World Economic Forum

In collaboration with Accenture

Shaping the Future of Energy and Materials
System Value Framework – Europe Market Analysis
October 2020

Contents

System Value of the clean energy transition in Europe

The System Value framework more holistically evaluates economic, environmental, social and technical outcomes of potential energy solutions across markets. The framework aims to **shift political and commercial focus beyond cost to include value.**

Using the System Value framework, the World Economic Forum, supported by Accenture, conducted analysis across several geographies as part of market evaluations **that examined recovery opportunities to accelerate economic growth and the clean energy transition**.

Key System Value dimensions for Europe have been prioritized across the framework based on current market dynamics and its relative maturity of transition towards an integrated energy system delivering net-zero GHG emissions.

Economic, environmental, societal and energy value

CO_2 Emissions
CO_2 emissions based on energy source, generation mix and load changes

Jobs and Economic Impact
Influx of jobs due to energy transition and renewables

Water Footprint
Water footprint based on energy source, generation mix and load changes

Air Quality and Health
Impacts to human health and natural environment from air and water pollutants, land use

Access to Electricity
Physical and economic access to clean electricity to support individual or society development

Energy Productivity and Systemic Efficiency
Energy efficiency plus systemic efficiency optimization of interactions among energy value chain elements) to maximize energy productivity

Resiliency and Security
Uninterrupted and diversified energy supply at affordable prices and the ability to bounce back from disruptions

Foreign Direct Investment
Market attractiveness for FDI with reliable energy and skilled resources

Reliability and Service Quality
Life cycle approach to ensuring high system availability; improved customer service

Flexibility
Ability to manage generation, demand and power flows (incl. power quality) across the grid, enabled by digitalization and storage

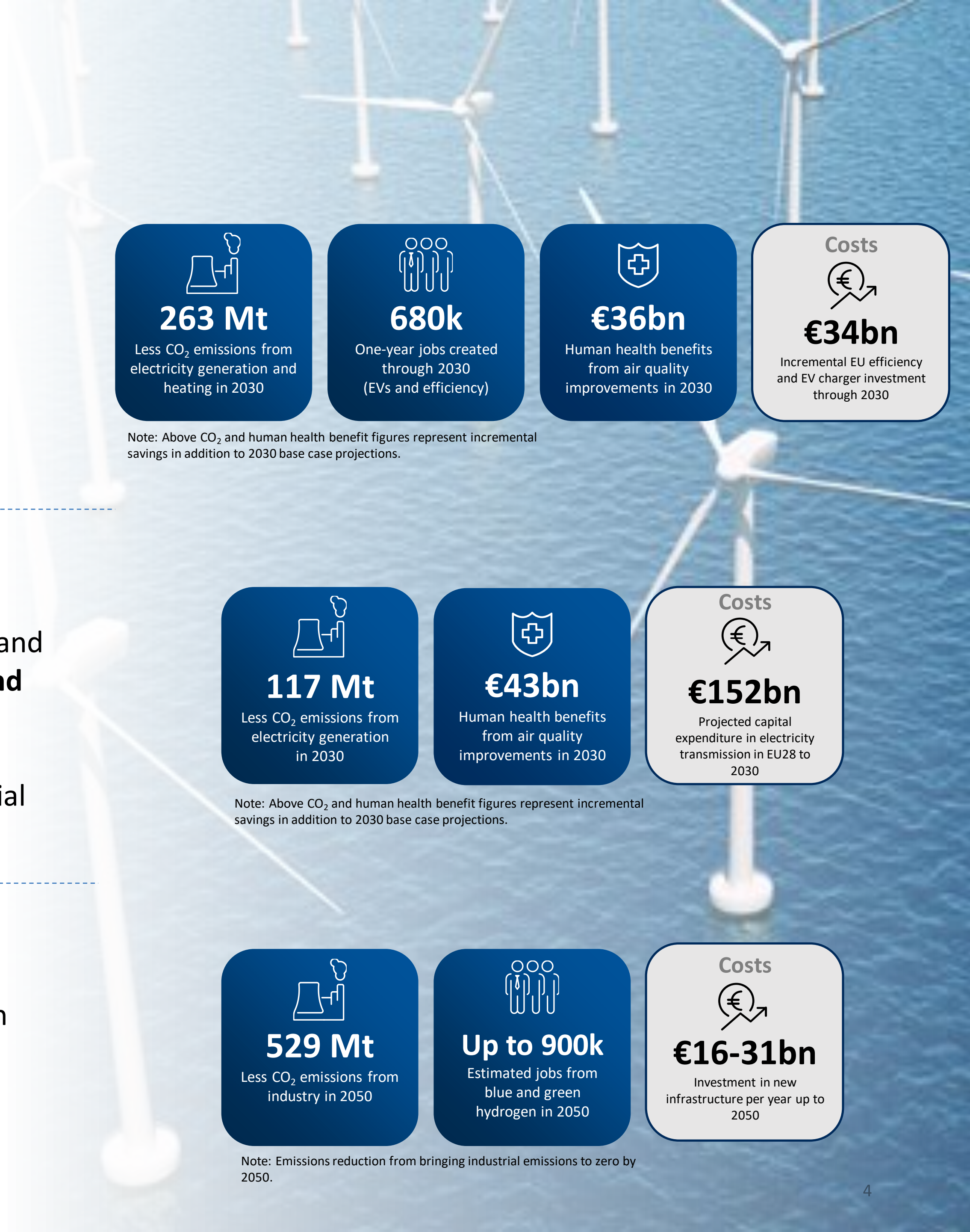
System Upgrade
Technology (incl. digital) and capital investments in T&D (incl. interconnections) to upgrade the system for variable renewables and distributed energy resources (DER)

Cost and Investment Competitiveness
Market attractiveness and policy certainty to businesses and policymakers for investment including R&D and levelized cost of energy

⬢ Priority outcomes for European system

Europe recovery solutions

Solutions to deliver the 2030 ambition



Connected Cities and Electrification

To continue decarbonizing Europe's cities, increase efficiency of power use and distributed energy resources, leverage **digitalization** and **demand optimization** for greater **smart flexibility**, and accelerate **electrification** through transition to **e-mobility** and **decarbonized heating systems.**

263 Mt
Less CO_2 emissions from electricity generation and heating in 2030

680k
One-year jobs created through 2030 (EVs and efficiency)

€36bn
Human health benefits from air quality improvements in 2030

Costs
€34bn
Incremental EU efficiency and EV charger investment through 2030

Note: Above CO_2 and human health benefit figures represent incremental savings in addition to 2030 base case projections.

Renewables, Power Markets and Networks of the Future

Transform grids, networks and power markets to support increased variable renewable and distributed resources, enabling a grid with **55%-60% share of wind and solar by 2030 and >70% renewables.**

By 2030, variable renewables will power a larger share of transport, heating and industrial applications, which currently are not electrified.

117 Mt
Less CO_2 emissions from electricity generation in 2030

€43bn
Human health benefits from air quality improvements in 2030

Costs
€152bn
Projected capital expenditure in electricity transmission in EU28 to 2030

Note: Above CO_2 and human health benefit figures represent incremental savings in addition to 2030 base case projections.

Hydrogen Economy

Build a **green hydrogen** market and infrastructure to enable cost-effective bulk hydrogen transport, storage of renewable energy and **decarbonization of Europe's 3,000 industrial clusters** (representing 54 million jobs).

529 Mt
Less CO_2 emissions from industry in 2050

Up to 900k
Estimated jobs from blue and green hydrogen in 2050

Costs
€16-31bn
Investment in new infrastructure per year up to 2050

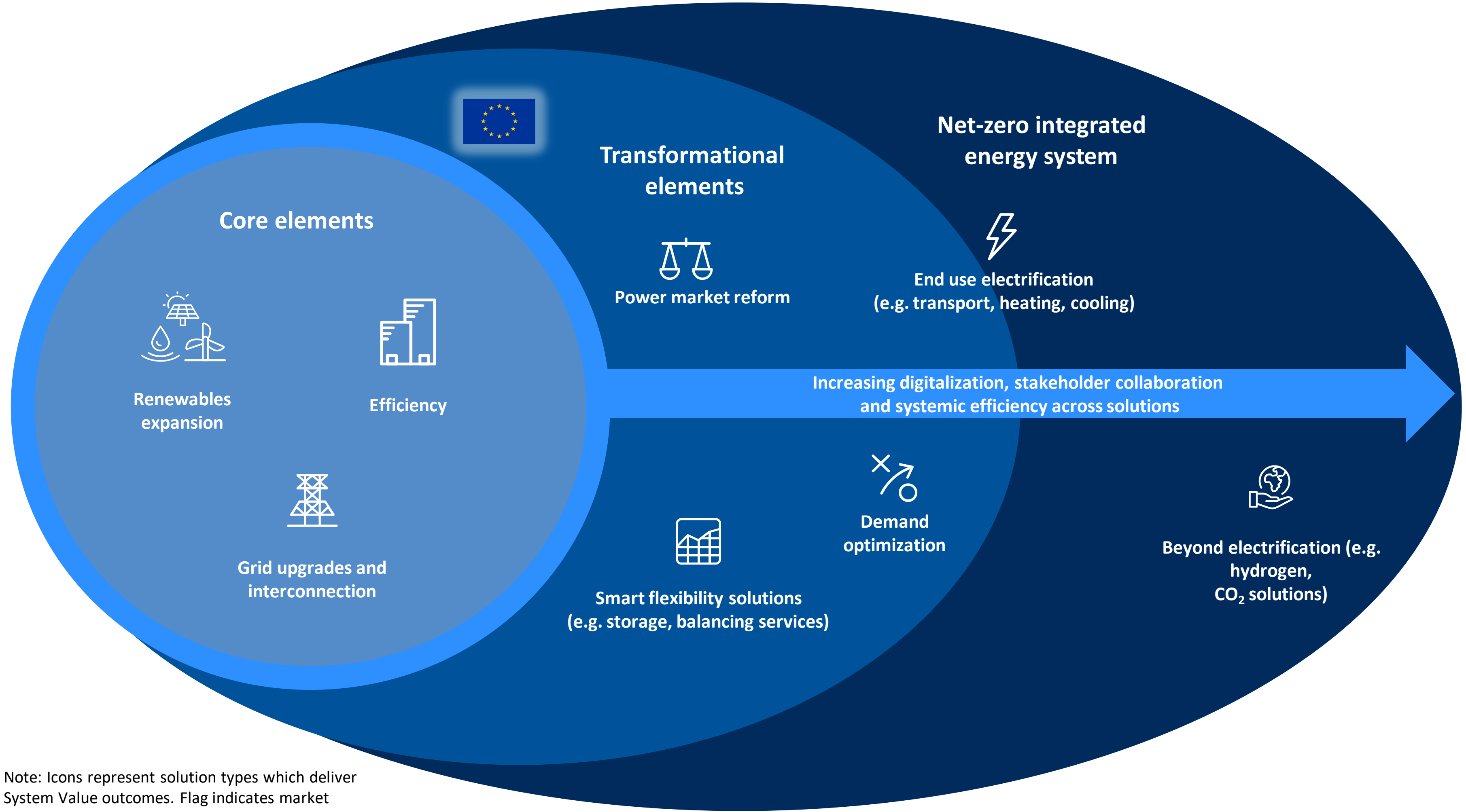
Note: Emissions reduction from bringing industrial emissions to zero by 2050.

Europe's path to maximize System Value

Markets are moving from addressing core elements of the electricity sector transition…

…through "pivot points" where generation mix hits 20%-30% annual variable renewables (>50% instantaneous) and transformational elements enable…

… acceleration to a net-zero integrated energy system with a strong focus on systemic efficiency



Core elements

Renewables expansion

Efficiency

Grid upgrades and interconnection

Transformational elements

Power market reform

Smart flexibility solutions (e.g. storage, balancing services)

Demand optimization

Net-zero integrated energy system

End use electrification (e.g. transport, heating, cooling)

Beyond electrification (e.g. hydrogen, CO_2 solutions)

Increasing digitalization, stakeholder collaboration and systemic efficiency across solutions

Europe is at the pivot point

Recovery solutions deliver against **core transition elements** and **push forward beyond the pivot point** towards an integrated energy system delivering net-zero GHG emissions.

Next Generation EU has potential to **accelerate the pace** towards an integrated energy system

CO_2 Emissions

Air Quality and Health

Energy Productivity and Systemic Efficiency

System Upgrade

Jobs and Economic Impact

Flexibility

Note: Icons represent solution types which deliver System Value outcomes. Flag indicates market progression along the path.

Analysis purpose and overview

The World Economic Forum, supported by Accenture, has developed the **System Value framework** to move beyond cost to a **more holistic evaluation** of energy sector opportunities **across economic, environmental, societal, and energy system value dimensions**.

Europe's electricity market was one of several markets chosen to demonstrate how the System Value framework can be used to evaluate opportunities that **accelerate economic recovery and a clean energy transition**.

The following analysis of the European electricity market aims to answer several key questions for energy industry leaders and can be leveraged to consider opportunities to pursue and prepare for conversations with a range of stakeholders.

- What is the state of COVID-19-related stimulus and recovery activity at the EU level?
- What short- to medium-term growth opportunities can spur economic recovery and accelerate the clean energy transition?
- How can stakeholders move beyond a cost-centric dialogue to consider the value of outcomes to the economy, environment, society and energy system?

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Energy transition trends shaping the European electricity industry

Digitalization	Increasing electrification	• **Buildings**: Smart, efficient electric appliances changing the load profile of buildings; heating/cooling also being electrified. • **Mobility**: Electrification of passenger vehicles, fleets. Heavy duty transport exploring electrification and Power-to-X options. • **Industry**: Electrification of light industrial applications and Power-to-X applications beginning to support new net-zero GHG emission goals of heavy industry and agriculture.
	Growth of green technology	• **Utility-scale renewable generation**: New capacity is dominated by utility-scale renewables. • **Distributed energy generation**: Decreasing costs driving increase in rooftop PV, batteries and microgrids. • **Energy efficiency technologies**: Decreasing and controlling consumer demand and, therefore, the need for new capacity.
	Network of the future	• **Resilient grid**: Pressure to ensure power supply, withstand intense environmental events and cybersecurity threats. • **Flexibility**: Need for greater flexibility through storage, matching forecasting to variable generation, increased interconnection and demand management. • **Development**: Reinforcing or building new grid capacity, often in the face of customer NIMBY objections.
	Enterprise customer goals	• **Corporate sustainability goals**: 200+ companies have made 100% renewable commitment as part of RE100 initiative. • **PPA growth**: Increasing share of wind and solar development financed by industrial and commercial customer commitments. • **Energy management**: Growing interest in site-level energy data and analysis to optimize energy usage, purchases and generation.
	Consumer activism	• **Youth activism**: Youth-led climate activist groups such as School Strike for Climate fuel international movements. • **New values beyond price**: Additional considerations motivate consumers, from buying green electricity to efficiency. • **Digital expectation**: Consumers, influenced by other industries and companies, expect seamless digital interactions. • **Greater choice**: Consumers adopt a more active role, increasing self supply and optimizing consumption.
	Investor activism	• **Sustainable generation scrutiny**: Activist investors target electric utilities to accelerate decarbonization efforts. • **Pressure on financiers**: Activist investors put pressure on banks to limit or halt financing for carbon intensive projects. • **Investors going green**: Large investors BlackRock and Vanguard pledge to include sustainability in investment criteria.
	Cities in transition	• **Systemic efficiencies**: Increased focus on advancing the clean transition in cities through building electrification, new green mobility and cross-sector efficiency optimization. • **Net-zero and air quality**: From transit to buildings, cities move to net-zero and circularity principles, improving air quality. • **Energy poverty**: Growing emphasis on addressing energy poverty issues such as heating, cooling and rent affordability.
	Investment in clean energy technology	• **Driving down costs**: Investments to drive down cost and scale technologies, e.g. hydrogen production, hydrogen transport and use; 10 MW+ electrolysers; lithium-ion batteries; CCUS; floating offshore wind. • **R&D in new technologies**: New clean energy technology, i.e. storage technologies beyond lithium-ion, new materials.

Sources: RE100, Blackrock, Vanguard, Accenture analysis

Digitalization underpins the energy transition

Digital is an enabler for all energy transition trends

AUTOMATION

Routine tasks executed without human intervention (e.g. substation inspections)

IT/OT

Integration of operations and information technologies across networks

PLATFORMS

Cloud platforms providing new ways of delivering energy services

SECURITY

Protection for the connected ecosystem

MOBILITY

Mobility solutions extending to customers and field workers

ROBOTICS

Physical activities conducted by machines

ANALYTICS

Cognitive analytics and big data applications (e.g. generation and demand forecasting)

SOCIAL

Premium collaboration and multidisciplinary decision-making

COVID-19 impacts in Europe on energy transition trends

Digitalization	Increasing electrification	• **EV charge points**: 11 European countries postponed rollout of EV charge points due to COVID-19. Mobility restrictions and overall decrease in electricity usage leads to income declines up to 70% for charge point operators. • **Short-term drop in EV sales**: Global 2020 EV sales expected to fall 43% according to WoodMac, while BNEF anticipates a moderate fall of 18% as the overall automotive market is impacted, with ICE vehicle sales seeing a greater decline of 23%.
	Growth of green technology	• **Construction and refurbishment delays**: Some EU member states have reported delays due to supply chain issues, delivery of equipment or workforce availability. • **Renewables share increases but margins challenged**: European utilities see increased share of renewables but more volatile and frequently lower (negative) pricing. However, commitment to the growth in renewables portfolios remains strong.
	Network of the future	• **Record share of renewables provide challenge for SOs**: With reduced electricity demand, coal-based power generation fell by 25% in Q1 2020 compared to Q1 2019, with the share of renewable generation reaching 43% and some countries running entirely coal-free. The increased share of variable generation has proved challenging but manageable to system operators as they balance the system, resulting in more price volatility and more frequent negative prices.
	Enterprise customer goals	• **Call for green recovery plans**: 155 multinational firms in the Science Based Targets initiative, including H&M Group, IKEA and Nestlé, sign letter reaffirming their own commitments and urging for recovery plans to be tied to net-zero targets. • **Short-term PPA market slowdown**: Companies are postponing signing long-term PPAs or negotiating for better terms; many developers may wait for prices to recover and look to mitigate off-taker risks associated with the pandemic.
	Consumer activism	• **Remote workforce**: 30% of workers indicate that they plan to increase the amount they work from home in the future, as consumer perceptions of external benefits of remote working, such as reduced transport congestion and cleaner air, may lead to a more permanent behaviour shift.
	Investor activism	• **Accelerated growth in ESG investing**: 35% of wealth managers expect a significant increase in interest in ESG investing resulting from COVID-19.
	Cities in transition	• **Reduced air pollution**: Concentrations of NO_2 dropped by ~20%-50% across major cities due to reduced road transportation. • **Cycling and walking schemes**: Cities such as London, Milan and Paris have announced measures to build networks of cycling lanes and car-free zones to support a low-carbon recovery.
	Investment in clean energy technology	• **EU Recovery Fund**: 30% of EU budget will be allocated to climate investments and additional funding for Horizon Europe, which targets investment in energy transition technologies.

Sources: Wood Mackenzie; Green Tech Media (1, 2); Bloomberg; Renews; ICIS; Carbon Brief; Science Based Targets; Eurelectric; European Environment Agency (1, 2); PV Magazine; ACEA; Accenture Research; New Energy Update; Reuters; European Commission; Reuters; Atlantic Council

COVID-19 impact on Europe’s electricity market

COVID-19-related shutdowns caused Europe’s largest electricity markets to decline 8% in the first half of 2020 with coal down 25% in Q1; however, demand has begun to return close to normal levels in some markets as of late summer 2020.

Electricity demand falls across markets

- **Electricity demand in Europe’s five largest electricity markets[1] declined by 8% year-over-year in the first half of 2020**

Generation mix shifts further away from coal

- **Coal-based power generation fell by 25%** in Q1 2020 compared to Q1 2019, comprising only 12% of EU and UK combined generation
- **Share of renewable generation reached 43%** in the same period, **increasing by 8% since 2019**

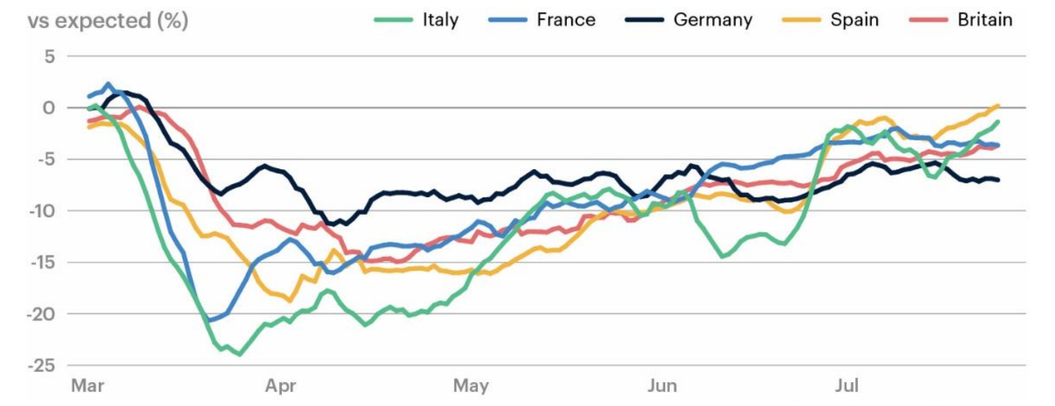
Wind and solar deployments slow

- Renewables additions impacted by **supply chain disruption and worker restrictions**
- Wind energy installations reported to be 20% below 2020 forecast
- Financial impact of the crisis on member states’ budgets will compromise auction schedules

Recovery timelines remain uncertain

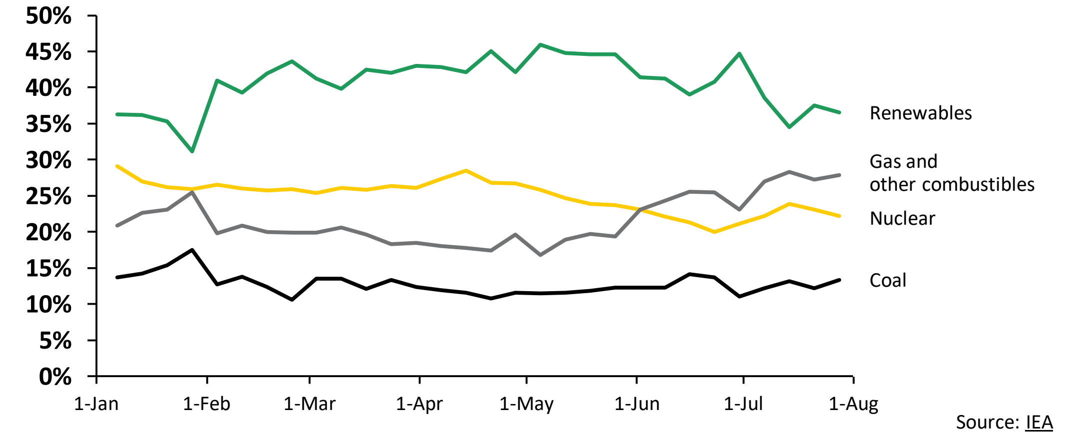
- Demand is recovering close to normal in some geographies, such as Spain and Italy, while other countries are still below normal
- Questions surround economic viability of coal plants and whether COVID-19 will accelerate closures

Electricity demand across Europe’s large markets is rebounding



Source: ICIS, 7-day rolling average

Electricity mix in Europe, January-July 2020



Source: IEA

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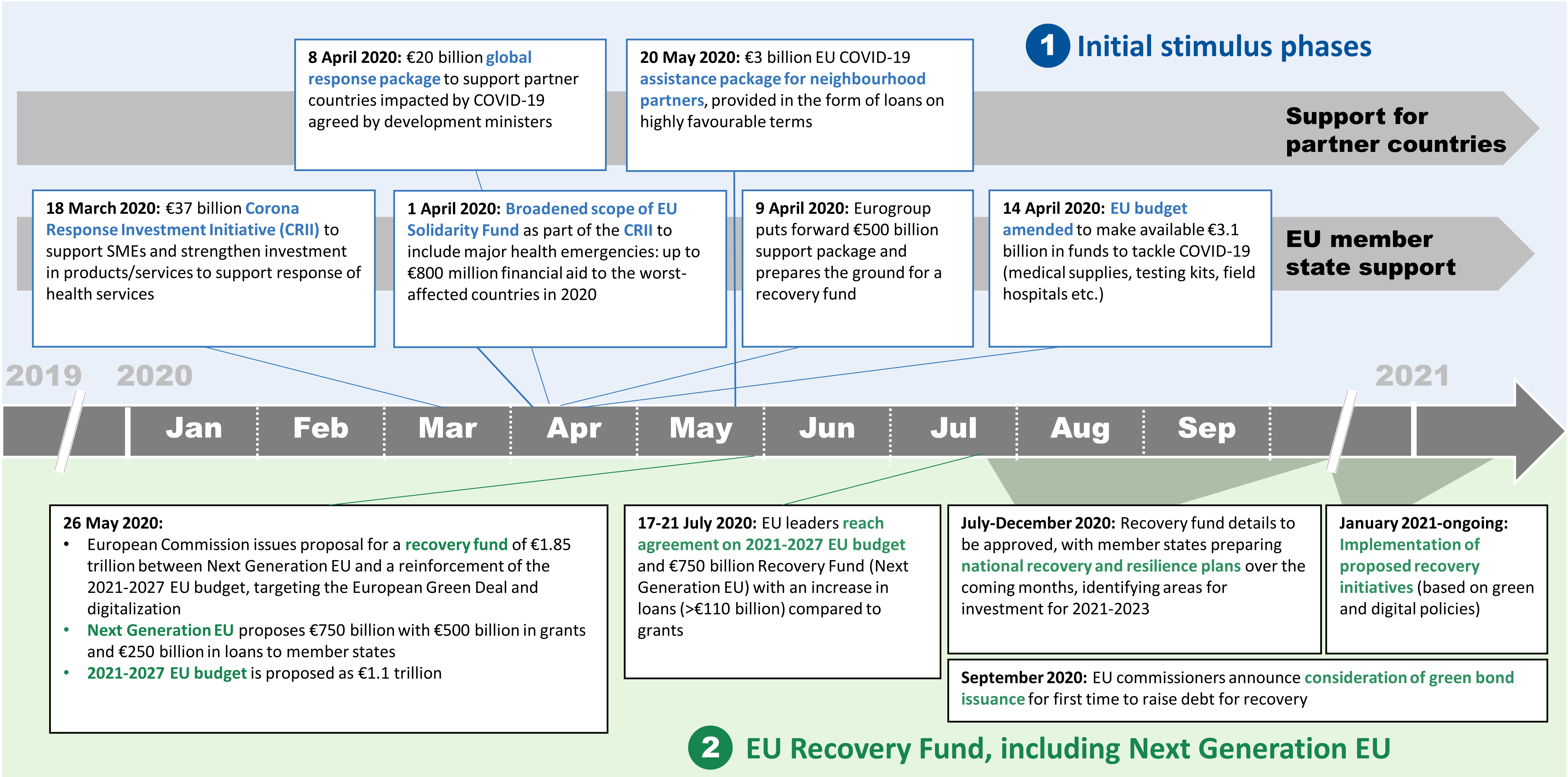
[1] Germany, France, Italy, Spain, Great Britain

Sources: S&P Global; IEA (1, 2); Wind Power Monthly; European Commission

EU COVID-19 stimulus timeline



① Initial stimulus phases

Support for partner countries

8 April 2020: €20 billion **global response package** to support partner countries impacted by COVID-19 agreed by development ministers

20 May 2020: €3 billion EU COVID-19 **assistance package for neighbourhood partners**, provided in the form of loans on highly favourable terms

EU member state support

18 March 2020: €37 billion **Corona Response Investment Initiative (CRII)** to support SMEs and strengthen investment in products/services to support response of health services

1 April 2020: **Broadened scope of EU Solidarity Fund** as part of the **CRII** to include major health emergencies: up to €800 million financial aid to the worst-affected countries in 2020

9 April 2020: Eurogroup puts forward €500 billion support package and prepares the ground for a recovery fund

14 April 2020: **EU budget amended** to make available €3.1 billion in funds to tackle COVID-19 (medical supplies, testing kits, field hospitals etc.)

26 May 2020:
- European Commission issues proposal for a **recovery fund** of €1.85 trillion between Next Generation EU and a reinforcement of the 2021-2027 EU budget, targeting the European Green Deal and digitalization
- **Next Generation EU** proposes €750 billion with €500 billion in grants and €250 billion in loans to member states
- **2021-2027 EU budget** is proposed as €1.1 trillion

17-21 July 2020: EU leaders **reach agreement on 2021-2027 EU budget** and €750 billion Recovery Fund (Next Generation EU) with an increase in loans (>€110 billion) compared to grants

July-December 2020: Recovery fund details to be approved, with member states preparing **national recovery and resilience plans** over the coming months, identifying areas for investment for 2021-2023

January 2021-ongoing: **Implementation of proposed recovery initiatives** (based on green and digital policies)

September 2020: EU commissioners announce **consideration of green bond issuance** for first time to raise debt for recovery

② EU Recovery Fund, including Next Generation EU

Sources: EU Council (1 , 2, 3); European Commission; Financial Times

European Commission response to COVID-19

European Commission stimulus response

- The European Commission proposed a **€750 billion recovery instrument**, **"Next Generation EU"**, embedded within the long-term budget
- Proposed €750 billion will be split: €390 billion in **grants** and €360 billion in **loans**
- This will be raised on the financial markets through bond issuance and paid back over 30 years using carbon emissions tax, tax on unrecycled plastics, or a digital tax

Long-term EU budget

- European Commission also **proposed 2021-2027 EU budget amounting to €1.1 trillion**
- Recovery based on green and digital policies as well as increased resilience from lessons learned from COVID-19

European Green Deal

- European Green Deal is the EU's growth strategy, with **twin green and digital transitions** expected to strengthen Europe's global position
- **30%** of the EU budget will be spent **on climate investments** with focus on **unlocking investment in clean technologies**, accelerating the deployment of **sustainable vehicles, alternative fuels** and financing the **installation of 1 million charging points**
- Potential to create **more than 700,000 new jobs** by 2030 through circular economy investments

Components of the €750 billion proposed investment

Recovery and Resiliency Facility represents €672.5 billion in grants (€312.5 billion) and loans (€360 billion) to implement investments essential for sustainable recovery

ReactEU €47.5 billion to extend the coronavirus crisis response and repair measures

Just Transition Fund of €10 billion in grants to address social and economic consequences of the EU climate targets, with additional €7.5 billion allocated from the overall budget

European Agricultural Fund for Rural Development provides €7.5 billion to support resources management and sustainable development of the rural economy

Invest EU
€5.6 billion to support the financing of the installation of 1 million charging points, clean fleet renewals by cities and companies, sustainable transport infrastructure and shift to clean urban mobility

Horizon Europe
€5 billion grant to unlock investment in clean energy and value chains, investing in technologies key for energy transition, clean hydrogen, batteries, carbon capture and storage and sustainable energy infrastructure

RescEU
€1.9 billion in grants to enhance protection of citizens from disasters and the management of emerging risks, such as health emergencies, extreme weather conditions and other threats

Sources: EU Recovery Plan, European Commission; European Green Deal; EU Commission Environment Ministers; European Parliament; EU Council (1, 2); Fi-compass; EU Commission React EU; EU Commission rescEU; Next Gen EU Pillars

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Recovery solution selection criteria

Selected recovery solutions are required to meet the following criteria:

1 Accelerates the energy transition

The recovery solution moves the market closer to net-zero

2 Stimulates economic recovery

Implementation of the recovery solution should stimulate job creation by 2021

3 Enables meaningful System Value assessment

*Model and assess the recovery solution for meaningful results within a 2030 time horizon**

** With the exception of Hydrogen Economy which looks at a 2050 horizon*

Recovery solutions can support Europe post-COVID-19 and advance the clean energy transition

	2030 Outlook				2050 Outlook	
	Connected Cities and Electrification			Renewables, Power Markets and Networks of the Future	Hydrogen Economy	
	Efficiency and Demand Optimization	Electrification of Transport	Decarbonized Heating and Cooling Systems	Renewables, Power Markets and Networks of the Future	Decarbonization of Industrial Clusters	Green Hydrogen
Solution overview	Operators can **leverage efficient DERs such as behind-the-meter batteries and smart technologies to optimize demand**, increasing grid reliability while integrating more variable generation	Governments can **support transition to electrified transport** by investing in **EV charging infrastructure** and supporting mechanisms to enable **smart charging** to unlock value from grid flexibility	Comprising half of EU energy usage, heating and cooling applications can be decarbonized through **district heating and electrified heat pumps** as well as combined with smart solutions to aid flexibility	**T&D networks and power markets must be transformed to support increased variable and distributed resources** as variable generation hits 30% in many European markets and will become majority by 2030	Europe can enable deeper decarbonization through creation of **Industrial Clusters** across the continent that use a combination of solutions, including **CCUS, and hydrogen production for industrial feedstock**	Building a **green hydrogen market and infrastructure will allow for cost-efficient bulk transport and storage of renewable energy**, enabling net-zero GHG emissions across hard-to-abate industrial sectors
Capacity and generation impact	• Higher efficiency reduces load, 41 TWh of coal generation by 2030 • Demand optimization reduces curtailment, enabling 8 TWh additional wind and solar	• Drive for zero-carbon transport enables additional 145 TWh renewables generation (116 TWh wind, 29 TWh solar) in 2030 to meet demand from electrified transport	• Decarbonization of heating systems will require significant renewable energy expansion; for example, to convert natural gas space heating consumption, an estimated 1,650 TWh of renewable energy is needed	• Development of next-generation network and power markets can enable grid with 55%-60% share of wind and solar by 2030 (base case versus accelerated case)	• Development of a hydrogen and CCUS network for blue and green hydrogen to displace coal and natural gas can decarbonize current EU industrial sector emission of 529 Mt CO_2 by 2050	Decarbonizing 80% the EU industrial sector via green hydrogen will require an estimated: • 45 Mt hydrogen • 235 GW offshore wind capacity • 196 GW solar capacity
CO_2 emissions	↓ 50 Mt 21% reduction in base case 2030 electricity emissions (290 Mt cumulative reduction through 2030)	↓ 76 Mt 10% reduction in 2018 base case road transport emissions (362 Mt cumulative reduction through 2030)	↓ 137 Mt 9% reduction in 2030 building emissions if EU replaces 20% of natural gas space heating with renewable electricity (20% of 2015 baseline)	↓ 117 Mt 50% reduction in 2030 base case electricity emissions	↓ 529 Mt Emissions reduction from bringing industrial emissions to zero by 2050	
Water footprint	↓ 87bn litres Reduction in 2030 water footprint (146 B litre reduction through 2030)	*Not included in analysis*	*Not included in analysis*	↓ 205bn litres Reduction in 2030 water footprint	*Not included in analysis*	*Not included in analysis*
Jobs impact	↑ 489k Total incremental jobs created from 2021 to 2030	↑ 192k Total incremental jobs created in 2030	*Not included in analysis*	↑ >1m Total incremental jobs created from 2021 to 2030 by growing 2030 wind and solar share from 55% to 60%	↑ 387k-912k Total incremental jobs created through 2050	
Air quality and health	↑ €20bn Human health benefits in 2030 from decreased air pollution	↑ €12bn Human health benefits in 2030 from decreased air pollution	↑ €3bn Human health benefits in 2030 from decreased air pollution	↑ €43bn Human health benefits in 2030 from decreased air pollution	*Not included in analysis*	*Not included in analysis*

Notes: While hydrogen was selected for analysis, innovation and R&D are essential enablers of the clean energy transition.
Figures in above recovery solutions assume each is enacted in isolation. Mt = million (metric) tons.
CO_2 percentage electricity reductions reflect coal and natural gas total compared to 2030 base case.
Estimated human health benefits from reduced NOx, SO_2, PM levels from lower fossil fuel generation.

Connected Cities and Electrification

Overview

Over 60% of Europe's carbon emissions come from its cities. Furthermore, in light of short-term COVID-related externalities, such as improved air quality and reduced traffic congestion, there is increasing pressure to redesign urban infrastructure to accelerate the transition to a low-carbon economy.

Thoughtful design of greener, more efficient and smarter cities can enable greater integration across energy production and consumption for a more connected, optimized system.

2030 outlook

Europe will need to place increased focus on system integration by increasing efficiency and DERs, leveraging demand optimization for greater flexibility, accelerating the transition to e-mobility, and decarbonizing heating and cooling systems.

Efficiency and Distributed Energy Resources (DER)

- Prioritization of smart, low-carbon urban infrastructure, decentralized renewable generation paired with battery storage, and energy management system (EMS) platforms.

Demand Optimization and Energy Flexibility

- Furthering dynamic tariffs and time-of-use (ToU) pricing and demand response programmes to match demand with times of high VRE production, enable behind-the-meter (BtM) optimization and wider integration with e-mobility via smart charging.

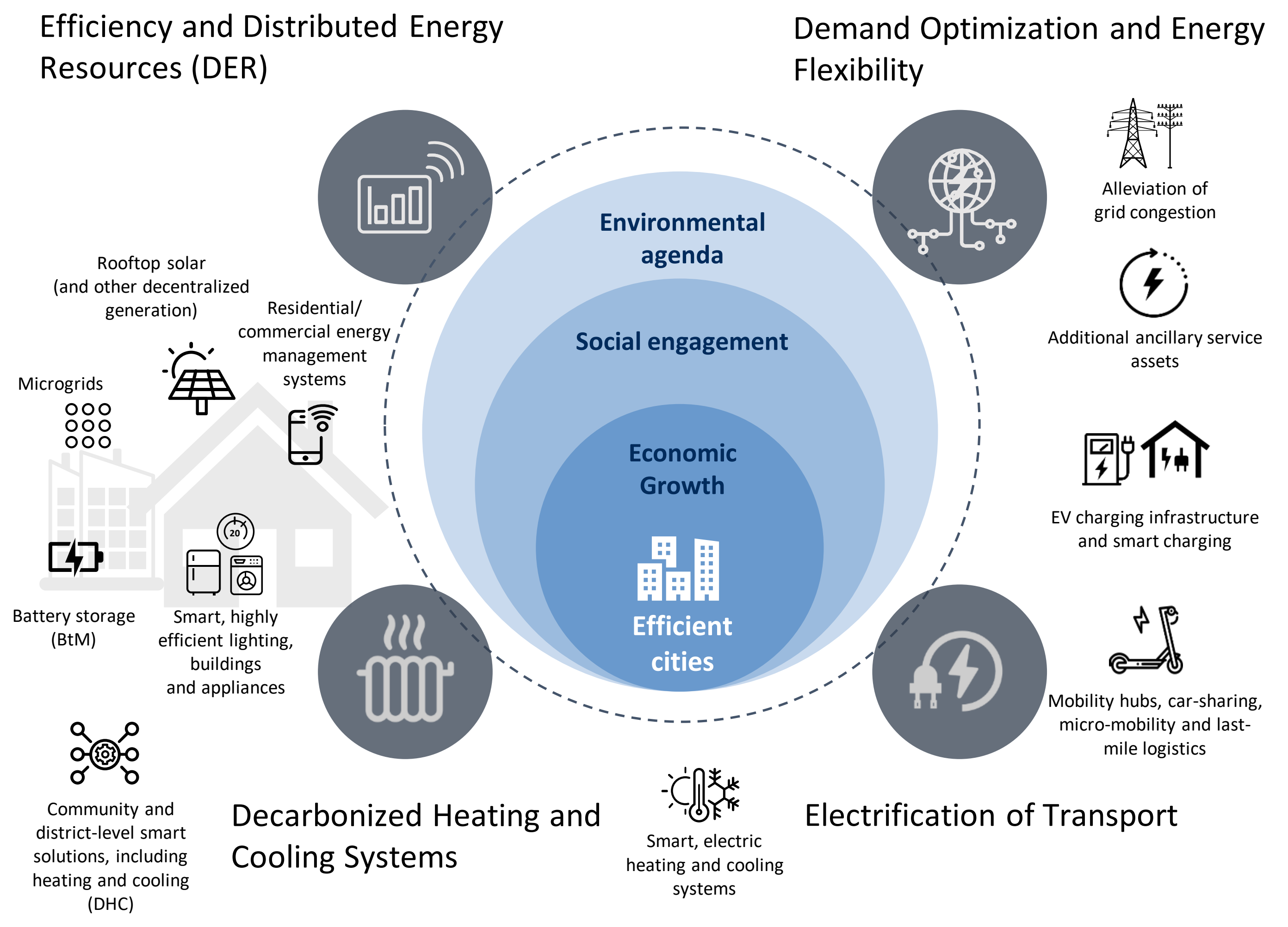
Electrification of Transport

- EVs can play a prominent role in efficient grid and micro-grid management in cities with smart charging aiding grid flexibility, and city authorities can develop shared transport initiatives.

Decarbonized Heating and Cooling Systems

- From district heating to heat pumps, myriad energy-saving, smart heating and cooling solutions are emerging.

Greater digitalization and system integration can enable efficient, climate-neutral cities



Sources: *The Conversation; European Commission; OECD; IEA; IRENA; ETI; Accenture*

Efficiency and Demand Optimization

Overview

Building energy usage contributes to 36% of EU carbon emissions. There is substantial opportunity to reduce load and building fuel consumption as countries such as Finland and its 6 Cities programme place increased emphasis on smart technology, efficiency and sustainable cities. Additionally, as variable renewable generation is projected to increase to 55% share by 2030 according to BNEF, it is essential to advance demand optimization and flexibility through increased storage, digitalization and electrification, coupled with managed consumption.

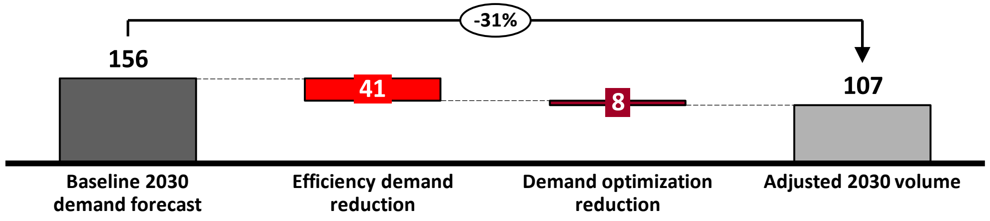
This recovery solution considers the impact of potential €2.5 billion annual efficiency investment[1] from the European Commission through 2030 as well as demand optimization potential from €3.2 billion investment in behind-the-meter storage, to match demand with times of high renewable energy production and reduce curtailment of renewables.

Efficiency and demand optimization opportunities for COVID-19 recovery

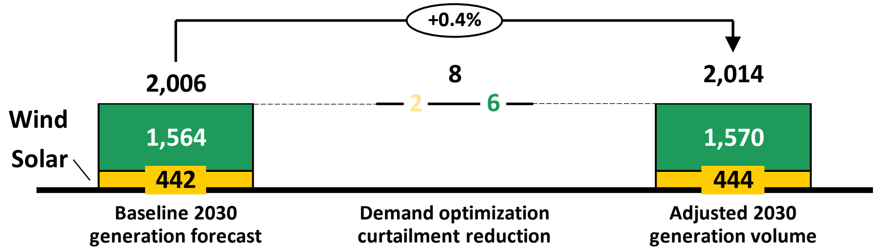
- *Building efficiency*: Mitigating household energy poverty is increasingly important in the context of COVID-19. Building upon new building energy performance rules set forth in 2018's Clean Energy for All Europeans package, Europe can strengthen support for smart efficiency retrofits and renewable energy projects for low-income households, neighbourhoods and commercial properties.
- *Smart, efficient appliances*: Increasing the deployment and requirements of smart, efficient appliances and electric heat pump systems, particularly in existing buildings, can accelerate energy management, curb building emissions and grow DR participation.
- *Distributed solar and behind-the-meter batteries*: Self-supply solar can be combined with small-scale batteries to increase energy supply efficiency by reducing T&D system losses and curtailment. Customers can be incentivised through user-friendly utility business models and favourable electricity rates or subsidies to decrease peak demand.
- *Dynamic pricing, ToU rates and demand response*: Increasing the ambition and incentives of demand response programmes, dynamic pricing and time-of-use (ToU) rates can increase customer participation, further reduce wind and solar curtailment, and save money for customers.
- *DSO and DER aggregation*: New incentives and programmes that encourage aggregation from DSOs/DERs can provide peak load and congestion management and voltage support services to support majority variable generation system.
- *Conditional bailouts*: Corporate bailouts for energy-intensive companies and fossil fuel entities can be made conditional upon participating in flexibility markets, lowering carbon intensity or increasing self-generation.

Projected 2030 impacts on coal, wind and solar generation volume

Demand decreases with increased efficiency and optimization (TWh)



Wind and solar generation increases due to reduced curtailment (TWh)



Source: Baseline generation and capacity mix based on BNEF forecasts

System Value impacts of efficiency and demand optimization

Benefits			Costs
↓ **50 Mt** 21% reduction in base case 2030 electricity emissions (290 Mt cumulative reduction through 2030)	↑ **489k** Additional one-year jobs through 2030 based on €2.5 billion annual efficiency investment	↑ **€20.6bn** Human health benefits in 2030 from decreased air pollution	**€28bn** Assumed incremental EU investment through 2030, based on €3.2 billion storage and annual €2.5 billion efficiency investments

Notes: Analysis based on EU 27 + UK data; (1) Figure based on EU-level €18 billion investment from 2014 to 2020 through European Structural & Investment Funds; (2) Figure based on late 2019 announcement of seven-nation Important Project of Common European Interest (IPCEI) battery storage project
Sources: Euronews; IRENA; IEA (1, 2); Transport & Environment; European Commission (1 , 2, 3); Smart Energy International

Electrification of Transport

Overview

This analysis focuses on how electrification will contribute to diversifying energy sources for transport and facilitate further integration of renewables, as the share of generation in Europe is projected to grow to 55% by 2030.

The benefits of road transport electrification paired with smart charging are investigated in terms of reduced renewables curtailment and capacity additions, along with grid flexibility enhancement. EVs and smart charging can be used to stabilize the grid by balancing supply and demand. Europe is estimated to have a BEV[1] uptake amounting to 47 million passenger and commercial vehicles between 2020 and 2025, and 180 million by 2030, with a ~38% weighted average[2] forecast EV uptake as a percentage of annual new vehicle sales by 2025, and ~59% by 2030. Additionally, Accenture Research has demonstrated the value of total annual flexibility gains to be €4.2 billion in 2030 across six target markets[3] in Europe.

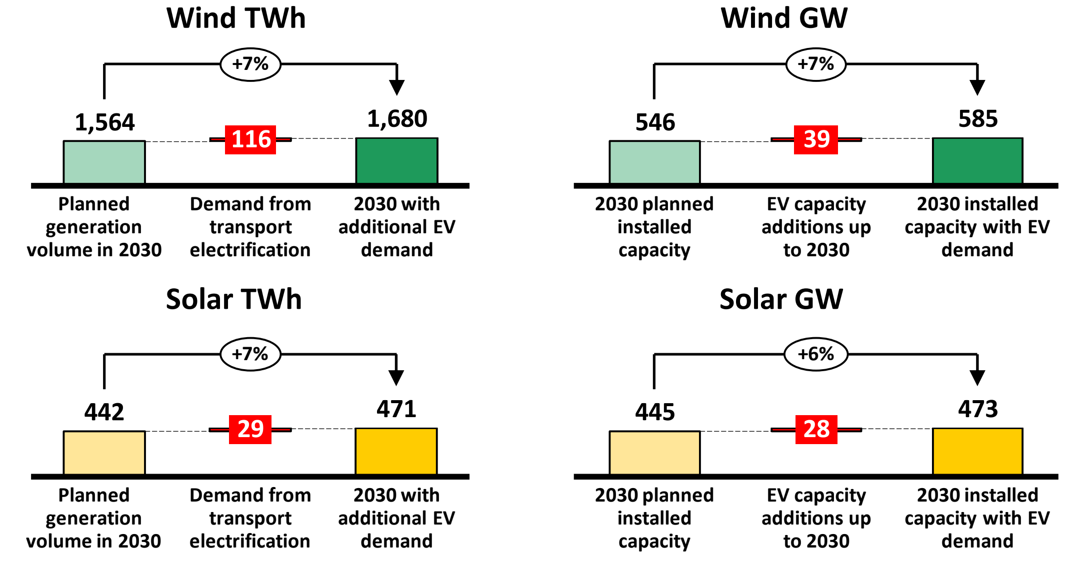
EU recovery funding

- With the goal of reducing GHG emissions in road transport by 15%[4] by 2030 (compared to 2008), the Connecting Europe Facility, InvestEU and other funds have committed to support financing of 1 million charging points installations, clean fleet renewals and sustainable transport infrastructure.
- This proposed recovery solution would achieve a 10% emissions reduction, focusing on passenger and light commercial vehicles only, where the transition of public transport and heavy-duty trucks could account for the remaining 5%.
- It is estimated that a €6 billion investment would be needed to achieve the 1 million public charge point target; however, public investment should come with a incentive for industry to invest in private charging.

Electrification and smart charging opportunities for COVID-19 recovery

- *Clean air zones, national ICE vehicle sale bans[5] and EU vehicle emission standards*
- *Sponsorship, co-financing or subsidies* for BEV purchases and charge point deployment
- *Public/private sector partnerships and cross-industry synergies*: E-mobility and utility players investing in electric vehicle infrastructure (EVI) and smart charging
- *Smart charging incentives*: Efficient price signals to pair with supply (e.g. ToU) and enablement of new revenue streams (e.g. price arbitrage, ancillary services)
- *Planning permission and building regulation* to support EV charge point installation
- *Technology development* to enable dynamic pricing (e.g. consumer applications), and roll-out of smart chargers with V2G/V2H/V2B[6] capability

Projected renewables generation volume (including curtailment reduction linked to smart charging) and capacity growth



Source: Baseline generation and capacity mix based on BNEF forecasts

System Value impacts of road transport electrification

Benefits

⬇ 76 Mt
10% reduction in 2030 base case road transport emissions (362 Mt cumulative reduction through 2030)

⬆ 192k
Total transport electrification jobs created in 2030[7]
125k EV infrastructure
34k Power upgrades
33k Battery manufacturing

⬆ €12.6bn
Human health benefits in 2030 from decreased air pollution

Costs

€6bn
Estimated investment to achieve 1 million public charge point target, based on T&E report

Notes: Analysis based on EU 27 + UK data; (1) battery electric vehicle; (2) between 2020 and 2025; (3) UK, Germany, France, Netherlands, Italy, Spain; (4) Road transport % estimated based on EEA, EU 2030 target for transport emissions; (5) internal combustion engine, see appendix for further detail on the topic of clean air zones; (6) vehicle-to-grid (V2G), vehicle-to-home (V2H), vehicle-to-building (V2B), (7) Based on AIE report, not inclusive of negative job impact on ICE vehicle jobs (e.g. maintenance)
Sources: EU Commission; EU Federation for Transport and Environment; IRENA; AIE; T&E CO2 Report; Accenture

Decarbonized Heating and Cooling Systems

Overview and key technologies

Heating and cooling in buildings and industry accounts for ~50% of EU energy consumption, with 75% of consumption met from fossil fuels and only 19% from renewable energy. Decarbonization of heating systems (clean electrification or green hydrogen) will require significant renewable energy expansion. For example, to convert natural gas space heating consumption as of 2015, an estimated 1,650 TWh of renewable energy is needed.

- *District heating and cooling (DHC):* District energy systems are networks of underground insulated hot or cold water pipes that service multiple buildings within a district, creating synergies in the supply of heating, cooling, domestic hot water and electricity. Energy grids can be integrated to supply low-carbon and energy-efficient heating and cooling, as well as maximize the uptake of renewables. Pilot projects across Europe are being set up to test DHC innovations, such as the STORM[1] project in Sweden and the Netherlands that developed a DHC network controller using self-learning algorithms.
- *Electrification of heating*: Electrification can play a large role in decarbonizing the residential heating sector, such as the flexible use of electric heat pumps connected to district heating networks. Generated heat can be stored within a building structure or in hot water tanks, acting as a thermal battery. Adapting dynamic pricing (e.g. ToU tariffs, real-time granular pricing) for heat pumps would encourage customers to shift heating loads to off-peak times and incentivise the flexible operation of heat pumps.
- *Smart solutions* such as smart thermostats can better manage and save energy use alongside renewable heating technologies (biomass boilers, solar heating systems).
- *Hydrogen for heating*: Combined with natural gas or used independently, hydrogen offers a new heating fuel opportunity in the long-term.

Example initiatives to achieve sector decarbonization goals by 2030

- *Prioritize a data-driven approach* to maximize efficiency and manage consumption
- *Set up partnerships and government programmes to bridge private-sector involvement* in innovating and scaling up district heating networks
- *Establish a system approach to utilize synergies across sectors*, e.g. using waste heat sources, or using district heating to provide electricity sector flexibility
- *Ramp up investment in district heating* grids, infrastructure and supply, while shifting away from fossil fuel heating investments such as gas or oil boilers

Key measures proposed by EU directives

- EU members to set national cost-optimal minimum energy performance requirements for new and renovated buildings, for elements such as heating and cooling systems
- Regular heating and air conditioning inspection schemes must be in place
- From 2021, all new buildings must be nearly zero-energy buildings (NZEB)
- Smart technologies, such as temperature regulation devices, are promoted

System Value impacts

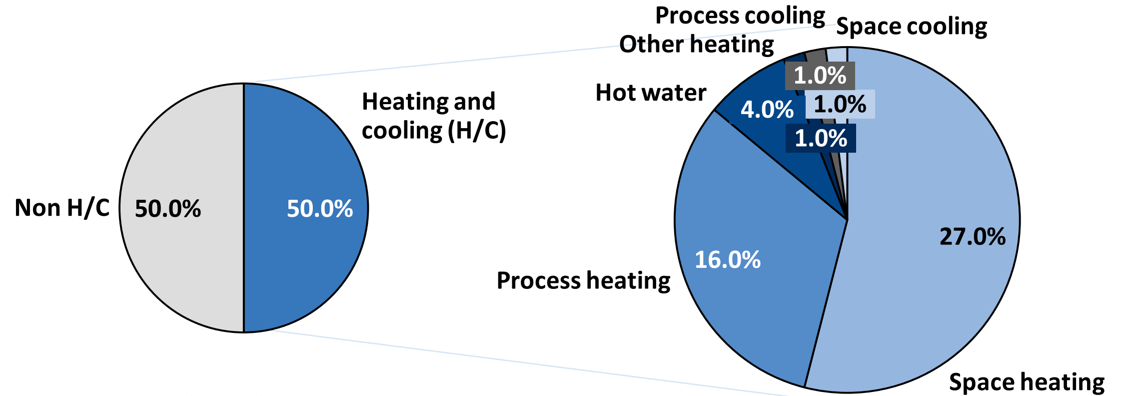
↓ **137 Mt**

9% reduction in 2030 building emissions if EU replaces 20% of natural gas space heating with renewable electricity (20% of 2015 baseline)

↑ **€3.5bn**

Human health benefits in 2030 from decreased air pollution

Space heating and hot water comprise 32% of EU energy demand



Source: Heat Roadmap Europe (2015 data)

Notes: Analysis based on EU 27 + UK data; (1) Self-organising Thermal Operational Resource Management

Sources: European Commission (1, 2, 3); Eurostat; EuroActiv, Euroheat, District Energy Initiative, BIEE, BNEF, Heat Roadmap Europe, New Scientist, Citu, IRENA; Accenture analysis

Renewables and Power Markets of the Future

Solutions to transform European power markets[1]	
Connected and harmonized balancing markets	• Implement various balancing and reserve market products through the European Network of Transmission System Operators for Electricity (ENTSO-E).
DER participation in balancing markets and T&D coordination	• Current European balancing markets do not sufficiently facilitate DERs and demand response participation in the transmission and distribution balancing markets. • Examples: Services to turn up demand versus curtail (e.g. repumping water, demand turn-up service); linking of T-D control rooms.
Market mechanisms to address negative pricing	• Sustained negative prices disincentivize renewables investment. • Products that work against negative pricing should be introduced, e.g. “demand turn-up” in the UK, ToU pricing to encourage EV charging and increased demand response participation. • Market structure that supports “revenue stacking” for batteries.
PPA contracting: sleeving and trading	• European markets need policies that support PPA sleeving (and virtual PPAs) to make it easy for renewable energy (RE) projects and buyers to develop renewables in the best areas and meet buyers’ needs. • Additional need for structured PPAs that can be traded on exchanges to benefit smaller I&C customers.

Sources: *Utility Dive*; *Euractiv*; *Andritz*; *Accenture analysis*

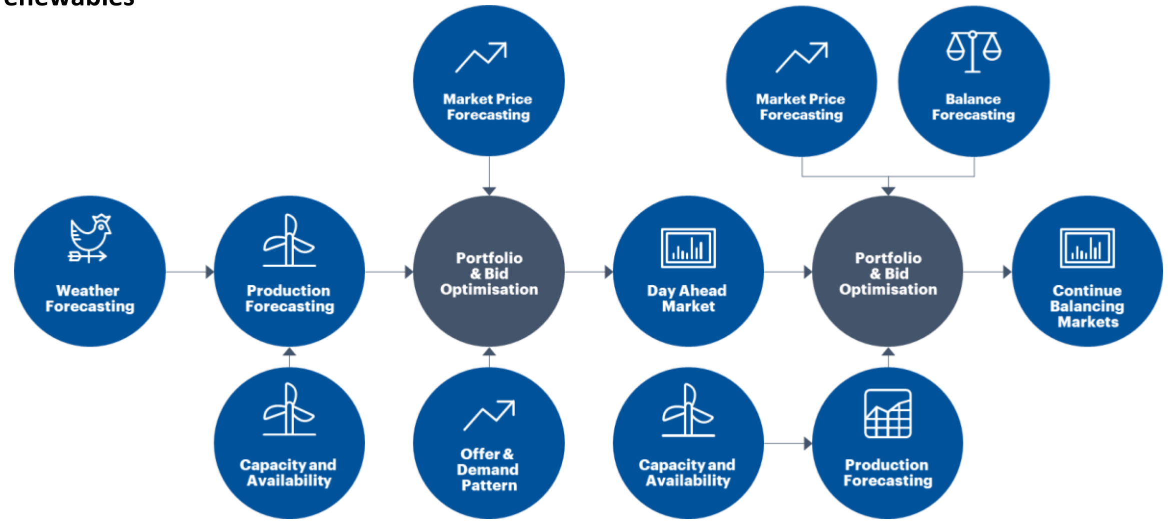
Overview

Renewables are becoming more dispatchable, controllable and forecastable, with renewable operators combining wind, solar, hydropower and storage (virtually or physically) to deliver committed production. Operators have improved the accuracy of production forecasting, can respond in real-time, and can install turbines and inverters with the power electronics that allow them to provide ancillary services.

Renewables of the future

- Batteries: Tesla’s 100 MW battery in Australia has 30 MW capacity to trade on wholesale market and 70 MW to stabilize the grid. In the first five months after it was connected, it took a 55% share of the state’s frequency and ancillary services market (2% capacity, 55% revenues), lowered prices by 90% and provided savings to consumers estimated at $35 million. Speed and versatility of the battery allows it to provide so many more bids than competitors – both charging and discharging
- Hybrid plants: 17 MW floating solar in France reduced conflicts over land, and local citizens were invited to take a stake in funding the project. It powers 4,733 local homes.
- Complementary hydropower: Hongrin-Leman is a 480 MW pumped storage power plant in Switzerland that was upgraded in 2011-2016, capable of providing stabilization services to the Swiss and European grids.

Commercial optimization of renewables



Improved forecasting

Real-time OT data

Analytics

Power electronics (turbines and inverters) capable of providing grid services

Source: *Accenture*

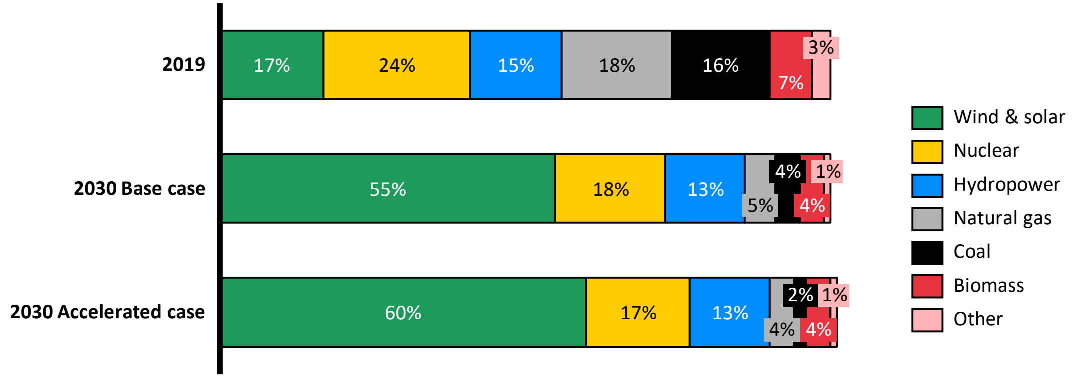
Networks of the Future

Europe will need to transform its network and power markets to support a grid with majority variable resources by 2030

Solutions to transform European networks[1]

Digital system operations R&D	• Increase incentives for digital technologies, including start-ups, that support capabilities to manage variable and distributed resources. • Examples: Real-time inertia measurement; wind, solar, demand forecasting; real-time auctions for ancillary services and platforms.
Investment support for interconnections and joint market operations	• Connecting markets to larger balancing and reserve area will reduce congestion, variability and individual reserve capacity requirements. • Investment support to increase interconnection among European markets is key to transforming to a more variable system (e.g. Ireland developing stronger network grid integration with UK).
Network planning, development and operation	• Investment planning approaches that consider congestion and network constraints. • Require wind and solar to be able to provide frequency response and other ancillary services. • TSO and DSO congestion and constraints markets.
Clarification of system operator roles and move to TOTEX returns	• Add clarity to roles across operators and provide adequate remuneration for additional activities, such as flexibility procurement. • Accelerate the switch from a cost-plus Regulatory Asset Base system to Total Expenses (TOTEX) based returns.

Europe set to increase variable renewable share from 17% in 2019 to 55%-60% in 2030



In 2030 accelerated case:

- Wind and solar generation share grows from 55% to 60% due to network and power market advancements
- Wind capacity increases by 46 GW by 2030, solar capacity increases by 38 GW
- Additional wind and solar generation decrease share of coal, gas and nuclear[2]

Source: Baseline generation and capacity mix based on BNEF forecasts

System Value impacts of raising variable renewable to 60% share from 55% in 2030

Benefits

⬇ **117 Mt**
50% reduction in 2030 base case electricity emissions

⬆ **>1m**
Incremental job impact through 2030 to enable additional solar and wind capacity investment

⬆ **€43.3bn**
Human health benefits in 2030 from decreased air pollution

Costs

€152bn
Projected capital expenditure in electricity transmission in EU28 between 2021-2030, based on Ecofys 2018 report

Notes: Analysis based on EU 27 + UK data; (1) See appendix for additional detail on eight solutions, (2) France planning to lower its share of nuclear from three-quarters to one-half by 2035 (Bellona)
Source: IRENA, Ecofys/European Commission

Building a hydrogen economy in Europe

Why does Europe need hydrogen?

- Hydrogen has significant potential to enable the transition to a climate-neutral economy, particularly where electrification is difficult or less cost-efficient.
- Hydrogen is the most promising technology capable of addressing decarbonization in hard-to-abate sectors of the economy. It can be used in the follow applications:
  - *Power*: Hydrogen provides a long-term, large-scale storage solution to support integration of intermittent renewable energy generation and can replace natural gas for power generation or heat.
  - *Industry*: Hydrogen can be used as a feedstock for high-pressure, high-heat industries which are difficult to electrify.
  - *Mobility*: Hydrogen has the potential to be used to derive fuels for long-haul land and maritime shipping as well as aviation.

The role of industrial clusters

- Industrial clusters, comprised of industries like cement, steel and chemicals, are heavy users of fossil fuels and account for about 20%[1] of Europe's GHG emissions (excluding transport). This figure could rise to 60%[1] of Europe's total GHG emissions as other industries abate their emissions.
- Industrial clusters hold promise, as they create an internal market for hydrogen, where production and consumption are co-located. Therefore, the market can develop without investment in long-distance infrastructure.

Europe's hydrogen strategy

- The EU's priority is green hydrogen, being the most compatible with the bloc's climate neutrality targets in the longer term.
- Transitioning from grey to low-carbon blue hydrogen is key to rapidly reducing emissions from existing hydrogen production and creating the infrastructure to support the uptake of green hydrogen.
- Lowering hydrogen prices through scaled-up production is critical to ensure uptake. The EU aims to bring the price down to €1-2/kg[2] as quickly as possible, with current initiatives focused on launching facilities mainly dedicated to green hydrogen production that are integrated with solar or wind.
- Hydrogen Roadmap for EU forecasts 24% share of final energy demand will be met by hydrogen by 2050, with €820 billion annual revenue from hydrogen and equipment sales.[4]

Key EU goals towards a hydrogen economy in Europe[1]

- Reduce EU carbon emissions in a cost-effective way
- Build a hydrogen economy in Europe, based on a whole value chain approach
- Enable competitive price levels for hydrogen by producing integrated hydrogen facilities at a gigawatt scale
- Design an open and competitive hydrogen market that ensures unrestricted cross-border trade and access for market players
- Cooperate with neighbouring markets to exploit synergies and replace fossil fuel imports with hydrogen imports

Simultaneous value chain collaboration for a successful green hydrogen system

Green electricity	Hydrogen electrolyser	Infrastructure	Market
Renewable energy produced via wind/solar	Large-scale electrolysers producing green hydrogen	Adaption of gas network to transport hydrogen	Readily available market for hydrogen as a low-carbon fuel

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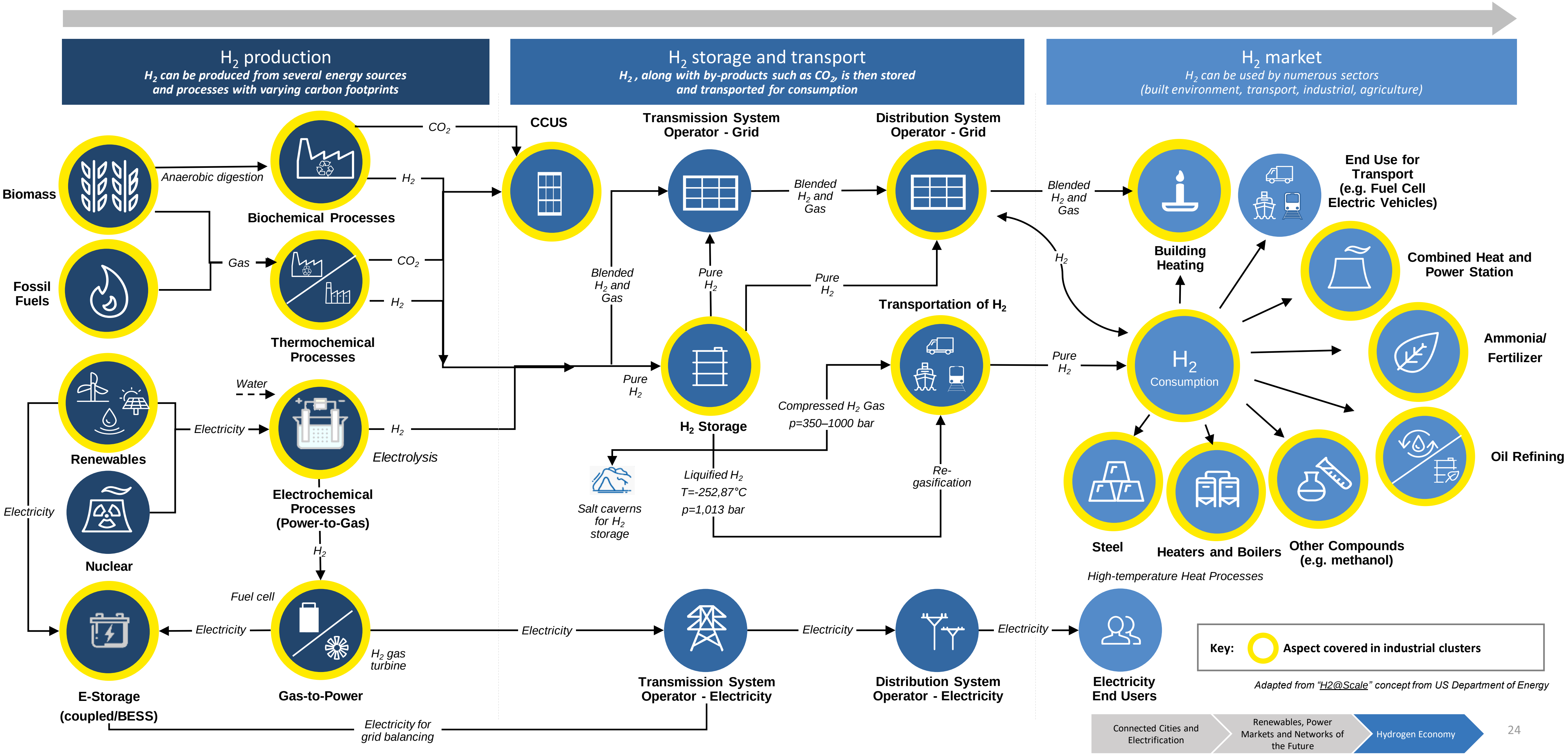
(1) Element Energy; (2) European Commission; (4) Hydrogen Roadmap Europe
Additional Sources: Europa

The hydrogen value chain

Industrial clusters create an internal market for hydrogen incorporating most of the hydrogen value chain



H_2 production

H_2 can be produced from several energy sources and processes with varying carbon footprints

H_2 storage and transport

H_2, along with by-products such as CO_2, is then stored and transported for consumption

H_2 market

H_2 can be used by numerous sectors (built environment, transport, industrial, agriculture)

Biomass

Anaerobic digestion

Biochemical Processes

CO_2

H_2

Fossil Fuels

Gas

Thermochemical Processes

CO_2

H_2

Renewables

Nuclear

Water

Electricity

Electrochemical Processes (Power-to-Gas)

Electrolysis

H_2

Electricity

Fuel cell

Electricity

E-Storage (coupled/BESS)

Gas-to-Power

H_2 gas turbine

Electricity

CCUS

Transmission System Operator - Grid

Blended H_2 and Gas

Distribution System Operator - Grid

Blended H_2 and Gas

Pure H_2

Pure H_2

Pure H_2

H_2 Storage

Transportation of H_2

Compressed H_2 Gas

p=350–1000 bar

Salt caverns for H_2 storage

Liquified H_2

T=-252,87°C

p=1,013 bar

Re-gasification

Transmission System Operator - Electricity

Electricity

Distribution System Operator - Electricity

Electricity

Electricity for grid balancing

Blended H_2 and Gas

H_2

Pure H_2

Building Heating

End Use for Transport (e.g. Fuel Cell Electric Vehicles)

Combined Heat and Power Station

Ammonia/ Fertilizer

Oil Refining

H_2 Consumption

Steel

Heaters and Boilers

Other Compounds (e.g. methanol)

High-temperature Heat Processes

Electricity End Users

Key: ○ **Aspect covered in industrial clusters**

Adapted from "H2@Scale" concept from US Department of Energy

Case study: Carbon-neutral Humber

Industrial cluster example – Humber

- Humber industrial cluster in Yorkshire is the UK's largest cluster by industrial emissions, emitting 12.4 Mt CO_2 /year.[1]
- The decarbonization of Humber will be underpinned by the deployment of CCUS to enable decarbonization of power and industry.
- Industrial sites and power stations in the industrial cluster are able to decarbonize by using blue/green hydrogen as a replacement for fossil fuels.

A carbon-neutral industrial cluster proposes new, CO_2-lean technologies. This analysis evaluates the benefits of the following stages of the Humber project:

1. Developing a carbon-capture usage and storage network

- Develop and install pre- and post-combustion CCUS capabilities to abate CO_2 from industry and power stations throughout the industrial cluster
- Expand the CO_2 transport network and develop a CO_2 storage infrastructure

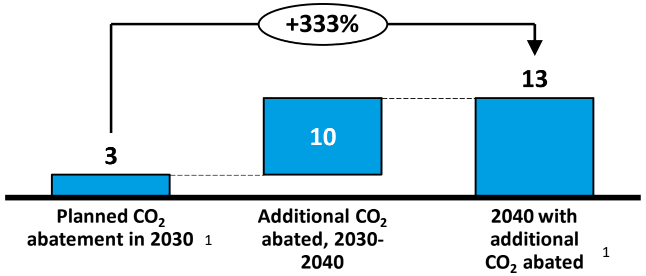
2. Producing low-carbon blue hydrogen and creating a hydrogen infrastructure

- Develop and install hydrogen demonstrator producing blue hydrogen through autothermal reforming (ATR) with CCUS
- Prioritize hydrogen use for harder to electrify industrial processes (e.g. high pressure, high temperature), heavy goods, marine transport and grid flexibility

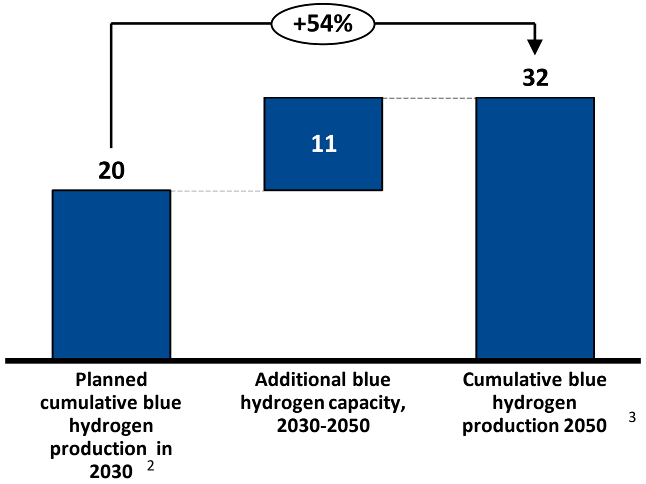
3. In the longer term, producing green hydrogen by offshore wind electrolysis

- Electrolysis from offshore wind and utility-scale solar, depending on location and access
- Efficiency and demand optimization opportunities to improve system efficiency of the cluster and to enable industrial plant participation in balancing/flexibility markets

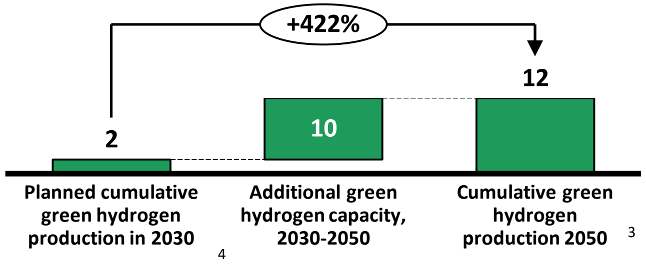
CO_2 abatement potential per annum (million tons)



ATR blue hydrogen cumulative production potential (TWh)



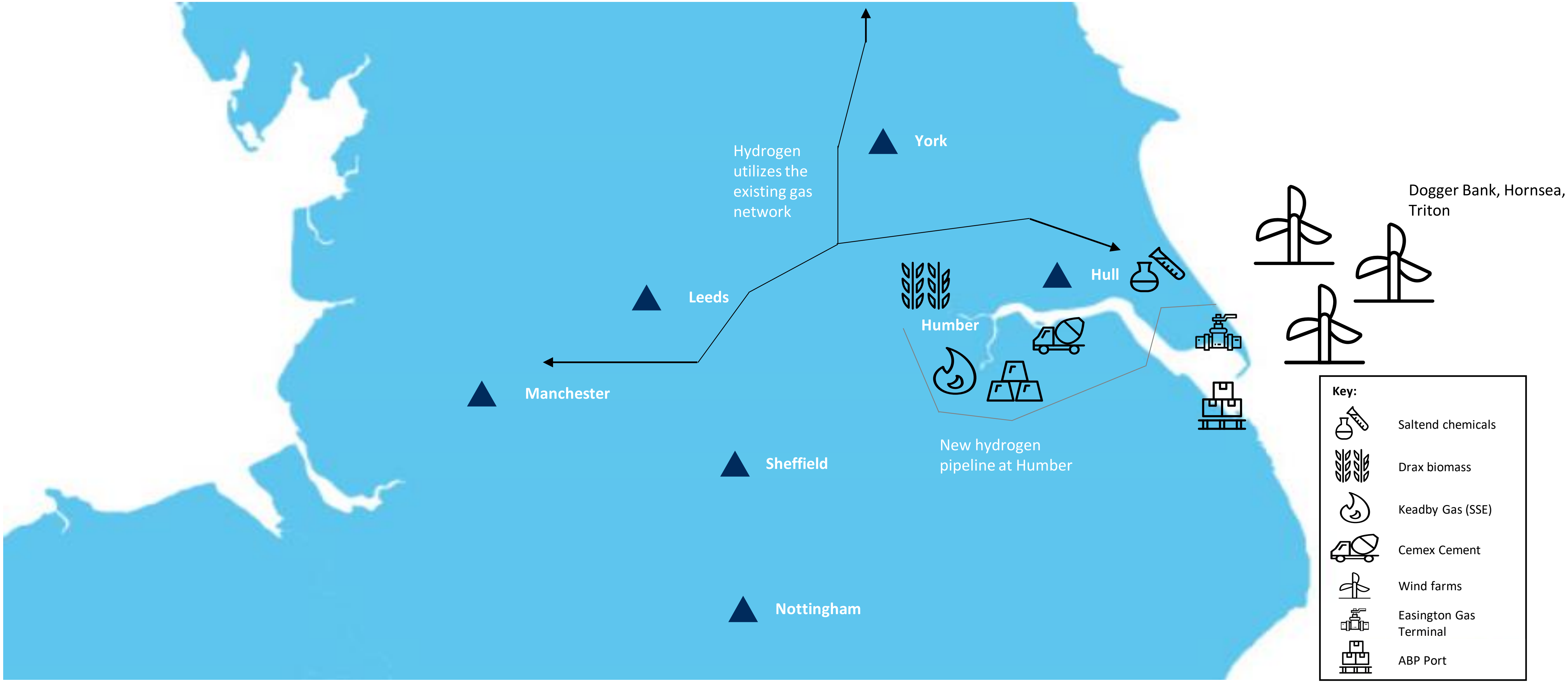
Green hydrogen cumulative production potential (TWh)



(1) Element Energy; (2) Element Energy; (3) Stakeholder interviews; (4) Siemens
Additional Sources: FCH Clean Hydrogen Alliance, Europa Hydrogen Energy Network
Footnote: 53 Mt CO2 captured in 2050 for Humber and the surrounding Yorkshire area

Case study: North of England ecosystem

Humber is connected to the Northern Gas Networks and is in close proximity to planned offshore wind projects



Hydrogen utilizes the existing gas network

New hydrogen pipeline at Humber

Dogger Bank, Hornsea, Triton

Key:

- Saltend chemicals
- Drax biomass
- Keadby Gas (SSE)
- Cemex Cement
- Wind farms
- Easington Gas Terminal
- ABP Port

Sources: Humber Roadmap

European carbon-neutral industrial clusters

Scaling up to Europe

Europe is home to 3,000 industrial clusters, which often are located by ports and represent 54 million jobs.[1] Implementing hydrogen, combined with cost-effective electrification opportunities, can chart a climate-neutral future for Europe's industrial clusters. Humber is one of many ongoing projects to decarbonize clusters across Europe, and is used in this analysis as a basis to scale up decarbonization benefits for carbon capture and job creation.

Blue hydrogen, produced through the process of steam methane reforming or autothermal reforming with carbon capture and storage (CCUS) can be used for hard-to-abate industries. Blue hydrogen infrastructure could then be used for green hydrogen production and transport. Overall, hydrogen could replace up to 35%[2] of gas and 36%[3] of coal production. For this analysis, carbon abatement potential was calculated using emissions from natural gas and coal consumption in industrial processes in Europe in 2017-2018.[4]

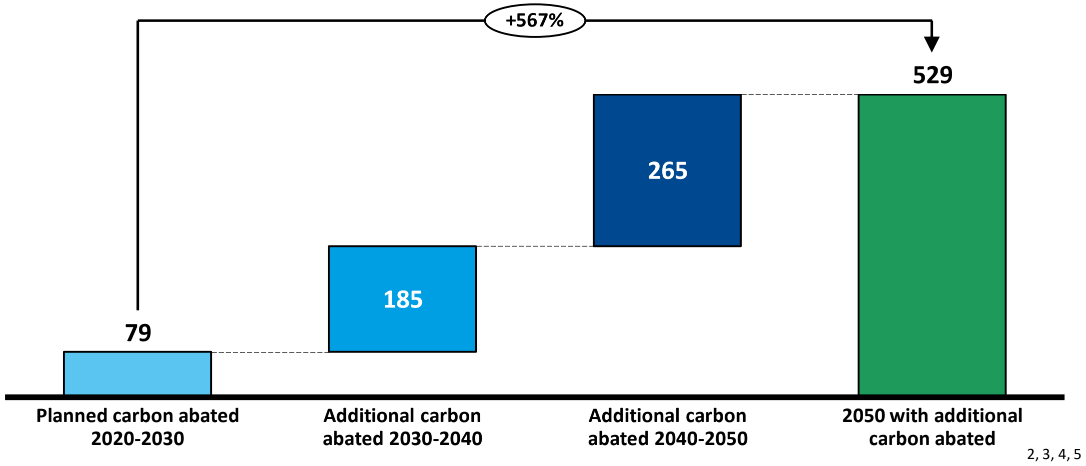
Outputs for blue hydrogen job creation were scaled using industry estimations[5] that 100 operations and 500 maintenance jobs are created for each million tons of CO_2 captured. For green hydrogen, 2030 forecasts[6] for 140,000-170,000 jobs in manufacturing and maintenance were extrapolated out to 2050 based on estimated electrolyser capacity need.

Tactics for creating a carbon-neutral industrial cluster

- Electrify light industrial demand, for example via rooftop solar, utility-scale solar or onshore wind
- Pursue efficiency and demand optimization opportunities to improve cluster system efficiency and for industrial plants to participate in balancing/flexibility markets
- Develop and install pre- and post-combustion CCUS capabilities to capture CO_2 from industry and power stations throughout the industrial cluster
- Develop CO_2 transport and storage infrastructure
- Develop a blue hydrogen plant with hydrogen infrastructure
- Conduct electrolysis from offshore wind and utility scale solar to produce green hydrogen, which can be integrated into hydrogen infrastructure

Europe 2050 projected carbon abatement potential

Carbon abatement potential per annum (million tons)



System Value impacts for industrial clusters

Benefits

529 Mt

529 Mt of CO_2 emissions reduction in 2050

387k-912k

Estimated jobs created in blue and green hydrogen through 2050

Costs

€16bn-31bn

Investment in new infrastructure per year up to 2050[7]

Sources: Accenture analysis, European Commission

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(1) Europa Industry Policy; (2) EEA; (3) EIA; (4) Accenture analysis, Stakeholder interviews; (5) Stakeholder interviews; (6) Hydrogen Europe; (7) Industrial Transformation 2050;
Additional Sources: Europa Clean Hydrogen Alliance, Europa Hydrogen Energy Network, EU Commission
Note: Jobs focused on hydrogen specifically and exclude 54 million current industrial clusters jobs in Europe

Green hydrogen system in Europe

Wind and solar capacity growth and importing hydrogen to Europe can enable the transition to a green hydrogen system
As a start, between 2020 and 2024, Europe aims to install at least 6 GW of renewable hydrogen electrolyzers.

Wind

Offshore wind generates electricity that can be converted to hydrogen via the electrolysis of seawater and transported via existing gas pipelines.

Examples of such projects include:

- Shell, Gasunie and Groningen Seaports have teamed up for a renewable hydrogen project to achieve annual production of 800,000 tons of green hydrogen by 2040 with power from up to 10 GW[1] of offshore wind.
- Orsted is planning a 5 GW[2] offshore wind hub connecting Denmark, Poland, Sweden and Germany, with large-scale production of green hydrogen.

Solar

Hydrogen can also be produced from solar electricity via water electrolysis or direct solar water splitting. Restrictions may also be eased for onshore wind, allowing co-siting with solar, providing further green energy for hydrogen production.

Examples of independent solar projects include:

- Iberdrola plans to connect a 100 MW/20 MWh solar and storage plant to hydrogen production in Spain.[3]
- ENGIE signed a deal with the Luberon, Durance, Verdon urban area (DLVA) and Air Liquide to develop the HyGreen Provence project, combining the production of 1,300 GWh of solar electricity in the south of France with the production of renewable hydrogen on an industrial scale.[4]

European industrial sector hydrogen opportunity

Currently, the European industrial sector consumes ~82.6 Mtoe[6] natural gas and ~78.6 Mtoe[7] coal annually, contributing approximately 529[8] million tons of CO_2 emissions. Decarbonization of the industrial sector by 2050 could be achieved through a combination of blue and green hydrogen, where annual natural gas and coal consumption is equivalent to 56 Mt[9] of hydrogen.

For example, if 80% of industrial energy needs were met by green hydrogen by 2050, approximately 45 Mt of hydrogen would be required, produced via a ~45 kWh electricity per kg hydrogen PEM electrolyser efficiency.[10] Assuming a 70:30 split across offshore wind (at 68%[11] capacity factor) and solar (at 35%[12] capacity factor), respectively, 235 GW wind and 196 GW solar installed capacity would be needed to meet this production need.

Importing hydrogen[5]

Due to its limited size and population density, the EU may not be able to produce all needed renewable energy in its territory. The EU has an opportunity to incentivize its neighbouring regions and countries (e.g. North Africa and Ukraine) to develop a 40 GW market to export back to the EU.

Countries in North Africa have huge potential in terms of land and resources to produce green hydrogen from wind and solar for export. Hydrogen can be imported from North Africa by pipeline, which is more cost-effective than import by ship, and could realize a sustainable energy system in Europe.

32.5 GW of the 40 GW electrolyser capacity will be installed for large-scale hydrogen production and fed into a hydrogen pipeline for export. Around 3 million tons (~ 118 TWh) could be available for hydrogen export to the EU in 2030, resulting in annual CO_2 emissions reduction of around 45 million tons.

Note: It is also important to consider related water requirements for hydrogen production, a significant impact to water-scarce nations in North Africa.

Sources: (1) Europa Green Hydrogen Project, (2) Recharge News, (3) PV Magazine, (4) Solar Power Europe, (5) Hydrogen Europe, (6) EEA 2017 figure (Mtoe = million tonnes of oil equivalent), (7) EU Commission 2018 figure, EIA (8) EIA, Accenture Analysis, (9) RMI, Accenture Analysis , (10) Stakeholder interviews, (11) Energy Central, (12) Energy Numbers

Contents

System Value of clean energy transition

System Value benefits are seen across all European recovery solutions

⬢ System Value dimension with quantitative analysis

⬡ System Value dimension with qualitative analysis

⬡ Priority System Value dimension

Economic, environmental, societal and energy value

		CO$_2$ Emissions CO$_2$ emissions based on energy source, generation mix and load changes	**Water Footprint** Water footprint based on energy source, generation mix and load changes	**Access to Electricity** Physical and economic access to clean electricity to support individual or society development	**Jobs and Economic Impact** Influx of jobs due to energy transition and renewables	**Air Quality and Health** Impacts to human health and natural environment from air and water pollutants, land use	**Resiliency and Security** Uninterrupted and diversified energy supply at affordable prices and the ability to bounce back from disruptions	**Energy Productivity and Systemic Efficiency** Energy efficiency plus systemic efficiency to maximize energy productivity	**Foreign Direct Investment** Market attractiveness for FDI with reliable energy and skilled resources	**Reliability and Service Quality** Life cycle approach to ensuring high system availability; improved customer service	**Flexibility** Ability to manage generation, demand and power flows (incl. power quality) across the grid, enabled by digitalization and storage	**System Upgrade** Technology (incl. digital) and capital investments in T&D to upgrade the system for variable renewables and DERs	**Cost and Investment Competitiveness** Market attractiveness and policy certainty for investment incl. R&D and levelized cost of energy
Connected Cities and Electrification	**Efficiency and Demand Optimization**	**50 Mt** 21% of projected electricity base case 2030 footprint	**87bn litres** Reduction in 2030 water footprint		**489k** Total incremental jobs created through 2030	**€20.6bn** Human health benefits in 2030 from decreased air pollution	◐	●		●	◐	●	Significant drop in price of Li-ion battery storage to **>€200/kWh** in 2019
	Electrification of Transport	**76 Mt** 10% drop in 2030 road transport emissions compared to 2018			**192k** Total incremental jobs created in 2030	**€12.6bn** Human health benefits in 2030 from decreased air pollution	◐	●		◐	◐	◐	EV vs ICE **cost parity** expected in **mid 2020s** Public infr. investment expected to drop **below €400** per EV by 2030
	Decarbonizing Heating and Cooling Systems	**137 Mt** Reduction in 2030 building emissions from gas space heating				**€3.5bn** Human health benefits in 2030 from decreased air pollution	◐	●		◐	◐	◐	
	Renewables, Power Markets and Networks of the Future	**117 Mt** Reduction in 2030 emissions (50% in base case elec. emissions)	**205bn litres** Reduction in 2030 water footprint		**>1m** Total incremental jobs created through 2030	**€43.3bn** Human health benefits in 2030 from decreased air pollution	●	●		●	●	●	
Hydrogen Economy	**Decarbonization of Industrial Clusters**	**529 Mt** Reduction from bringing industrial emissions to zero by 2050			**387k-912k** Total incremental jobs created through 2050		●	◐		○	◐	◐	
	Green Hydrogen						●	◐		●	●	◐	

🟦 *Analysis performed for given System Value dimension and recovery solution. For more detail, please see specific solution and/or relevant System Value dimension slide(s).*

⬜ *System Value dimension not as relevant to geographic market or not considered with given recovery solution.*

Relative System Value dimension benefit for given recovery solution within market

● High benefit ◐ Medium benefit ○ Minimal-to-no benefit

Sources: Transport & Environment, BNEF, CIBSE, Accenture analysis

System Value dimension: CO_2 emissions

Generation differential from coal and natural gas was examined to calculate CO_2 drop across solutions, with combined effect of efficiency and demand optimization and network and power markets lowering electricity sector 2030 base case CO_2 emissions by 71%.

CO_2 emission impact by solution in 2030

Efficiency and Demand Optimization	↓ **50 Mt** 21% of projected electricity base case 2030 footprint
Electrification of Transport	↓ **76 Mt** 10% decrease in 2030 road transport emissions compared to 2018, where the EU 2030 target is ~15% reduction
Decarbonizing Heating and Cooling Systems	↓ **137 Mt** decrease in building emissions if EU replaces 20% of natural gas space heating with renewable electricity (20% compared to 2015 baseline)
Renewables, Power Markets and Networks of the Future	↓ **117 Mt** 50% of projected electricity base case 2030 footprint in accelerated case (60% variable renewable share vs 55% in base case)

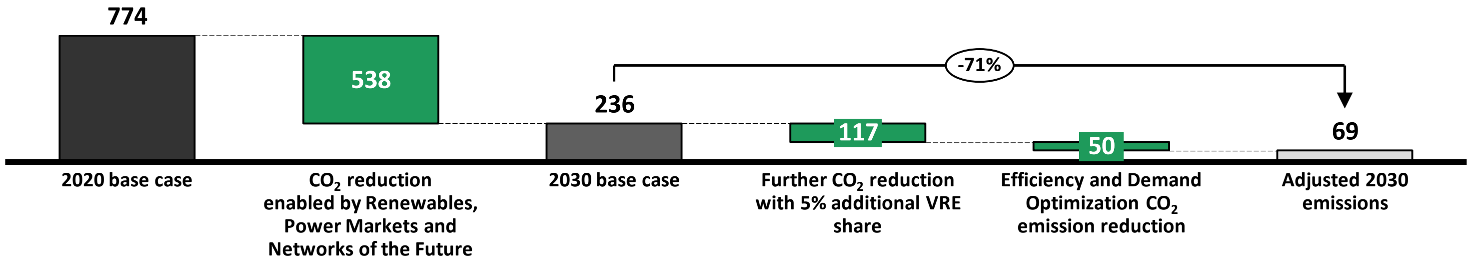
CO_2 Emission impact by solution in 2050

Decarbonization of Industrial Clusters and Green Hydrogen	↓ **529 Mt** 100% of coal and natural gas related industrial sector CO_2 emissions in 2050

CO_2 emissions reductions from electricity sector (coal and natural gas)[1]

Renewables, Power Markets and Networks of the Future/Efficiency and Demand Optimization

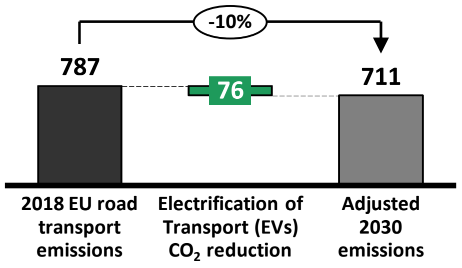
CO_2 emission reduction (Mt)



CO_2 emissions reductions from transport and industrial sectors

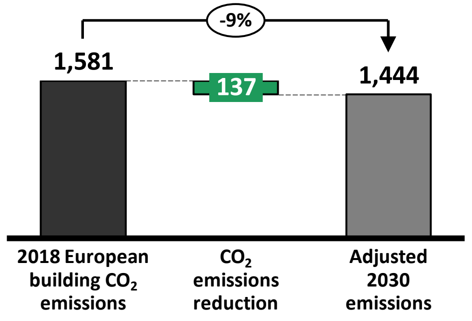
Electrification of Transport

CO_2 emission reduction (Mt)



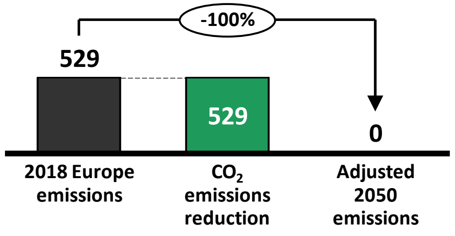
Decarbonizing Heating and Cooling Systems

CO_2 emission reduction (Mt)



Europe industrial sector

CO_2 emission reduction (Mt)



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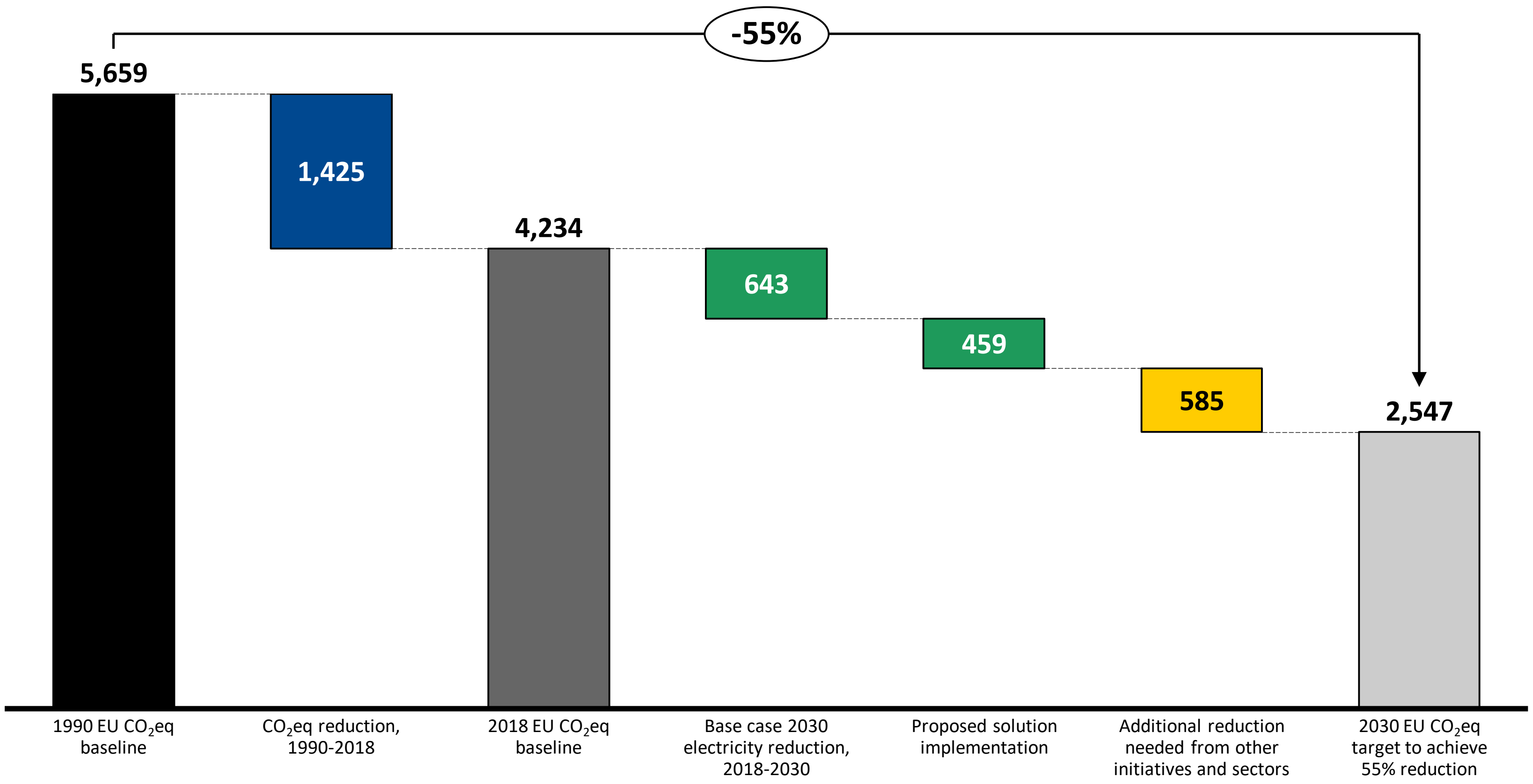
[1] *Emissions from electricity generation sources outside coal and natural gas were not evaluated; transport emissions were considered for the EVs for Connected Cities recovery solution*

System Value dimension: CO_2 emissions

In September 2020, the European Commission proposed raising its 2030 GHG reduction target from 40% to at least 55% compared to the 1990 baseline, with solution areas and base case electricity projections estimated to achieve 65% of needed additional reductions.

- From 1990 to 2018, the EU achieved a 25% reduction in GHG emissions (1,425 Mt CO_2eq)
- **By 2030, the EU will need to lower its footprint by an additional 30% from the 1990 baseline, equivalent to 1,687 Mt CO_2eq**
- The electricity sector is projected to lower emissions by an estimated 643 Mt in 2030, 38% of the remaining 2018 gap
- **Implementing the proposed three solutions in this analysis by 2030 could see an estimated additional 459 Mt reduction, 27% of the 2018 gap**
- This would leave an additional 585 Mt of needed reductions from other initiatives such as agriculture, aviation, marine, heavy goods vehicles and offsets

EU pathway to achieve 55% GHG emissions reduction target by 2030 (Mt CO_2eq)

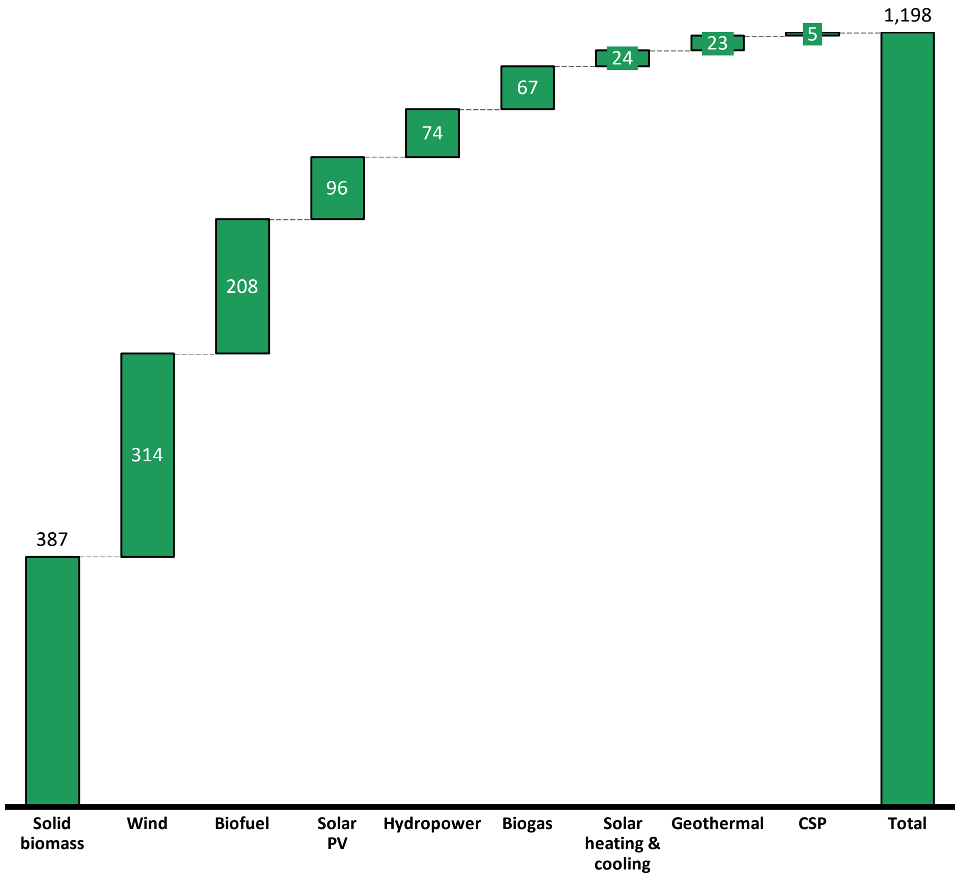


Note: Greenhouse gas (GHG) emissions refer to CO_2 equivalent emissions (CO2eq)
Sources: European Commission, European Environmental Agency

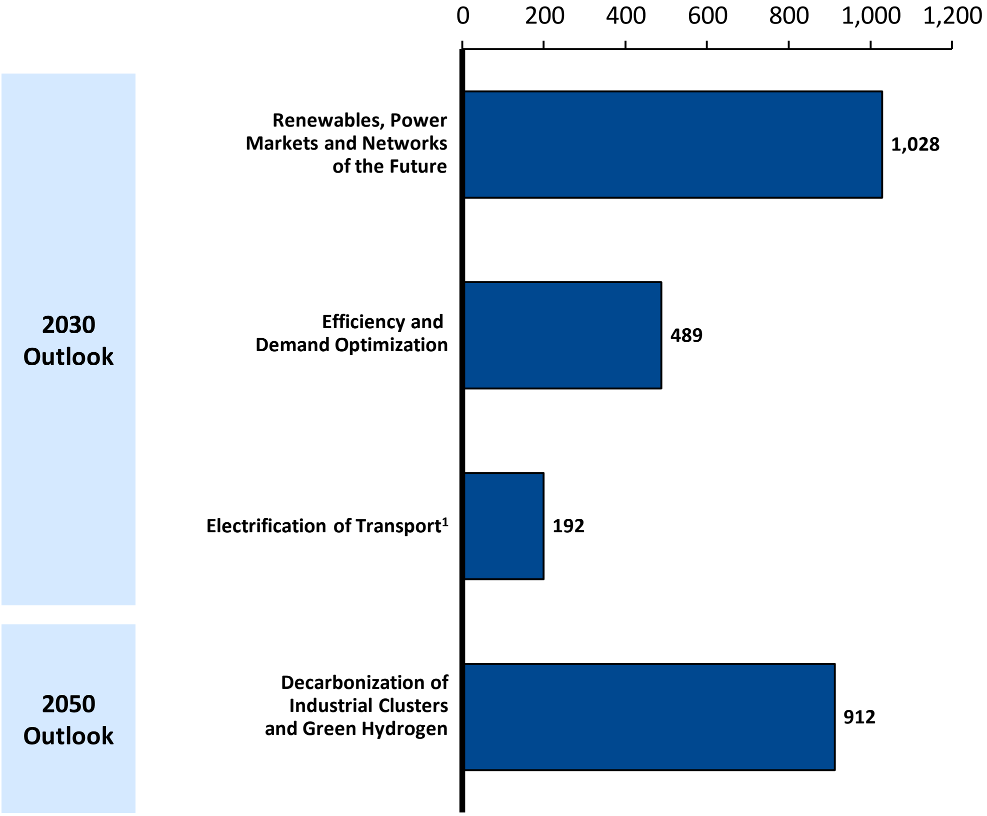
System Value dimension: Jobs and economic impact

Europe has a significant clean energy workforce that stands to grow significantly over the next decade as Europe heads towards an electric grid with majority wind and solar generation.

IRENA estimates the EU to have 1.2 million direct and indirect jobs from renewable energy and fuels as of 2018



Estimated job impact (in 000s)



Note: (1) Permanent jobs created by the year 2030
Sources: IRENA, EESI, AIE, Accenture analysis

System Value dimension: Air quality and health

Lower air pollutants across recovery solutions to result in nearly €80 billion in estimated human health benefits in 2030.

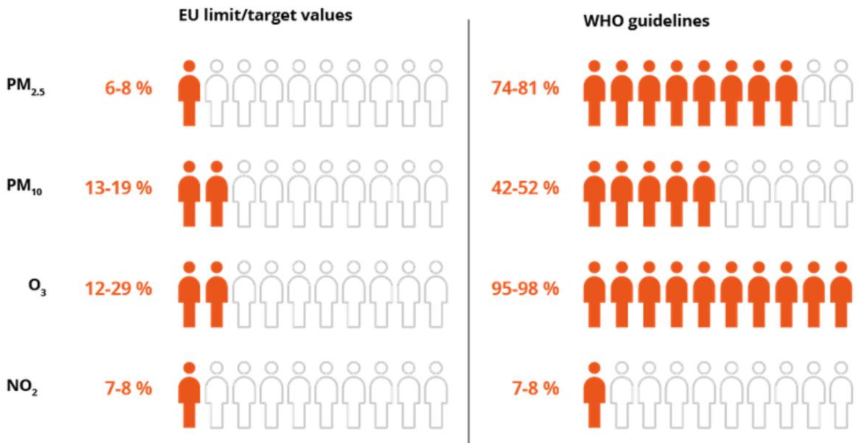
Europe overview

- The European Environmental Agency (EEA) has designated air pollution to be the “single largest environmental health risk in Europe”.
- In 2016, nearly 500,000 premature deaths in Europe were attributed to PM2.5 (83%), NO_2 (14%) and O_3 (3%) emissions.
- European cities saw a temporary decrease in PM2.5 emissions during April-May lockdowns (London 9%, Madrid 11%).

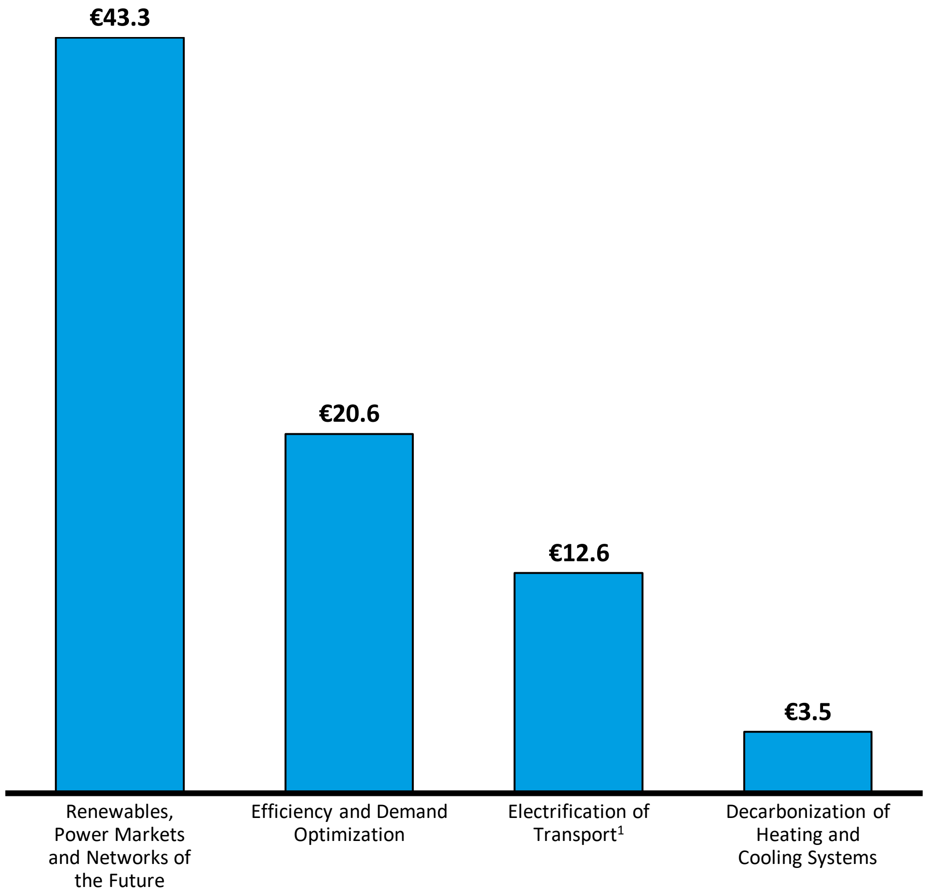
Analysis of recovery solutions

- The cost of air pollution was estimated based on EEA average value of statistical life (VSL) figures across NO_2 , SO_2, PM2.5 and PM10.

Share of EU urban population exposed to air pollutants above EU and WHO target limits (2015-2017)



Human health benefits by recovery solution in 2030 (€B)[1]



Notes: (1) SO_2 values not considered for the Electrification of Transport recovery solution

Sources: European Environmental Agency, Bloomberg; EEA

System Value dimension: Energy productivity and systemic efficiency

Efficiency improvements to increase energy productivity and optimize the energy system across the value chain can be achieved through identified recovery solutions.

Energy productivity and systemic efficiency benefits by recovery solution		
Efficiency and Demand Optimization	●	• Improvements in energy productivity can be achieved across sectors through smart appliances, greater building efficiency and energy conservation, achieving the same work or economic output for less consumption. • Demand optimization can improve systemic efficiency by better aligning supply and demand to ensure cost-effective, green generation and minimized curtailment.
Electrification of Transport	●	• Electric vehicles are more energy efficient than their fossil fuel counterparts, converting over 77% of the electrical energy to power at the wheel, whereas gasoline vehicles only convert 12%-30% of the energy stored in gasoline.
Decarbonizing Heating and Cooling Systems	●	• Power-to-heat systems can reduce or eliminate curtailment by taking excess electricity and storing it in thermal storage systems such as large electric boilers. • Heat pump systems can have three to five times the efficiency of a comparable fossil fuel system.
Renewables, Power Markets and Networks of the Future	●	• Greater European interconnection and transmission line build-out can improve systemic efficiency by reducing congestion and curtailment. • Facilitating DERs and demand response participation in the transmission and distribution balancing markets can ensure efficient system operation.
Decarbonization of Industrial Clusters	◑	• While hydrogen is the best decarbonization solution for many hard-to-electrify industrial applications, energy and cost-efficient electrification opportunities (e.g. industrial heat pumps) can be deployed where appropriate for select industrial processes.
Green Hydrogen	◑	• For transport, a fuel cell coupled with an electric motor is two to three times more efficient than an internal combustion engine running on gasoline. • Hydrogen has greater energy content per weight than natural gas, and its higher efficiency than LNG holds promise for industrial and non-road transport applications.

Sources: IRENA; US Department of Energy (1, 2); Energy & Environmental Science

Relative System Value dimension benefit for given recovery solution within market

● High benefit

◑ Medium benefit

○ Minimal-to-no benefit

System Value dimension: Flexibility

Recovery solutions create numerous flexibility benefits for European electric and energy systems, creating a more distributed and connected system.

Flexibility benefits by recovery solution		
Efficiency and Demand Optimization	◐	• The aggregation of DERs such as solar/storage systems into virtual power plants enables on-demand dispatch to aid greater grid flexibility. • Increasing the ambition and incentives of demand response programmes can give operators greater tools to balance variable demand.
Electrification of Transport	◐	• EVs can act as flexible loads and decentralized storage resources, with smart charging as an enabler for EVs to provide flexibility (supported by dynamic or ToU tariffs and other incentives). • EVs can enhance the integration of solar and wind generation by aligning EV charging with resource availability. • In development, V2G capabilities can be utilized in the future to use EV battery to serve as a flexibility resource.
Decarbonizing Heating and Cooling Systems	◐	• Aggregation of heat pumps and thermal storage systems can aid flexibility through coupled renewable energy and heating systems, smart load management.
Renewables, Power Markets and Networks of the Future	●	• Digital system operations can be instituted that allow DERs and renewables to participate in the Balancing Mechanism facilitating real-time signal integration and bidding automation. • Connecting markets into a larger balancing and reserve area will reduce congestion, variability and individual reserve capacity requirements.
Decarbonization of Industrial Clusters	◐	• Natural gas provides flexibility to the market, so removing this fuel will reduce flexibility. • However, hydrogen will provide valuable storage and industrial clusters can provide demand optimization capability and can continue to participate in flexibility markets.
Green Hydrogen	●	• Hydrogen is very suited to balance the electricity system as it can be stored and transported cheaply and easily. • Timing of hydrogen production can be set to match periods of excess renewable generation from sources such as offshore wind and utility-scale solar.

Relative system value dimension benefit for given recovery solution within market	● High benefit	◐ Medium benefit	○ Minimal-to-no benefit

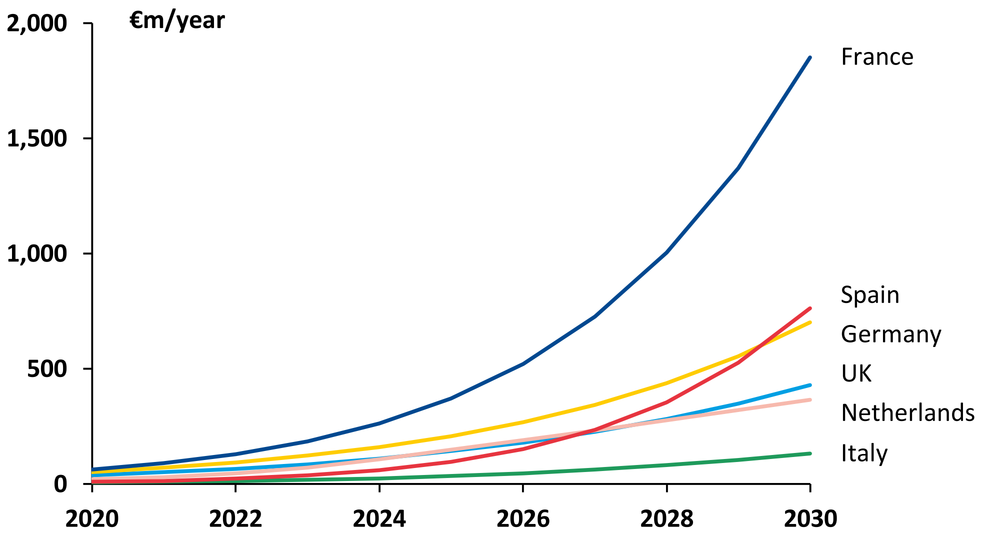
Smart flexibility: EV case study

With EV share of new car sales set to rise across Europe in coming years, there is a multi-billion dollar opportunity for utilities to actively use EV charging to enhance grid flexibility.

Emerging flexibility markets

- EVs can act as flexible loads and decentralized storage resources, presenting utilities with the opportunity to actively use EV charging to balance supply and demand. Focusing on creating a more flexible grid for e-mobility would enable better management of network congestion, reduce grid stabilization costs and optimize wholesale/retail portfolio spend.
- Accenture Research has demonstrated the value of total flexibility gains over €990 million in 2025, and €4.2 billion in 2030, across six target markets in Europe.

Projected value of smart charging in selected EU markets[1]



Source: Accenture Research 2020

Smart charging is an enabler for EVs to provide flexibility along with other assets, and can enhance the integration of solar and wind generation in the grid by aligning the EV charging profile with resource availability.

Smart charging for solar and wind profiles

Source: IRENA (2019)

Smartly charged EVs can help reduce variable renewable energy curtailment, improve local consumption of renewables production and reduce investment in peaking generation capacity.

Note: (1) Analysis assumes 80% consumer adoption of smart charging based on Accenture e-Mobility Research; Value assessment based in gains from price arbitrage (based on peak/off-peak/average wholesale price) and grid congestion management; 65% of total flexibility gains are attributed to the consumer and 35% to the utility
Sources: Accenture Research Utilities: Lead the Charge in eMobility; EU Commission; EU Federation for Transport and Environment; IRENA

System Value dimension: System upgrade

Digital and capital investments to upgrade the system for variable renewables and DER will support Europe in achieving a majority VRE energy mix by 2030.

System upgrade benefits by recovery solution		
Efficiency and Demand Optimization	●	• Investment in behind-the-meter storage and digitalization allows for more dispatchable renewable energy, while the installation of smart devices (e.g. smart meters) will enable improved system balancing and better management of grid congestion and constraints.
Electrification of Transport	◐	• Investment in grid upgrades to enable smart charging and other emerging technologies, such as V2G, allows for a seamless shift to VRE sourced power, aligning with resource availability as road transport transitions to EVs.
Decarbonizing Heating and Cooling Systems	◐	• Smart solutions, such as smart thermostats or smart heat pumps, can better manage and save energy alongside renewable heating technologies (biomass boilers, solar heating systems).
Renewables, Power Markets and Networks of the Future	●	• Increased incentives for digital technologies, including start-ups that build capabilities to manage variable and distributed resources, can support the transformation of European networks (e.g. improved accuracy of VRE production forecasting or real-time response, allow for greater DER participation in balancing markets). • Investment support to increase interconnection among European markets will be key to transforming to a more variable system, where larger balancing and reserve areas will reduce congestion, variability and individual reserve capacity requirements.
Decarbonization of Industrial Clusters	◐	• Hydrogen generation, storage and transport can reduce VRE curtailment and build a stronger case for further investment in renewables capacity additions.
Green Hydrogen	◐	• Hydrogen generation, storage and transport can reduce VRE curtailment and build a stronger case for further investment in renewables capacity additions.

Relative System Value dimension benefit for given recovery solution within market

● High benefit

◐ Medium benefit

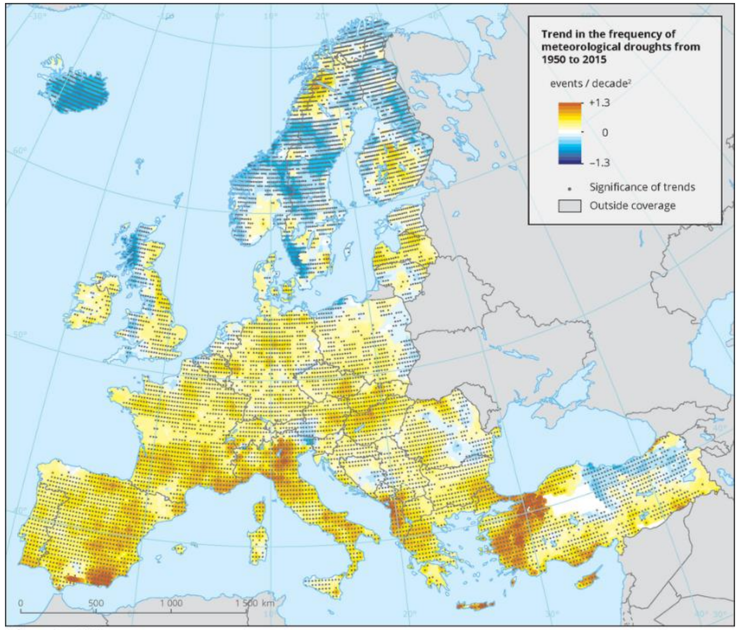
○ Minimal-to-no benefit

System Value dimension: Net water footprint

While Europe does not experience widespread water scarcity at present, fuel supply and electricity production should be evaluated in terms of risks of water shortage, particularly in southern Europe.

European water scarcity has increased in recent decades

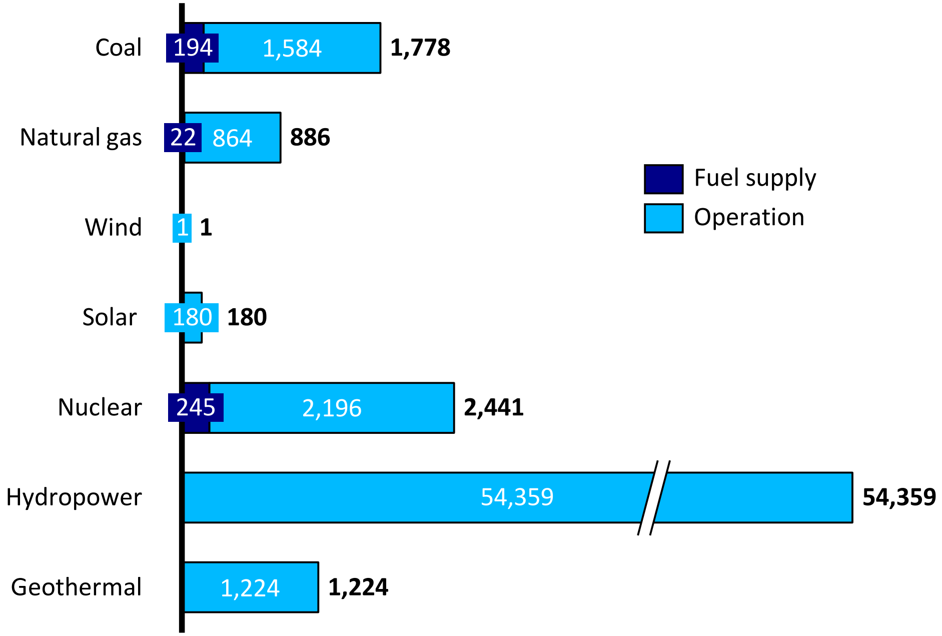
- Water scarcity and stress impacts 15%-25% of European territory, with more than half of southern Europe often living under conditions of water scarcity. Climate change is expected to increase the severity of this scarcity.
- According to the European Environment Agency, there was a 24% decrease in renewable water resources per capita across Europe between 1960 and 2010, with southern Europe particularly impacted.
- Droughts in Poland in 2015 and Germany in 2018 caused lower output from coal and nuclear power producers due to shortages in cooling water.



Reference data: ©ESRI

Shift to wind and solar will decrease pressure on water sources

Water footprint across generation sources (litres/MWh)



Cumulative water footprint impact by recovery solution

Efficiency and Demand Optimization	Network and Power Markets of the Future
⬇ **87bn litres** 0.1% of projected 2030 footprint	⬇ **205bn litres** 0.2% of projected 2030 footprint

Source: Royal Society of Chemistry; European Environment Agency (1 , 2); EnergyTransition.org; WWF; Accenture analysis
Note: Water footprint impact not evaluated for Electrification of Transport, Industrial Cluster, and Green Hydrogen recovery solutions

System Value dimension: Reliability and service quality

Ensuring grid reliability for a majority variable renewable system will be critical for Europe in the coming decade, with investments in batteries and hydrogen storage needed alongside the creation of next-generation network and power markets.

Reliability and service quality benefits by recovery solution		
Efficiency and Demand Optimization	●	• Proliferation of storage systems can flatten demand peaks to prevent blackouts and interruption events. • Customers can be incentivized to participate in balancing markets through user-friendly business models and favourable rates.
Electrification of Transport	◑	• Smart charging and associated pricing schemes can serve as dynamic load to assist grid reliability, while serving as a revenue stream for EV owners. • Roll-out of smart chargers with V2G/V2H/V2B capabilities will enable two-way electricity transfers, allowing for balancing services.
Decarbonizing Heating and Cooling Systems	◑	• Thermal storage systems can provide smart load balancing to reduce strain on the grid. • Reduced maintenance needs from heat pump systems compared to conventional fossil fuel heating system.
Renewables, Power Markets and Networks of the Future	●	• Congestion and constraints markets can support wider solutions, such as combining TSO and DSO congestion management. • Incentives can be increased for digital technologies, including start-ups, which support capabilities needed by TSOs and DSOs to manage variable resources such as forecasting wind, solar production and other DERs and management of real-time auctions for ancillary service products.
Decarbonization of Industrial Clusters	○	• No material benefit.
Green Hydrogen	◑	• Hydrogen production can be timed for low demand or high supply periods to assist with peak shaving and curtailment reductions, acting as flexible storage.

Relative System Value dimension benefit for given recovery solution within market	● High benefit	◑ Medium benefit	○ Minimal-to-no benefit

System Value dimension: Resiliency and security

Clean energy transition enables greater resiliency and security through more energy diversification, domestic production and secure digital operations, better insulating Europe's system from foreign shocks, cyber attacks and natural disasters.

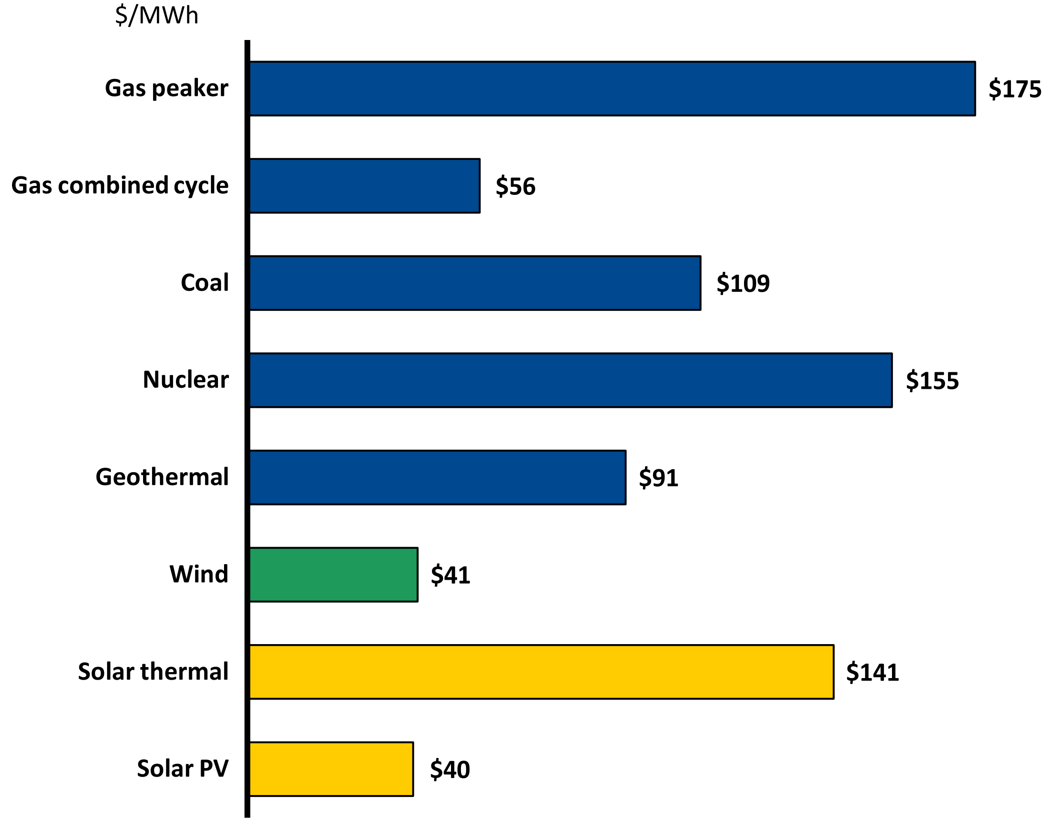
Resiliency and security benefits by recovery solution		
Efficiency and Demand Optimization	◐	• Storage systems (e.g. fuel cell, batteries, with solar) can provide local resiliency during outage events.
Electrification of Transport	◐	• Greater energy security through electrification of on-road vehicles via renewables as foreign oil dependence is reduced. • EV battery technology can be leveraged as a local power source for longer-term outages, e.g. during natural disasters.
Decarbonizing Heating and Cooling Systems	◐	• Greater local energy usage through power-to-heat systems rather than foreign imports of natural gas. • Thermal storage, either at district or building level, would allow continued deployment of heating and cooling to overcome multi-hour shocks.
Renewables, Power Markets and Networks of the Future	●	• Renewables expansion supported by next-generation power markets reduces import and physical supply risks. • More products can be compensated to encourage build-out of storage and virtual power plants, which can aid during longer outages. • Increased investment in smart digitalization of networks can provide greater security to detect cyberthreats.
Decarbonization of Industrial Clusters	●	• Industrial clusters create hydrogen that can be stored and utilized during resiliency events. • Decreased reliance on foreign fossil fuel resources reduces supply risks.
Green Hydrogen	●	• Stored hydrogen can be used as an energy source for a variety of sectors during disruptions to the energy system. • Reduced dependence on foreign oil through conversion of transport system that runs on green hydrogen.

Relative System Value dimension benefit for given recovery solution within market	●	High benefit	◐	Medium benefit	○	Minimal-to-no benefit

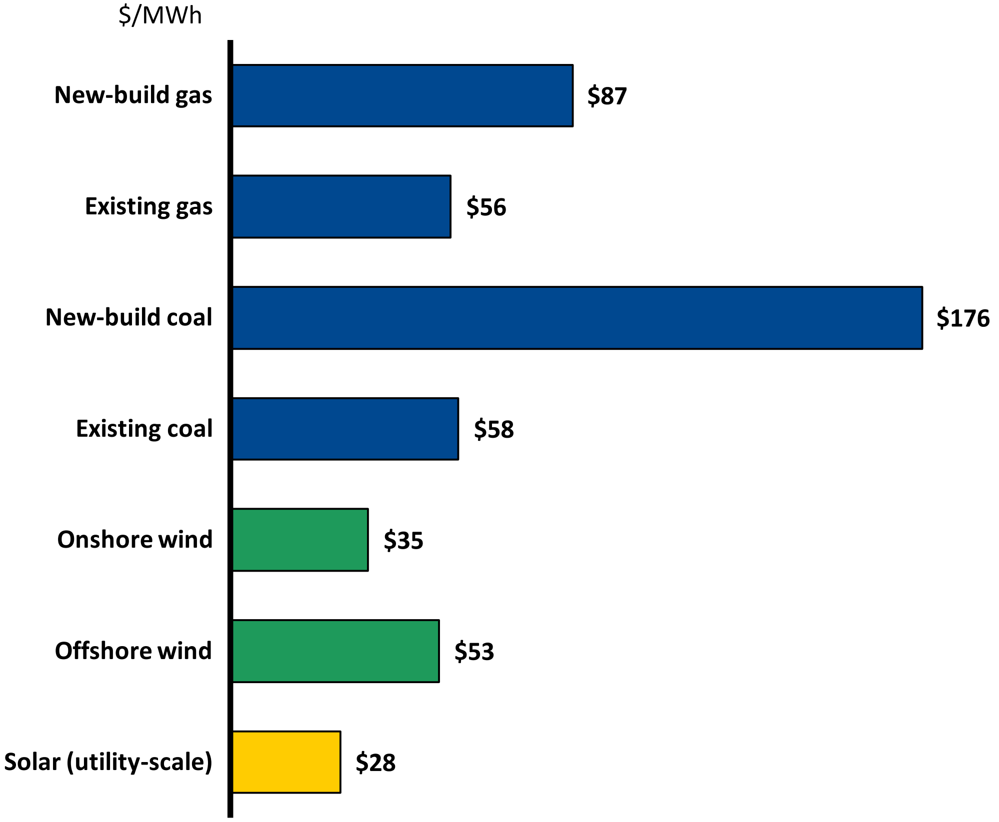
System value dimension: Cost and investment competitiveness

From an LCOE perspective, current wind and solar PV costs are lower than fossil fuel alternatives, and are forecast to drop further in Europe when looking out to 2040.

Lazard 2019 LCOE study shows cost competitiveness of wind and solar PV globally



BNEF European average LCOE 2040 forecast showcases widening gap between renewable and fossil fuel LCOE for both new-build and existing



Note: Where current European LCOE figures across all energy sources are not available, Lazard Global LCOE have been used above.

Source: Lazard LCOE Analysis 2019, BNEF Beyond the Tipping Point 2017

Contents

Key mechanisms for transport electrification

EU/National regulations and directives

- **Shift away from ICE vehicle sales**
    - EU target to reduce ICE vehicles in urban transport by 50% by 2030, and phase out in cities by 2050; achieving CO_2-free city logistics in major urban centres by 2030
    - Targets set across Norway (2025), France (2040, Paris 2030) and other countries
- **Targets for public EV charging infrastructure**
    - EU supporting the financing of 1 million charge points
- **Directives for car manufacturers**
    - EU emissions limit (95g CO_2/km) on new cars by 2021

Public/Private sector partnerships and cross-industry synergies

- **Large-scale demonstration and pilot projects** for e-mobility and smart charging
- **Synergies** across electricity and e-mobility (automotive and manufacturing) sectors, e.g. developing best practice standards and blueprints to increase operational efficiencies and drive down costs
- **City tenders for EVI**, e.g. City of Paris tender for shared vehicle charging stations
- **Charging and mobility hubs, emergence of new business models**
    - Fleet charging hubs to support fast charging for time-sensitive fleets (e.g. taxis)
    - Mobility hubs to incentivise shared vehicle use/micro-mobility
    - New business models and partnerships across last-mile logistics, on-demand mobility and EV charging infrastructure

Clean air zones

- **Fees charged to highest polluting vehicles** in cities, which is incentivising consumers and fleets to electrify
    - e.g. London's ULEZ, where cities such as Birmingham and Manchester are planning to implement clean air zones (CAZs) in the coming months
    - Other European cities with CAZs include Berlin, Amsterdam and Paris

Financial and convenience incentives for BEV adoption

- **Subsidies and government support in purchasing EVs**
    - Examples include the Netherlands contributing €4,000 towards the purchase of new EVs and €2,000 towards used EVs from July 2020; German state financial incentives to buy an electric car doubled to €6,000 in 2020
- **Private/public EV charging infrastructure deployment support** through funding (e.g. Connecting Europe Facility, or state aid), low-interest financial loans (e.g. via the European Investment Bank) or regulation and tariffs to enable smart charging
- **Emissions-based parking tariffs, parking configuration and other benefits**
    - Additional charges for higher polluting vehicles (e.g. Norway has created an ecosystem of subsidies, including parking benefits, access to bus or carpool lanes, road tax exemption among others)
    - Parking configuration adjustments by city to allow for limited residential parking and charging areas

Sources: EU Commission (1, 2); EU Federation for Transport and Environment; BBC; TNW; RingGo ; WEF; IRENA, EIB

Network and Power Markets of the Future

Eight solutions can transform European T&D networks and power markets to support increased variable and distributed resources

Digital system operations R&D

- **Incentives should be increased for digital technologies, including start-ups, that support capabilities needed by TSOs and DSOs to manage variable resources**.
- Examples include real-time inertia measurement; linking of TSO-DSO control rooms; forecasting wind, solar production and other DERs; management of real-time auctions for ancillary service products; and DERs and active network management platforms.
- **Digital system operations can be instituted that allow DERs and renewables to participate in the Balancing Mechanism**, facilitating real-time signal integration and bidding automation.

Connected and harmonized balancing markets

- **Implement various balancing platforms and initiatives through the European Network of Transmission System Operators for Electricity (ENTSO-E)**, representing 42 electricity TSOs from 35 European countries.
- Key projects include:
    - Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation (PICASSO)
    - International Grid Control Operation (IGCC)
    - Trans European Replacement Reserves Exchange (TERRE)
    - Manually Activated Reserves Initiative (MARI)
    - Frequency Containment Reserves (FCR)

DER participation in balancing markets and T&D coordination

- **Current European balancing markets do not sufficiently facilitate entry of DERs. It is critical to ensure wider DER participation and access to balancing markets.**
- For example, National Grid ESO has implemented:
    - Reactive power from non-traditional and embedded sources (distributed)
    - Wider participation in the Balancing Mechanism
    - Growing portfolio of demand-side response
    - Services to turn up demand versus curtail (e.g. repumping water, demand turn-up service)

Market mechanisms to address negative pricing

since COVID-19, as renewable generation hit 44% from January-May 2020. Sustained negative prices would disincentive investment.

- **To avoid negative power prices, more products should be compensated**, such as "demand turn-up", ToU pricing to encourage EV charging and increased demand response participation.
- **Increased storage can also help to avoid negative pricing through battery and storage "revenue stacking"** to ensure investors can recover their investment as the technology matures.

Investment support for interconnections and joint market operations

- **Connecting markets into a larger balancing and reserve area will reduce congestion, variability and individual reserve capacity requirements.**
- **Investment support to increase interconnection** among European markets **is key to transforming to a more variable system**.
- European markets are harmonizing market designs for day-ahead, intra-day, capacity and reserve markets through the Guideline on Capacity Allocation and Congestion Management (CACM), which will make it easier to connect markets.

Network planning, development and operation

- **Investment planning approaches that consider congestion and network constraints are critical in increasing the share of variable and distributed generation**. Renewable generators need to work with network operators to assess impact of new generation on congestion and provide recommendations.
- Transmission Network Use of System charges can be a significant share of the cost per MWh, with tariffs based on geographical zone.
- **Congestion and constraints markets need to support wider solutions, such as combining TSO and DSO congestion management.** TSOs will have to adjust their constraints market mechanism to consider renewables and DER.

Clarification of system operator roles and move to TOTEX returns

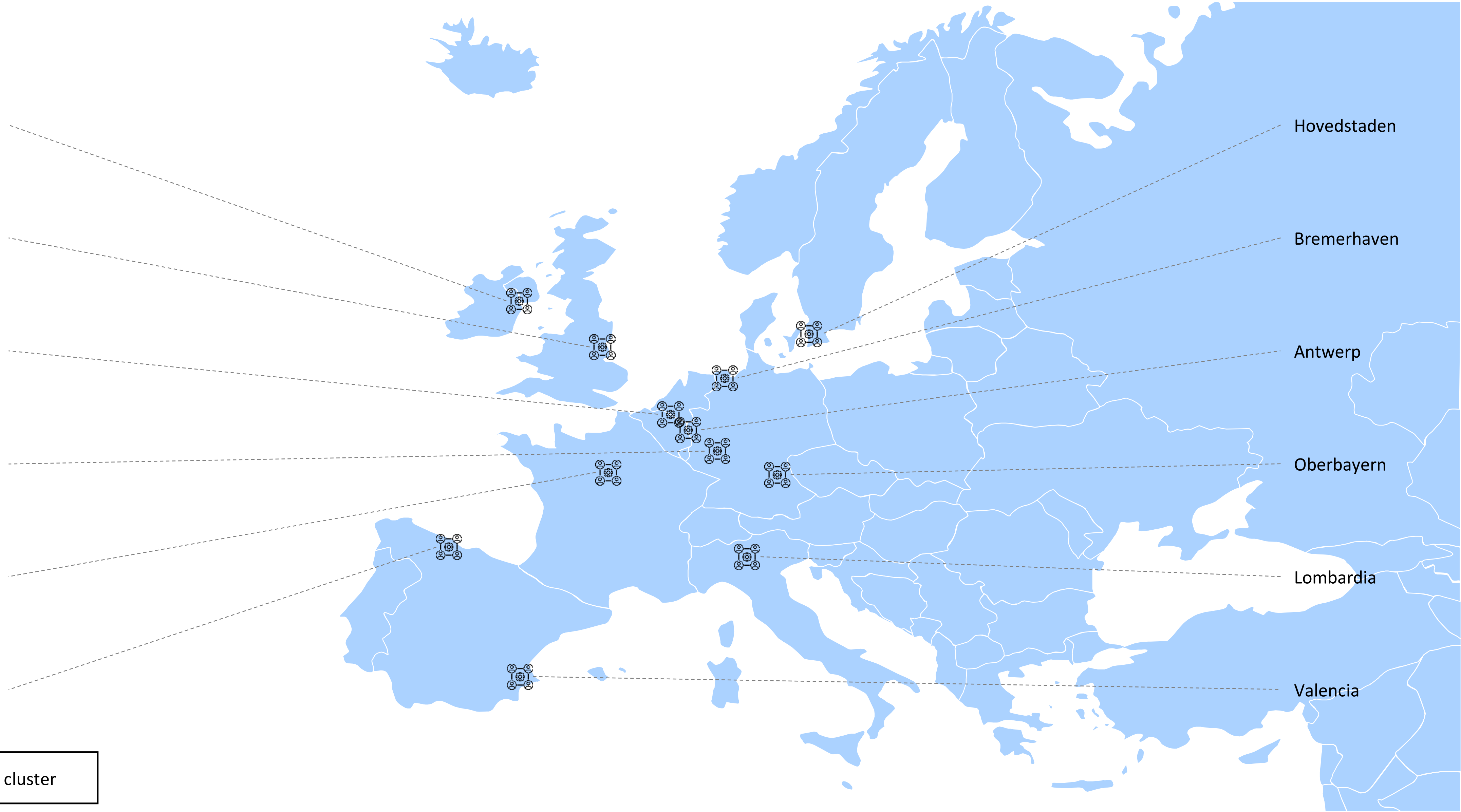
- **Add clarity to roles across operators and provide adequate remuneration for additional activities** such as flexibility procurement.
- **Accelerate the switch from a cost-plus Regulatory Asset Base system to TOTEX-based returns** where TSOs/DSOs are given flexibility of choosing how to allocate their expenses (P&L or capex), allowing them to find the most efficient combination.
- TOTEX-based returns will ensure that network operators are not oriented towards reinforcing investments over flexibility investments.

PPA contracting: Sleeving and trading

- **To support the growth of the I&C PPA market, European markets need to support PPA sleeving and make it easy for renewable energy (RE) projects and buyers.**
- In a sleeved PPA, an intermediary utility company handles the transfer of money and energy to and from an RE project on behalf of the buyer. The utility takes the energy directly from the RE project and "sleeves" it to the buyer at its point of intake for a fee.
- **Additionally, there is a need for smaller, structured PPAs that can be traded on exchanges to benefit smaller I&C customers** that may struggle to negotiate a custom-built PPA or be unable to commit to long-term deals

Sources: Accenture analysis

Key industrial clusters in Europe



East coast of Ireland

Humber

Rotterdam

Karlsruhe

Picardy

País Vasco

Hovedstaden

Bremerhaven

Antwerp

Oberbayern

Lombardia

Valencia

⌘ Industrial cluster

Sources: European Panorama of Clusters, Leading Clusters in Germany, Cluster Mapping