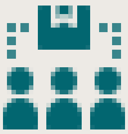
Electricity is traded in a **centralised platform** where participants can exchange electricity transparently according to the price they are willing to pay or receive and according to the capacity of the electrical network. The main players in the market include:

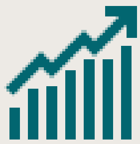

Generators


Aggregators


Suppliers


Traders


Consumers


Market and system operators

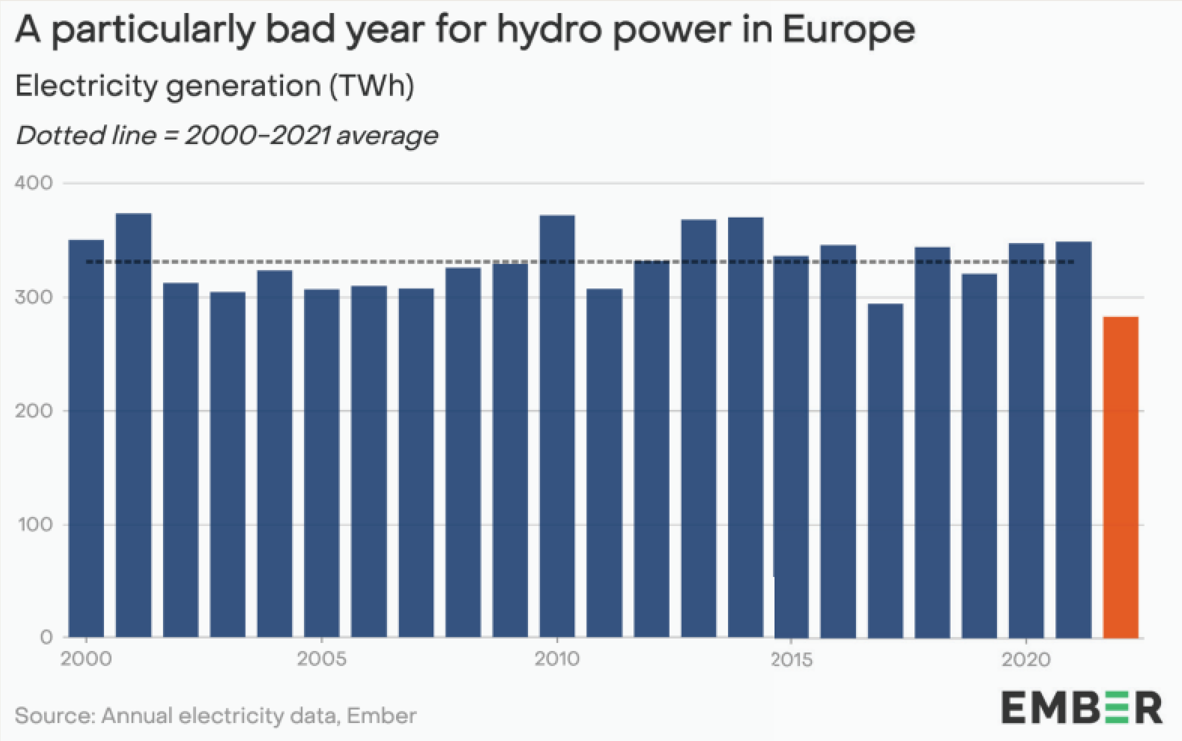
Because of the unique nature of electricity, the prices formed are the result of outcomes of an array of markets – day-ahead, intraday, forward, ancillary, balancing, capacity, market coupling, and OTC/bilateral. The market operates in such a way that the generators are dispatched in the order of increasing cost from the least to the most expensive until the demand is met, thus fulfilling the demand at the most affordable cost. The final price is determined by the marginal price of the last generator that has been dispatched, and all the generators dispatched at this point in time will receive a price equal to the marginal price of the last dispatched generator in the merit order. When the demand is high, the supply and demand curves meet at the cost of the additional generators, the gas turbines. And, when this occurs, when gas and CO2 allowances are expensive, the electricity prices peak.

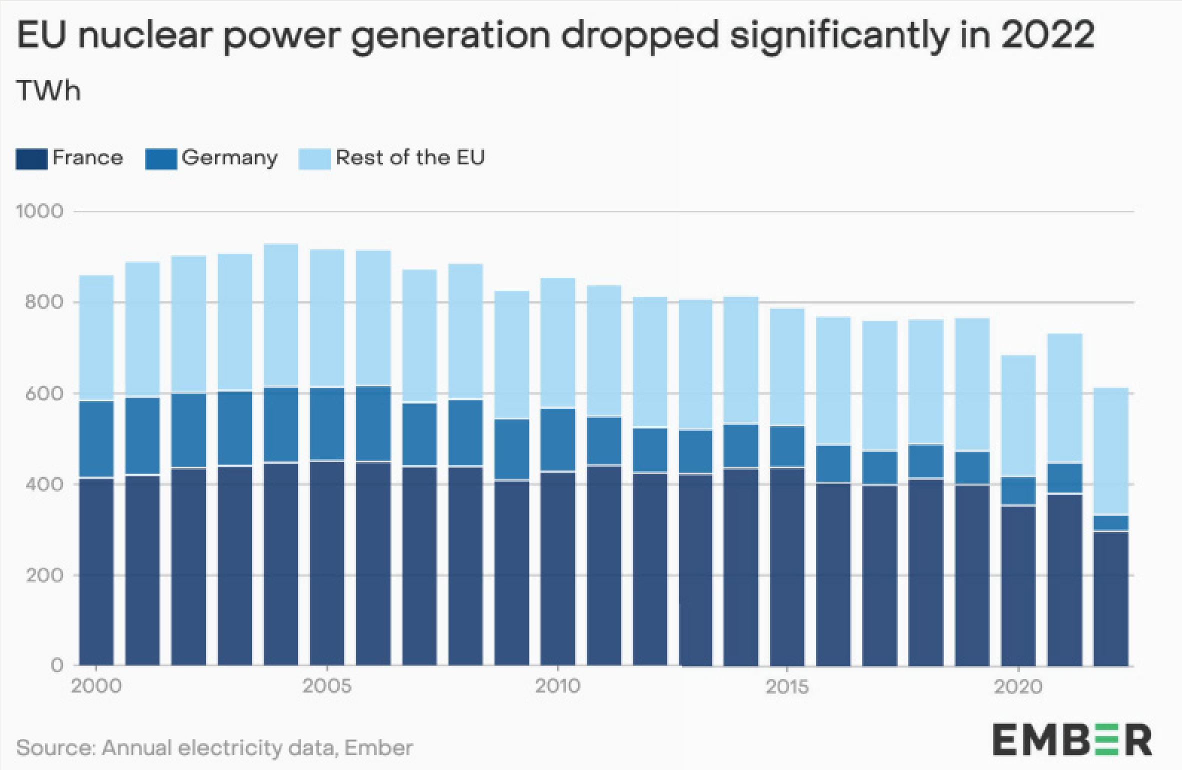
This system allows fair competition and encourages PV and wind investments due to their relatively lower marginal costs. The end cost paid by the customer depends on the type of agreement they have with their supplier (which the customers are free to choose thanks to liberalisation) but is influenced by the wholesale market price, transmission and distribution charges, and the taxes to fund renewable incentivisation and energy efficiency measures which vary widely from country to country.

3.2 What caused the electricity price spike?

The pandemic had a significant impact on the energy sector in the EU. Reduced mobility and economic activity resulted in a significant drop in energy demand. Digital solutions and changes in occupancy patterns led to new energy consumption patterns, with lower electricity consumption in buildings during certain times of the day. Reduced sales and lower revenues due to consumers' inability to pay their bills left energy utilities struggling. The pandemic also caused uncertainty in the supply chain, project shutdowns, and reduced revenues from energy sales, which reduced firms' and governments' capacity to invest in energy projects. As lockdown measures were lifted and industries resumed their activity, there was a surge in energy demand that led to higher energy prices[2]. Some EU Member States introduced support mechanisms such as tax exemptions to protect low-income consumers.

The Russian Federation's invasion of Ukraine further deepened the energy crisis as the EU relies heavily on Russian energy imports. Natural gas prices soared, leading to declining industrial output and increased household bills. These factors have led to a significant increase in energy prices, with EU day-ahead prices peaking at €405/MWh in August 2022, a 532% increase from January 2021[3]. By late 2022, these changes had begun to impact retail prices. Russia's deliberate actions precipitated the energy crisis to disrupt Europe's energy supply. As a result of the limited flow of gas into Europe, we are experiencing a supply crisis that has directly affected European electricity markets. Furthermore, there have been shortages in nuclear and hydropower generation, exacerbating the situation. In 2022, Europe faced its worst drought in at least 500 years, pushing hydro generation to its lowest level since at least 2000. EU nuclear power fell by 16% (119 TWh) in 2022. Of this fall, 69% was in France from outages, and 27% was because of German nuclear plants. In 2022, a record number of French nuclear reactors went offline, resulting in the lowest output in 30 years[4] .


A particularly bad year for hydro power in Europe
Electricity generation (TWh)
Dotted line = 2000-2021 average
400
300
200
100
0
2000
2005
2010
2015
2020
Source: Annual electricity data, Ember
EMBER


EU nuclear power generation dropped significantly in 2022
TWh
France
Germany
Rest of the EU
1000
800
600
400
200
0
2000
2005
2010
2015
2020
Source: Annual electricity data, Ember
EMBER

3.3 The EU Natural Gas Price Cap

On 19 December 2022, European Union energy ministers agreed on a cap on gas prices following months of debate. Prices at the main trading hub in the EU will be capped if they exceed €180 per megawatt-hour (MWh) for three consecutive days and exceed global prices by more than €35/MWh over the same three days. The measure, known as the market correction mechanism, could be extended to other trading hubs. The European Commission will submit a second legislative proposal by the end of March 2023. Germany, the Netherlands and Austria were not convinced of the price limit, with Hungary voting against measure 5.

The Czech EU Council Presidency wants to reach a deal on gas price caps by favouring qualified majority voting since countries like Germany need to be fully on board with the idea. The measure will be in place for a year from 15 February 2023. The triggers for the cap are lower than the European Commission's original proposal, which was called useless by many countries as it would not have prevented the price spike experienced in August this year. A lower cap means the mechanism is more likely to come into effect and be in place for longer. The energy regulator agency (ACER) will monitor markets and publish a notice on its website, preventing transactions above a "dynamic bidding limit".

The agreement also means the EU has unlocked two other pieces of emergency legislation merged into a package at a previous energy ministers meeting. This includes measures to boost European solidarity around gas supplies, like mandatory joint purchasing and a fallback agreement between countries in case of a supply emergency. The agreement also unlocks a law to speed up the process of building renewable energy infrastructure. While there are safeguards in place, it is difficult to see the ultimate impact the measure could have, commented Simone Tagliapietra, a senior fellow at the Bruegel economic think-tank in Brussels.

3.4 How did the EU survive winter 2022?

The European Union tackled the energy crisis of 2022 by increasing wind and solar energy generation and reducing electricity demand. Only a small portion of the energy gap created by nuclear and hydro was filled with increased coal generation, and only 14% of the 28 TWh increase in EU coal power in 2022 can be attributed to the reactivation of coal units. The fall in electricity demand towards the end of 2022, due to mild temperatures, energy efficiency investments, and reductions in industrial and commercial output, contributed to lower coal and gas generation. In addition, some mandatory electricity demand reductions introduced by the European Commission in September 2022 have been implemented, applying only until 31 March 2023.

Moreover, the invasion of Ukraine by Russia in 2022 caused gas shortages and fossil fuel price hikes, resulting in a cost-of-living crisis in Europe. However, wind and solar energy successfully delivered through the energy crunch, with solar power generating more than a fifth of EU electricity in 2022, which was a record. The increase in solar energy generation, along with the rise in installations and capacity, was the largest ever absolute increase in solar electricity generation, rising by 39 TWh (+24%).

Furthermore, solar energy's contribution to the energy mix was higher between May and August, producing 12% of the EU's electricity, and exceeded 10% for the first summer in history. Households in Europe also installed rooftop solar panels massively, adding 25 GW in 2022, which is 8 GW more than in 2021, representing 66% of the EU's installed solar capacity.

European governments responded to Russia's invasion of Ukraine by accelerating climate policies, cutting fossil fuel imports, and reducing electricity demand, but the public's significant investments in rooftop solar panels were a silent revolution that complemented top-level action.

3.5 What will be the future?

Since the liberalisation, the European Electricity market has operated on rules overseen by the **European Union's Agency for the Cooperation of Energy Regulators (ACER).** The future of energy in the EU is promising, with solar power leading the way. According to Solar Power Europe, the installed solar capacity is expected to increase significantly in 2023, with a medium scenario prediction of 54 GW and a high scenario prediction of 68 GW. This growth rate is expected to continue, with annual capacity additions reaching 85 GW (medium) and 120 GW (high) by 2026. The European Commission has set solar capacity targets of 400 GW by 2025 and 740 GW by 2030 as part of its REPowerEU plan to replace fossil fuels with renewables. However, Solar Power Europe's high scenario shows that these targets may not be ambitious enough. It is crucial for Member States to ensure that their regulations and infrastructure enable the rapid deployment of renewables necessary to meet these targets.
In 2022, coal and gas generation increased due to outages of France's nuclear power plants and a drought, but in 2023, fossil generation is expected to decrease significantly due to the return of French nuclear plants, an increase in solar and wind generation, hydro returning to normal, and a continuing fall in electricity demand. The fall in gas generation is expected to be faster than coal, and the power sector is expected to be the fastest falling segment of gas demand in 2023, contributing to a more secure gas system in the EU.

To further accelerate the deployment of renewables and protect consumers from volatile fossil fuel prices, the European Commission has proposed a reform of the EU electricity market[6]. This reform aims to provide more protection to consumers, boost renewables, and support demand-side measures. It also enables EU citizens to become more active players in the energy market, granting them a wider choice of contracts and clearer information. Energy retailers will be required to inform households about the "advantages and risks of different types of contracts". The proposal seeks to empower consumers and enable them to share energy within a community, while reinforcing protection for small consumers. However, more action will be needed, especially by network operators, to ensure the EU takes advantage of 21st-century digital technologies and promotes consumer-focused innovation.

In conclusion, the future of energy in the EU is trending towards renewables, with solar power leading the way. The European Commission's REPowerEU plan and the proposed reform of the EU electricity market are steps in the right direction to expedite renewables deployment and protect consumers from volatile fossil fuel prices. However, more action will be needed to ensure the EU meets its solar capacity targets and takes full advantage of digital technologies to promote consumer-focused innovation. The EU energy crisis presents both challenges and opportunities for the future of energy in the EU, and it is crucial for Member States to work together towards asustainable and secure energy future.

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4. Energy Prices changes across Europe

The ongoing war crisis between Russia and Ukraine has had a significant impact on energy and electricity prices in EU member states. The crisis began in early 2022 when Russia launched a military offensive in Ukraine, leading to a surge in gas prices and disruptions to gas supplies to Europe. This article will explore the changes in energy and electricity prices in EU member states in recent months due to the war crisis.

One of the most significant impacts of the war crisis has been on gas prices. Gas prices in Europe have soared due to the disruption in gas supplies from Russia, which is one of the primary suppliers of gas to the EU. The price of gas in the European Union has increased by over 500% compared to the same period last year, reaching record highs in some countries. This has had a severe impact on households and businesses that rely on gas for heating and energy.

The increase in gas prices has also led to a rise in electricity prices. Many countries in the EU rely on gas-fired power plants to generate electricity, and the increase in gas prices has led to a rise in the cost of producing electricity. This, in turn, has led to an increase in electricity prices, which has affected both households and businesses.

The impact of the war crisis on energy and electricity prices has been felt across the EU, but some countries have been hit harder than others. Countries that are heavily dependent on Russian gas, such as Bulgaria and Slovakia, have been particularly affected.

Some EU member states have implemented measures to mitigate the impact of the energy and electricity price increases. For example, the German government has announced that it will provide financial assistance to low-income households to help them pay their energy bills. The French government has also announced measures to help households and businesses cope with the increase in energy prices, including tax breaks and subsidies for renewable energy projects.

In conclusion, the ongoing war crisis between Russia and Ukraine has had a significant impacton energy and electricity prices in EU member states. The increase in gas prices has led to a rise in electricity prices, affecting households and businesses across the EU. While some countries have been hit harder than others, the impact of the crisis has been felt across the region. Governments and businesses will need to continue to implement measures to mitigate the impact of the price increases and invest in alternative sources of energy to reduce their reliance on Russian gas.

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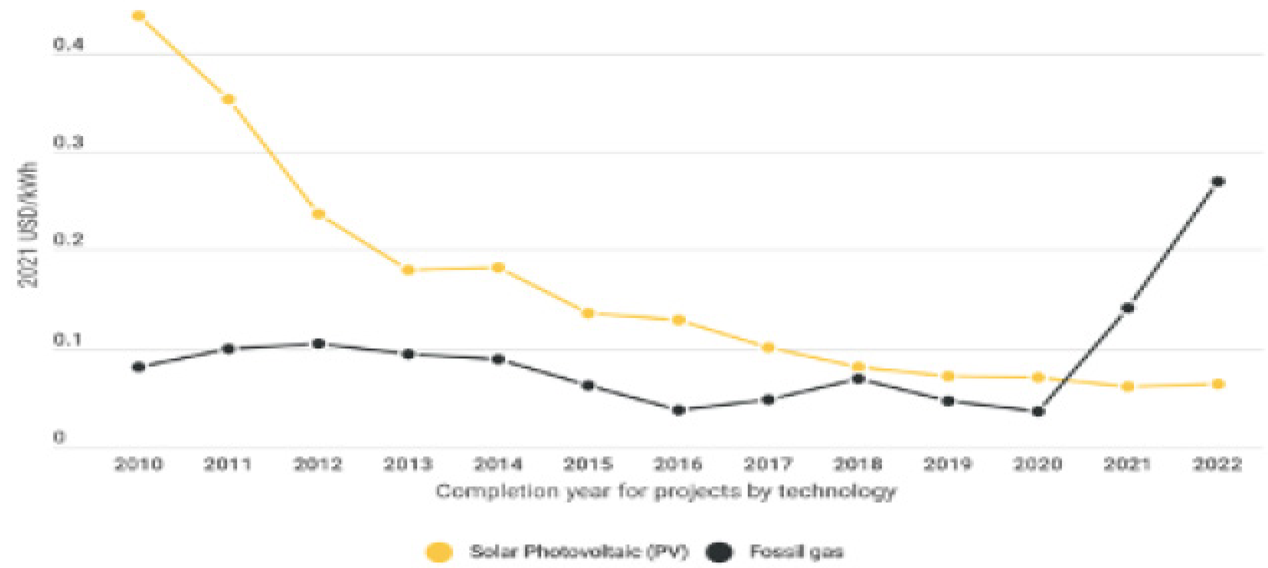
4.1 The future of Energy depending on costs

The problem with renewable energies and new technologies has always been mainly one of cost. As with any novelty introduced into society, it takes time for it to become the preserve of all. However, in the case of energy, there is not much time, and there is a need for decisive and effective intervention by national governments to invest more in research and to reduce the production costs of the materials needed to build energy transformation plants.

The war in Ukraine has clearly demonstrated how, among others, the cost of fossil fuels is directly proportional to any political instability on a global scale, and this cannot be borne by individual states, nor can it be a justification for reactivating local resource extraction plants with high CO2 emissions.

In contrast to fossil fuels, renewable energies have a more stable and independent cost, as it is within the possibilities of each state to concentrate investments on one or more technologies in line with the natural conditions of the territory. For example, the UK can focus more on wind power than on photovoltaics.

On that note, we should dwell on the two aspects discussed so far and draw clear conclusions: on war and photovoltaics.



Utility scale solar PV becomes starkly competitive over fuel and CO_2 cost in Europe

The graph here clearly demonstrates how costs for photovoltaic systems have fallen significantly over the last ten years, while fossil gas costs have soared over the last two years. Of course, this does not distract from the need to reduce the total costs of new installations even more, but it is important to bear in mind that energy transition projects are long-term in nature, and therefore large sums of money must be invested now to see significant benefits in the future. More specifically, the cost of building new facilities for clean resources is still less than the total long-term maintenance cost of existing fossil gas plants.

Considering that prices for renewable energy are at historic lows; and considering a 16% decline for Concentrated Solar Power (CSP), 13% for onshore wind and 9% for offshore wind in the last year; and considering that new renewable energy projects added in 2020 alone will save emerging economies up to $156 billion throughout their lifetime—the choice is simply political and dependent on the foresight of national governments and energy companies.

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4.2 The new path and analysis on different markets

Meeting the energy needs of European citizens is a complex task, as European countries have different internal and external energy sources.
The various different crises that have hit the continent have obviously shaped the energy market and public opinion. The characteristics of the 2008 financial crisis differ from those of the 2020 pandemic era, thus leading to different needs and different investment projects at national and European level.

The most important objective to reduce emissions and complete the energy transition is to modulate the energy taxation system. The current model dates back to 2003, which is not in line with European political plans and the Green Deal, so the European Commission proposed to the European Parliament and the Council to re-evaluate the system and update it to the current situation.

The guidelines indicated by the European Commission envisage a recalculation of taxes no longer on the basis of the volume of energy produced, but on the basis of environmental and production efficiency. The idea is therefore to impose heavier taxes on the most polluting energy productions, and turn that revenue to invest in renewable energy and the construction of new plants. Specifically, according to the 2020 European Commission report, taxes and levies account for 41% and 30-34% of households and industry electricity prices, respectively, and for 32% and 13-16% of the households and industry gas price.

This analysis is in line with the positive trend followed by the EU. To date, the costs of producing clean electricity are equal to those of producing energy from fossil fuels; the only obstacle is the cost of the raw material of the plants and the adaptation of old transmission equipment to new technologies.

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5. The European Strategic Energy Technology Plan developments

HYDROGEN

Hydrogen deserves special focus. This energy carrier has great potential for the future, as it allows energy produced from clean sources to be transported without polluting. For the purposes of our analysis, it is worth focusing on just two types of hydrogen: blue and green.

The first type involves the transformation (Steam Methane Reforming) of natural gas into hydrogen and CO2, the latter being stored so as not to be released into the environment and cause damage. However, there might be unintentional leakage of methane during conversion processes.

The second, which is of greater interest, is the one that does not emit any pollutants. When energy is produced through a renewable source, such as wind and solar, this is then processed through electrolysis, from which hydrogen and oxygen are generated; the latter released into the atmosphere without causing any damage.

It is precisely here that investment must be made so that this process is more usable and becomes the primary source of energy production.

1

In the first instance, it is important to reduce the costs of activating the electrolysis process. The research and development sector needs more funds so that further cost-effective solutions can be found, as dependence on the cost of electricity alone is fickle. Of course, it is good that hydrogen made by electrolysis of water is now cost-competitive, thus following a trend that helps achieve the 2030 and 2050 targets of the European Union and the Paris Agreement, but the market is ever changing, and the situation might pose new obstacles.

2

Secondly, another issue to consider is the transport of hydrogen itself. To date, the current European gas network is suitable for the efficient transport of natural gas, not for renewable gas.

Since the European Union has the goal of not using hydrogen generated from natural gas from 2030 onwards, it is important to focus large investments on upgrading the European network to be suitable for hydrogen without damaging plants and equipment.

In view of this, to accelerate the achievement of the goals set in the Green Deal, it is worth opting for blue hydrogen over other polluting energy sources. However, there is a serious risk of losing sight of the ultimate goal, and thus delaying the adaptation of national and EU policies in favour of green hydrogen.

5.1.1 The Regulatory Framework of Hydrogen

Recently, the European Commission has launched two consultations on two delegated acts clarifying EU rules applicable to renewable hydrogen under the 2018 Renewable Energy Directive. Once adopted, these documents will complete the Commission's overall proposal for a regulatory framework for renewable hydrogen. The first proposal, covering Renewable Fuels of Non-Biological Origin (RFNBO), sets the criteria for products that fall into the "renewable hydrogen" category, important to meet the renewable energy targets for the transport sector. The second proposal on the methodology for GHG savings puts forward a detailed scheme to calculate the life-cycle emissions of renewable hydrogen as well as recycled carbon fuels to meet the greenhouse gas emission reduction threshold set in the Renewable Energy Directive.

However, hydrogen production could incentivise electricity generation from fossil sources, which would undermine the climate benefit of hydrogen and its role in strengthening EU energy security. This is why the Commission is also setting requirements that will ensure that increased generation of renewable hydrogen is matched with a corresponding rise in the renewable power production. Hydrogen has been identified as an important part of the solution for hard-to-decarbonise sectors, such as aviation and maritime and certain industrial sectors. In the REPowerEU plan, the Commission tabled the concept of the hydrogen as an accelerator to roll out this new technology even more quickly. The REPowerEU ambition is to produce 10 million tonnes of renewable hydrogen in the EU by 2030 – increased from the 5.6 mt already foreseen within the proposals of the EU framework to decarbonise gas markets published in December 2021 – and to import 10 mt of renewable hydrogen from third countries[7].

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5.1.2 Hydrogen issues

Nowadays almost all hydrogen demand comes from refining and industrial uses, as it is involved in production of chemical products, such as plastics and fertilisers. In Europe 96% of hydrogen production is through natural gas, resulting in significant amounts of CO2 emissions[1].
Renewable hydrogen can be obtained via electrolysis using renewable electricity to split water into hydrogen and oxygen. In 2020, this process accounted for ~0.03% of hydrogen production for energy and chemical feedstocks worldwide. Of installed global electrolyser capacity of 290MW, more than 40% is based in Europe[2].

Thus, hydrogen can be used to replace fossil-based transport and industrial processes, since in fuel cells the opposite reaction occurs, producing electricity from hydrogen. When produced at times when solar and wind energy resources are abundantly available, renewable hydrogen can also support the EU's electricity sector, providing long-term and large-scale storage. Therefore hydrogen can help improve the flexibility of energy systems by balancing out supply and demand when there is either too much or not enough power being generated, helping to boost energy efficiency throughout the EU.
Although renewable hydrogen offers a solution to decarbonize the EU economy, several challenges need to be addressed, such as the high investment cost of technologies and the high energy losses and the storage issues due to the physical properties of hydrogen.

5.1.3 Hydrogen Hubs

Hydrogen hubs are regions where various users of hydrogen across industrial, transport andenergy markets are co-located. Hubs help in reducing the cost of the infrastructure, and support economies of scale in producing and delivering hydrogen to customers. Hubs also facilitate opportunities for sectors to innovate and collaborate, while developing the workforce and skills needed to support a future hydrogen industry. Indeed, hubs are likely to reduce carbon emissions in hard-to-abate sectors (e.g., iron and steel, petrochemical industrial sub-sectors), improve air quality, grow and diversify the regional economy creating new jobs, provide businesses with more choices to increase revenue and reduce emissions and last - but not least - improve energy security.

Concerning the European framework, the FCH-Regions' Hub supports regional and local authorities and other public bodies across the European Union to develop and turn their concepts for regional hydrogen and fuel cell (FCH) projects into detailed work plans. In this perspective, raising awareness and providing project development assistance to regional FCH projects will further accelerate the deployment of hydrogen in Europe, contributing to carbon neutrality and zero pollution.
Several hydrogen hubs are going to be built across Europe. For instance, in April it has been announced that a 500 MW green hydrogen facility — one of Europe's largest single-site renewable H2 projects — is to be built at the Portuguese port of Sines by 2025.

It will use 500 MW of electrolysers to produce 50,000 tonnes of green hydrogen and 500,000 tonnes of green ammonia annually. In total, 11.9 GW of green hydrogen projects have been unveiled in Iberia in the first four months of the current year[4], making Iberia quickly become Europe's green hydrogen hub.As for Italy, protocols have started for the realisation of 'Hydrogen Valleys', green hydrogen production sites in disused industrial areas in several regions. Indeed, the goal declared in the Italian National Recovery and Resilience Plan (NRRP) is to install 5 GW of electrolyzers by 2030. In Denmark, instead, the project Green Hydrogen Hub Denmark is a large-scale hydrogen hub project that aims to establish a complete Power-to-X value chain by 2025 comprising of a 350 MW electrolysis plant, 200,000 MWh large-scale hydrogen storage and a number of industrial hydrogen customers, including a 320MW Compressed-Air-Energy-Storage (CAES) facility.

5.2.4 Energy Storage

As previously stated, storage - as well as hydrogen storage - can play a crucial role both in balancing the supply and the demand and in reducing the dependence from fossil fuels. However, the storage of hydrogen is challenging. Being the lightest molecule, hydrogen gas has a very low density: 1 kg of hydrogen gas occupies over 11 m3 at room temperature and atmospheric pressure[5]. Thus, for the storage of hydrogen to be economically viable, its storage density must be increased. Several methods to store hydrogen at increased density exist.
However, all these methods require some input of energy in the form of work, heat, or, in some cases, hydrogen-binding materials.
Hydrogen storage technologies are divided into three main categories:

1. Hydrogen may be stored as gas or a liquid in pure, molecular form without any significant physical or chemical bonding to other materials;

2. Molecular hydrogen may be adsorbed onto or into a material, held by relatively weak physical van der Waals bonds;

3 Atomic hydrogen may be chemically bonded (absorbed). Nowadays, the most common methods are compression and liquefaction.

Concerning the compressed hydrogen, the low hydrogen density leads to large storage specific volumes, and, thus, high investment costs. The storage of compressed hydrogen can be situated underground mainly in salt cavities which are the most suitable for a number of reasons, including low construction costs, low leakage rates, and minimal risks of hydrogen contamination[6]. However, not all regions have the proper geological prerequisites for salt cavity storage, or even less preferred underground storage options, such as depleted oil or gas fields,and aquifers. Alternatively, metal containers are chosen. While a metal container increases investment costs, it ensures the stability of the storage, the purity of stored hydrogen, and it can be applied independently of location.

The density of pure hydrogen may also be increased via its liquefaction (condensation). However, it is a very energy-intensive process as the boiling point of hydrogen is extremely low (253 C at 1 bar) and, moreover, hydrogen gas does not cool down during throttling processes (adiabatic, isenthalpic expansion) for temperatures above around 73 C. The latter problem necessitates precooling in the liquefaction process, most often by the evaporation of liquid nitrogen. Nonetheless, even if the specific energy demand of liquefaction can be significantly lowered, the capital costs of a liquefaction plant are still a significant part of the overall costs of liquefaction, even for larger plants. For instance, it has been estimated that the capital investment constitutes around 40-50% of the specific liquefaction costs for a new 100 tpd liquefaction plant.
After the hydrogen has been liquefied, it is essential that it can be stored so that evaporation is minimised. The evaporation of liquid hydrogen constitutes not only a loss of the energy spent liquefying the hydrogen but also, eventually, a loss of hydrogen as the evaporated gas must be vented due to the pressure build-up inside the storage vessel [6].

Summing up, most of the covered storage technologies are still being very actively researched, indicating that further advances are still to be made. Beyond physical, thermodynamic, and economic arguments, it is fundamental to remark that the initial successful choice of a large-scale hydrogen storage technology is likely to significantly impact the further developments of a hydrogen infrastructure, since few full-size alternatives exist globally. The production and storage of large amounts of hydrogen for one application may well catalyse other actors to move in a similar direction due to reasons of economy of scale and availability. Therefore, possible synergies between applications or industries should be taken into account at an early stage, at least regionally. One example of such a synergy may be between an industrial application of large-scale hydrogen storage and a hydrogen distribution network for fuel cell vehicles.

5.2.5 Hydrogen engines in transportation

Transport remains one of the most polluting industries worldwide and is expected to recover after the COVID-19 pandemic[1]. In 2018, road transport alone accounted for 26% of all carbon dioxide emissions in the European Union[2]. As global transport is expected to rebound after the COVID-19 pandemic[3], transport-related emissions are bound to increase as well. The use of zero- and low-emission vehicles in both public and private transportation is seen as one of the key drivers of green transition[4].

The market share of electric vehicles has been growing steadily in recent years[5], raising both hopes for a more sustainable future and concerns related to disposing of used batteries as well as the carbon footprint of the entire value chain[6]. However, hydrogen-powered vehicles remain a novelty and enjoy limited popularity, mostly in the public sector. Hydrogen-based technologies are generally younger than their electric counterparts and raise more serious safety concerns[7]. The engineering complexity of hydrogen engines and the fact that the hydrogen must be highly compressed for road use are often quoted as obstacles to the development of this technology[8].

Finally, it should be noted that clean methods of production of hydrogen are expensive and relatively inefficient. Industrial-scale production of hydrogen uses up large amounts of fossil fuels and causes large emissions. As a matter of fact, in the current state of technology, hydrogen is an energy sink, rather than an energy source[9]. Scaling up electrolysis (the most common and very energy intensive hydrogen production method) is likely to result in an increase of pollution, as the majority of European infrastructure still runs on fossil fuels. Therefore, the main challenge hydrogen faces right now is the lack of “green” method of production.

Nevertheless, European Union seemingly moved away from endorsing hydrogen as fuel in transportation, focusing instead on promoting the production of green hydrogen to decarbonise heavy industries, such as steelmaking[10]. In late 2021, the “Clean Hydrogen Partnership” replaced the “Fuel Cells and Hydrogen 2 Joint Undertaking” as EU’s principal hydrogen development plan. The move underlined the change in focus in the EU hydrogen approach from personal and public mobility towards heavy industry.

Nowadays, in the context of transportation, hydrogen is used predominantly as bus fuel across the European Union, which must cut its transportation emissions by 72% to be able to reach the 2˚C Paris Agreement target[11]. However, hydrogen buses are far from becoming the mainstream solution. In some countries, such as Poland, only a handful of them are in use in major cities[12], due to lack of financing and the required infrastructure (hydrogen refueling stations). German cities ramp up their orders for new hydrogen buses, but they are currently in the initial phases of the procurement process[13]. It seems that the next stage of development of hydrogen technologies in public transport is going to be the emergence of hydrogen-fueled trains. For instance, as part of its hydrogen policy, Poland plans to have its first hydrogen train up and running by 2025, although it is not out of the question that the first vehicles of this kind will be operational sooner, as companies intensify their efforts[14].

In terms of private transportation (i.e., personal vehicles), the main barriers to widespread use of hydrogen fuel cells cars are primarily cost and lack of infrastructure. Like many new technologies, hydrogen fuel cells are expensive to manufacture, produced in quantities much smaller than their conventional counterparts and still viewed by consumers as a novelty rather than a viable alternative to traditional engines. Safety concerns remain a factor, despite the fact that according to recent research, potential risks are comparable to, or possibly smaller than, those resulting from the use of gasoline[15]. In terms of pricing, hydrogen cars are generally considered more expensive to purchase, which limits their popularity. As far as infrastructure is concerned, it should be noted that hydrogen cars require specialised refuelling stations, which are more difficult to build and maintain than typical EV charging stations. Hydrogen must be stored, vaporised and compressed on site, which means that hydrogen charging stations are more likely to resemble traditional gas stations - and be more expensive to construct and maintain as a consequence.

In conclusion, the application of hydrogen as fuel in both public and private transportation is likely to be slowed down by relatively high investment costs (especially when funding is more urgently needed in other energy sectors, including RES) and the fact that the majority of hydrogen that can be currently produced is not green. It seems that producing clean hydrogen at scale will be only a result of a successful energy transition, rather than its key component.

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SOLAR ENERGY

PV energy represents one of the most widespread clean energy resources along with hydropower and wind. It has been very successful in recent years, accounting for almost 10% of the energy generated worldwide. In particular, it generated more than 1,000/TWh in 2021, just below wind energy, which stands at around 1,800/TWh in the same year.

From 2010 to 2020, we saw an exponential decrease in the production costs of photovoltaic systems, but an opposite trend occurred between 2020 and 2021 due to the halt in the production of materials and components because of the COVID-19 pandemic. Crucial is the sourcing and cost of a material, polysilicon, which is mostly produced in China. Emblematic in this regard is the price difference from $11/kg at the beginning of 2021, to well over $30/kg at the end of the same year.
Although costs have now stabilised, it is clear that these are not everlasting and are, instead, susceptible to external events. It is expected, however, that in the longer-term this energy resource will become even more competitive in the world energy market, and this is mainly due to the continuous research and development of new technologies that optimise the use of materials and more efficient plant construction. One example of this is the further adoption of bifacial technologies from increasingly efficient cells. More specifically, from 2010 to 2020 there has been an increase in crystalline module efficiency of more than 7%, which is the result of research that has changed the technique of plant development.

All in all, when it comes to Solar PV total installation costs, these depend on optimised production processes, labour costs and module efficiency. By investing more in research, and adapting labour and labour costs to new energy trends, together with tax revenues from less clean energy, the total production costs of new photovoltaic systems can be drastically reduced.

CARBON CAPTURE

The future of Carbon Capture and Storage (CCS) in the European Union has been the focus of much discussion and research over the past few years. At its core, CCS technology captures emissions from major industrial sources and stores them underground in hopefully a future where they can be permanently eliminated.
The technology has been in development for many years, but has hit a few roadblocks in recent years, most notably the potential cost of constructing and maintaining the necessary infrastructure. This subtitle will provide a brief overview of CCS technology, including an explanation of the potential benefits and costs of implementing this approach to emission reduction. It will then discuss the legal and economic aspects of CCS in the European Union, including the likely impact of new legislation and the potential for private market involvement. Finally, will provide a tentative conclusion on the future of CCS in the EU, suggesting that while there are many obstacles to overcome, the potential benefits of this technology warrant continued investment in its development. CCS technology captures emissions from industrial sources and stores them underground.

The stored emissions can then be disposed of in a way that doesn't contribute to climate change, potentially eliminating them from the atmosphere in a future where GHG emissions are reduced. There are a number of different applications for CCS, including the capture of CO2 from coal-fired power plants, industrial emissions from oil and gas production, and the removal of CO2 from waste management facilities.

The potential benefits of CCS depend largely on the future level of global emissions, but include the following key advantages: Reduced emissions – CCS technology is effective at reducing emissions from major industrial sources. In some cases, it is estimated that CCS could reduce emissions by up to 90%. CCS technology is simpler and more efficient than other approaches to emission reduction, such as emissions trading schemes. This means that it would be easier to comply with existing regulations and would require fewer resources to manage. Longer-term storage – Unlike other emission-reducing technologies, such as solar or wind power, CCS has the ability to store emissions for a prolonged period of time, potentially eliminating them from the atmosphere in a future where GHG emissions are reduced.

However, despite the many benefits of CCS, the technology has been met with several roadblocks in recent years. chief among these are the potential cost of constructing and maintaining the necessary infrastructure, as well as the potential for private sector involvement.

While these challenges remain, many believe that CCS has the potential to play a significant role in reducing global greenhouse gas (GHG) emissions and thereby preventing the most serious consequences of climate change. The legal and economic aspects of CCS in the European Union are nascent and largely undefined at this stage. Significant gaps in the legal framework exist, notably around the ownership and management of CO2 storage facilities. Some analysts have suggested that private sector involvement could be crucial to the long-term success of CCS in the EU, but the specifics of this involvement remain largely absent.

Given the infancy of the legal and economic aspects of CCS in the EU, it is difficult to provide a definitive conclusion on the likely impact of new legislation. However, it is likely that new legislation would play a role in accelerating the development and uptake of CCS in the EU. It is also likely that the private sector would be involved to some degree, although the specifics of this involvement are still largely absent.

In conclusion, CCS technology has the potential to play a significant role in reducing global greenhouse gas (GHG) emissions and thereby preventing the most serious consequences of climate change. While there are many obstacles to overcome, the potential benefits of this technology warrant continued investment in its development.

NUCLEAR ENERGY

Many European countries see nuclear energy as an important solution for achieving both energy security and climate goals. As of September 2022, there are 171 operational reactors spread across 13 European countries[16]. However, a handful of EU countries, notably Germany, oppose the development of more nuclear power plants, which they consider dangerous and not environmentally friendly. Despite their opposition, the European Parliament voted to keep nuclear energy in the Complementary Delegated Act for the EU Taxonomy[17]. As a consequence, generating energy from nuclear sources is now formally considered an environmentally sustainable economic activity - a move that will make it easier to obtain financing for developing new facilities.

All nuclear activities must meet the necessary safety and waste management standards, be in complete conformity with all applicable legal obligations, use the best available technology, and be subject to Commission oversight in order to qualify. When it comes to finance, decommissioning planning, and waste disposal, more and tighter restrictions have been anticipated in the stated regulation.

1. Research, development and deployment of advanced technologies (“Generation IV”) that minimise waste and improve safety standards;

2. New nuclear plant projects with existing technologies for energy generation of electricity or heat (“Generation III+”);

3. Upgrades and modifications of existing nuclear plants for lifetime extension purposes[18]

The countries that want to increase the number of nuclear power plants or build their first ones usually have in place policy or strategy documents that outline the basic assumptions and goals that are to be achieved in a specific time frame. Below follows an outline of nuclear energy policies in selected EU countries. About 10% of the world's energy is generated by some 440 nuclear power plants. The percentage is not very high but will increase in view of new plants being built and the reduction in the use of polluting energy sources. Surprisingly, the cost of energy produced by nuclear power is higher than that of cleaner energies, such as solar power ranging from $36 to $44/MWh, and energy produced by onshore wind between $29 and $55/MWh. Nuclear power, on the other hand, costs approximately $152/MWh. Without wishing to argue about the convenience or otherwise of the reliance on nuclear energy, and the time required for new plants to be built, it is important to focus the analysis on the very cost of building a plant.

As highlighted by a study by the Nuclear Energy Agency (NEA), the biggest problem concerns the capital to be invested. Since these are long-term projects, with a plant to be completed in no less than three years, investors require greater guarantees for their invested capital, which increases interest rates. Capitalised financial costs therefore increase with the lead time of a project and, as a result, vary significantly from one project to another. This is also due to the fact that it takes time for the investment to pay off, which a priori compromises the start of a project, and consequently undermines a process of reducing CO_2 emissions. It would then be possible to target various points in the process of building a nuclear plant in order to reduce total costs. Summarizing:

1. Labour costs must be addressed, and this can be reduced by developing more accurate;

2. Better governance and control of the work could reduce costs, as time would be;

3. Since turbines and reactors are the most expensive components of the entire project, it would be useful to invest in research so that engineers would have more resources to develop new systems that optimise final costs.

4 By reducing the time, which can be achieved by investing in the previous points first, financial costs are obviously reduced, and thus the cost of capital is significantly reduced, resulting in a total reduction in the cost of building a plant.

References

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[18] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32020R0852

BUILDINGS

Commercial buildings, such as office buildings and shopping malls, also consume a significant amount of energy. The energy consumption of commercial buildings is higher than that of residential buildings due to the need for lighting, heating, cooling, and ventilation for larger spaces.
To reduce energy consumption in commercial buildings, energy-efficient lighting and HVAC systems can be installed, and renewable energy sources such as solar and wind power can be utilized. Energy audits can also be conducted to identify areas for energy efficiency improvements.
EU member states have implemented various measures to improve the energy efficiency of buildings. These include:

Energy Performance Certificates (EPCs): EPCs provide information on the energy efficiency of buildings and are required for all buildings that are sold or rented out. The certificates rate buildings on a scale from A (most efficient) to G (least efficient).

Building Codes: Building codes set minimum energy efficiency standards for new buildings and major renovations.

Energy Audits: Energy audits identify opportunities to improve energy efficiency in buildings and recommend cost-effective measures to reduce energy consumption.

Different EU member states have implemented various initiatives to improve the energy efficiency of buildings. Here are some examples:

Germany has implemented the Energiewende (energy transition) initiative, which aims to reduce greenhouse gas emissions by transitioning to renewable energy sources. The country has also implemented the KfW Efficiency House program, which provides financial incentives for building owners to invest in energy-efficient upgrades.

Denmark has implemented the Energy Renovation Scheme, which provides financial incentives for energy-efficient upgrades to buildings. The country also requires all new buildings to meet the energy efficiency standards of the low-energy class, which is equivalent to an EPC rating of A.

France has implemented the Grenelle de l'Environnement initiative, which sets targets for reducing greenhouse gas emissions and improving energy efficiency. The country has also introduced tax incentives and low-interest loans for energy-efficient upgrades to buildings.

The Netherlands has implemented the Energy Performance of Buildings Directive, which requires all new buildings to be nearly zero-energy buildings by 2021. The country also provides subsidies for energy-efficient upgrades to buildings.

The building sector is not the only sector that consumes energy. Other sectors, such as transportation and industry, also play a significant role in energy consumption. However, the building sector is unique in that it offers a significant opportunity for energy savings through energy efficiency improvements.

According to the International Energy Agency, the building sector has the potential to deliver almost 40% of the energy savings required to meet global energy and climate goals. In comparison, the transportation sector has a potential to deliver approximately 25% of energy savings, while the industry sector has a potential to deliver around 15% of energy savings.
Therefore, while other sectors also contribute to energy consumption, the building sector is uniquely positioned to make a significant contribution to reducing energy consumption and greenhouse gas emissions through energy efficiency improvements.

In conclusion, the building sector, including both residential and commercial buildings, is a significant consumer of energy globally. However, through the implementation of energy-efficient measures, such as the use of renewable energy sources and energy-efficient lighting and appliances, significant energy savings can be achieved. Compared to other sectors, the building sector offers a significant opportunity for energy savings, making it an important area of focus for policymakers and energy efficiency experts.

References

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5.5.1 Cooling Technologies in the Building Sector

As global temperatures continue to rise, the need for cooling technologies in the building sector has become increasingly important. In the European Union (EU) member states, cooling technologies are used in both residential and commercial buildings to maintain comfortable indoor temperatures.
There are two main types of cooling technologies:

Active Cooling Technologies

Active cooling technologies rely on electricity to function and include air conditioning units and mechanical ventilation systems. These technologies are effective at providing quick and consistent cooling, but they consume a significant amount of energy and can be costly to operate.

In recent years, there has been a push towards more energy-efficient active cooling technologies in the EU. For example, the EU has implemented regulations that require air conditioning units to meet minimum energy efficiency standards. This has resulted in the development of more energy-efficient air conditioning units, such as those that use inverter technology or utilise natural refrigerants instead of synthetic ones.

Passive Cooling Technologies

Passive cooling technologies, on the other hand, rely on natural phenomena such as ventilation and shading to cool buildings. These technologies do not require electricity to function and can be more cost-effective in the long run.

Passive cooling technologies include natural ventilation, shading devices such as blinds and awnings, and building orientation and design to maximise natural ventilation and shading. Passive cooling technologies can be particularly effective in areas with mild to moderate climates, where cooling demands are lower.

According to the European Environment Agency, energy use for cooling buildings has increased by 212% in the last decade. Passive cooling technologies can reduce energy consumption for cooling in buildings by up to 90%. Passive cooling technologies can also improve indoor air quality and provide a more comfortable indoor environment.

The need for cooling technologies differs from one country to another according to the diverse weather conditions.

Spain is known for its hot and dry summers, and cooling technologies are a necessity in many buildings. Active cooling technologies such as air conditioning units are commonly used in residential and commercial buildings in urban areas.

However, passive cooling technologies are also gaining popularity, especially in rural areas. One example of passive cooling technology used in Spain is the use of earth tubes. These are underground pipes that circulate cool air into buildings.

Italy has a warm Mediterranean climate, and cooling technologies are commonly used in buildings. Active cooling technologies such as air conditioning units are prevalent in commercial buildings. In residential buildings, passive cooling technologies such as shading devices and cross-ventilation are commonly used. One example of passive cooling technology in Italy is the use of loggias. These are open-air spaces that provide shade and ventilation to buildings.

Belgium has a temperate climate, and cooling technologies are not as commonly used as in warmer countries. However, with the increase in summer temperatures due to climate change, cooling technologies are becoming more prevalent. Passive cooling technologies are the most commonly used in Germany, and building regulations require energy-efficient design features.

Sweden has a cooler climate than many other EU countries, and the need for cooling technologies is relatively low. However, with the increase in summer temperatures, cooling technologies are becoming more prevalent. Passive cooling technologies are the most commonly used in Sweden, and energy-efficient building design is a priority.
One example of passive cooling technology used in Sweden is the use of thermal mass. This is the use of materials that can absorb and release heat, providing a natural cooling effect.

Greece has a hot and dry climate, and cooling technologies are necessary in many buildings. Active cooling technologies such as air conditioning units are commonly used in both residential and commercial buildings.

However, passive cooling technologies are also gaining popularity. One example of passive cooling technology used in Greece is the use of wind towers. These are tall structures that provide ventilation and cooling to buildings.

In conclusion, active cooling technologies currently dominate the building sector in Europe, particularly in countries with warmer climates. However, there is a growing interest in passive cooling technologies due to their energy efficiency and low environmental impact. As building codes and regulations become more focused on sustainability, it is likely that the share of passive cooling technologies will continue to grow in the coming years.

References

[1] Cooling buildings sustainably in Europe: exploring the links between climate change mitigation and adaptation, and their social impacts

5.5.2 Recommendations to reduce energy consumption in the building sector

Reducing energy consumption in the building sector is essential for both individuals and policymakers to tackle climate change and meet energy targets. Here are some recommendations for both individuals and policymakers to reduce energy consumption in the building sector:

Recommendations for Individuals

1. **Upgrade insulation:** One of the simplest and most effective ways to reduce energy consumption in the building sector is to upgrade insulation. This helps to keep the building warm in winter and cool in summer, reducing the need for heating and air conditioning.

2. **Install energy-efficient lighting:** Switching to energy-efficient lighting such as LED bulbs can help to reduce energy consumption significantly. They consume less energy and last longer than traditional incandescent bulbs.

3. **Upgrade to energy-efficient appliances:** Replacing old appliances with energy-efficient models can help to reduce energy consumption significantly. Look for appliances with the Energy Star label, which indicates that they meet energy efficiency guidelines.

4. **Use natural light:** Maximising natural light in a building can reduce the need for artificial lighting, which in turn reduces energy consumption.

5. **Optimise temperature control:** Setting the thermostat to a reasonable temperature can help to reduce energy consumption. Reducing the temperature in winter and increasing it in summer can help to save energy.

Recommendations for Policymakers

1. **Implement building codes:** Policymakers should implement building codes that mandate energy-efficient designs and construction practices. This will ensure that new buildings meet energy efficiency guidelines and help to reduce energy consumption in the building sector.

2. **Provide incentives:** Policymakers can provide incentives for property owners to upgrade insulation, install energy-efficient lighting, and replace old appliances with energy-efficient models. This can include tax incentives, rebates, and grants.

Increase public awareness: Policymakers should increase public awareness about the importance of energy efficiency in buildings. This can include public campaigns, educational programs, and workshops. 3

Encourage the use of renewable energy: Policymakers should encourage the use of renewable energy sources such as solar and wind power in the building sector. This can include incentives for property owners to install solar panels or wind turbines. 4

Implement energy efficiency programs: Policymakers should implement energy efficiency programs that target the building sector. This can include energy audits, energy management systems, and building retrofit programs. 5

The benefits of reducing energy consumption in the building sector are significant. It can help to reduce greenhouse gas emissions, lower energy bills for individuals and businesses, and create jobs in the energy efficiency industry. Additionally, energy efficiency measures can improve indoor air quality and make buildings more comfortable for occupants.

Moreover, reducing energy consumption in the building sector can help to create a more sustainable future. With the world's population expected to reach 9 billion by 2050, the demand for energy is only going to increase. Therefore, it is essential to reduce energy consumption in the building sector and promote sustainable development.

References

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6. Final thoughts

The Russia-Ukraine war has quickly sent shock waves to the European economy, causing an increase in price of primary energy commodities, thus influencing all the energy chain.

Furthermore, the uncertainty related to the supply of natural gas from Russia represents a matter of interest for the future of our continent, both in short and long term. According to the European Commission, 85% of Europeans believe that the EU should reduce its dependency on Russian gas and oil as soon as possible to support Ukraine. Concerning young Europeans, we interviewed a sample population in order to investigate how they are perceiving this energy crisis and whether and how they are facing it. Almost 80% of them think that this unstable condition is already having an impact on their daily life.

During the last winter, 54% of the interviewees turned down their heating system whenever it was possible, in order to save natural gas but also money as its price experienced a steep increase after the beginning of the war. Only 5% of the total sample population continuously turned down the heating system, even giving up their own comfort.

Concerning expectations for last summer the statistics are much more heterogeneous. To the question “During this summer, how much are you willing to use less air-cooling?” 16% replied “Not at all”, 16% “I won’t use it”, while the remaining fraction is mostly not supposed to renounce to keep home cool. This result may be due to the fact that this survey was conducted in the first weeks of this summer, when the hot temperatures were already taking toll in all the continent, reaching, for instance, the unprecedented 40°C in the UK and temperatures even higher in the Mediterranean area.

After investigating the behaviour in the residential sector, responsible for 28% of final energy consumption, we focused on the transport sector, as oil products’ price has started increasing significantly after the invasion. For instance, smart working was revealed to be a usual solution to save money for private transport for almost 45% of young people, comprehending students and employees. However, for those owning a car, 53% declared that they have not started yet to use it economically, for instance reducing speed whether possible. At the same time, 64% of interviewees have significantly increased the use of public transport in this year. Indeed, 45% preferred many times to walk or bike short journeys instead of driving. In this context, it is fundamental to enhance this positive trend, as it is happening in Spain, where the government has recently announced that 100% of local rail transport season tickets will be refunded to passengers while in Germany the choice to reduce to €9 the three-month season, valid for all local public transport (i.e., trams, regional trains, metros and ferries), has provoked a huge shift of the demand from private to public transport.

Summing up, there is a higher willingness to reduce consumption and also CO2 emissions in the transport sector rather than in the residential one. Surely, energy saving alone can not be the answer for Europe's energy security issues, as it needs to be supported by actions such as energy efficiency improvements, diversification of supplies and roll-out of renewable energy.

However, energy savings are the quickest and cheapest way to address the current energy crisis, and reduce bills as stated by the European Commission in the REPowerEU plan. Therefore, knowing which is the perspective of young Europeans can be a starting point for a further discussion. Finally, 77% of them declared to be worried about what may happen during next winter, when natural gas demand will reach its annual peak and the political situation will still be too uncertain.