Decarbonization pathways

European economy

EU electrification and decarbonization scenario modelling
Synthesis of key findings

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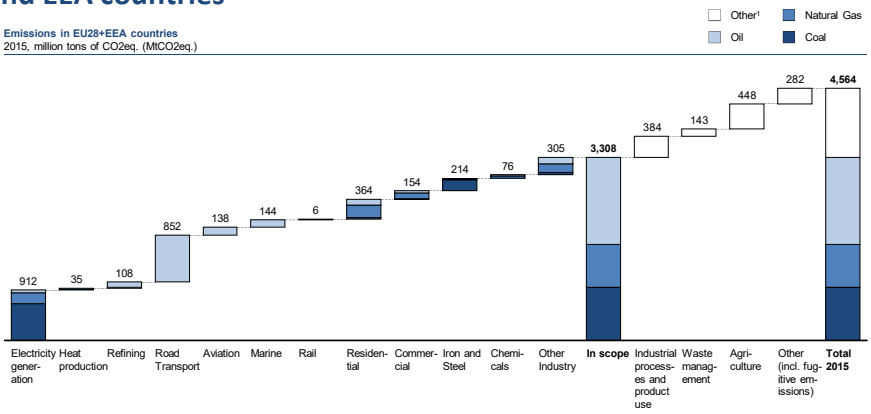
Our project focuses on all energy related emissions for all EU28 and EEA countries

Emissions in EU28+EEA countries
2015, million tons of CO2eq. (MtCO2eq.)



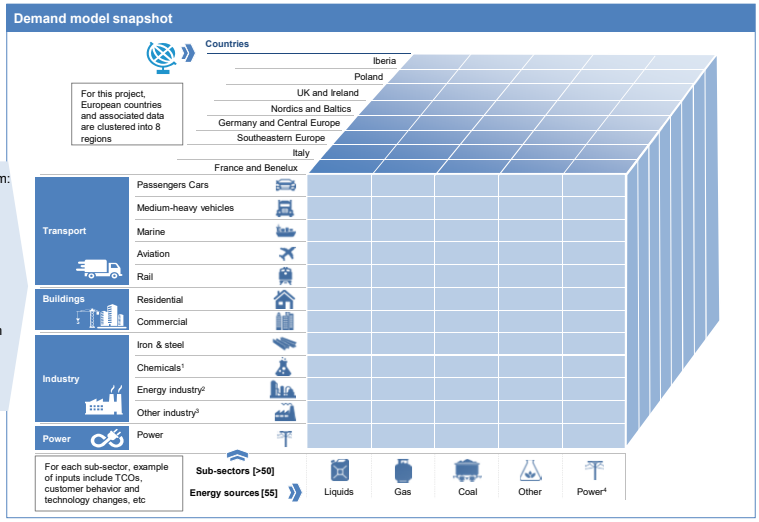
Energy related emissions				Non-energy related emissions
Energy	Transport²	Buildings	Industry	
Share of emissions: 23%	25%	11%	13%	28%

1. E.g. methane emissions from land-fills or agriculture and GHG emissions from waste burning
2. Includes international aviation and marine for consistency purposes
SOURCE: Energy Insights, EuroStat, EU inventory, team analysis

Detailed inputs collected bottom-up contribute to the robustness of the demand forecasts of energy and electricity

Bottom-up inputs from:

- National associations and their members
- Eurelectric committees and working groups
- External stakeholders from different perspectives: NGOs, industry associations, etc



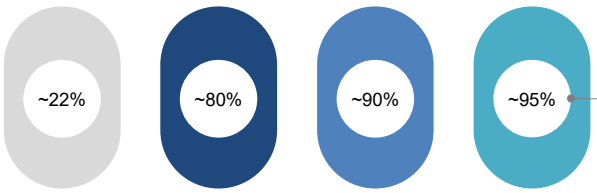
1. Organic, Ammonia, Other; 2. Oil & Gas, Own use, Other 3. Construction, Food & Agriculture, Manufacturing, Materials, Mining, Non-Energy, Other; 4. Separate global granular model

SOURCE: Energy Insights, a McKinsey Solution – Global Energy Perspective

eurelectric designed 3 deep EU decarbonization scenarios

2015 - Baseline | 2050 scenarios

EU economy decarbonization achieved vs. 1990[1,2]



4 underlying pre-requisites and drivers per scenario: level of ambition, technology development, consumer behavior and regulation

1 Emissions out of scope are expected to contribute proportionally to the decarbonization effort required in each scenario

2 Decarbonization will be different by sector depending on relative costs and available technologies, industry contributing least with below 80% of emission reduction in all scenarios

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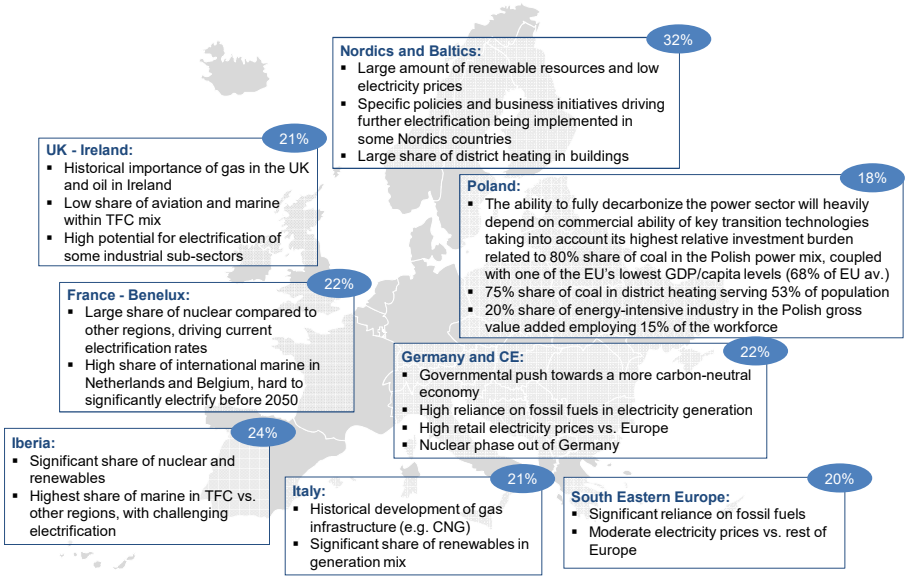
Different starting points in the energy transition

2015 baseline – direct electrification rate



Nordics and Baltics: 32%
- Large amount of renewable resources and low electricity prices
- Specific policies and business initiatives driving further electrification being implemented in some Nordics countries
- Large share of district heating in buildings

UK - Ireland: 21%
- Historical importance of gas in the UK and oil in Ireland
- Low share of aviation and marine within TFC mix
- High potential for electrification of some industrial sub-sectors

Poland: 18%
- The ability to fully decarbonize the power sector will heavily depend on commercial ability of key transition technologies taking into account its highest relative investment burden related to 80% share of coal in the Polish power mix, coupled with one of the EU's lowest GDP/capita levels (68% of EU av.)
- 75% share of coal in district heating serving 53% of population
- 20% share of energy-intensive industry in the Polish gross value added employing 15% of the workforce

France - Benelux: 22%
- Large share of nuclear compared to other regions, driving current electrification rates
- High share of international marine in Netherlands and Belgium, hard to significantly electrify before 2050

Germany and CE: 22%
- Governmental push towards a more carbon-neutral economy
- High reliance on fossil fuels in electricity generation
- High retail electricity prices vs. Europe
- Nuclear phase out of Germany

Iberia: 24%
- Significant share of nuclear and renewables
- Highest share of marine in TFC vs. other regions, with challenging electrification

Italy: 21%
- Historical development of gas infrastructure (e.g. CNG)
- Significant share of renewables in generation mix

South Eastern Europe: 20%
- Significant reliance on fossil fuels
- Moderate electricity prices vs. rest of Europe

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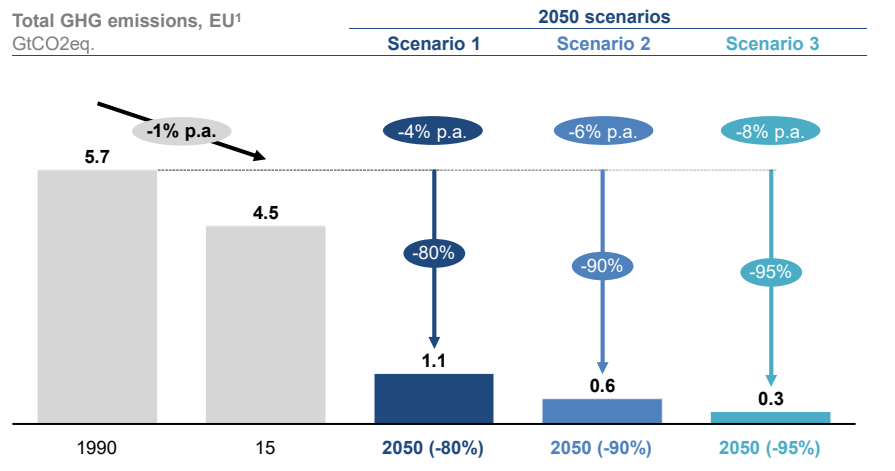
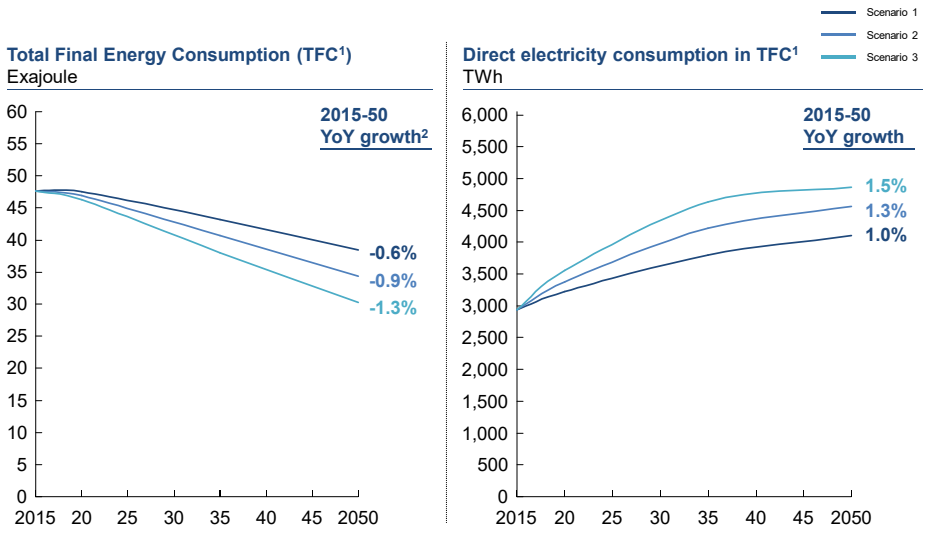
The 3 scenarios deliver unprecedented but necessary reductions in CO2 emissions

-x% p.a. Required annual emission reduction rate between 2015-2050 to achieve target



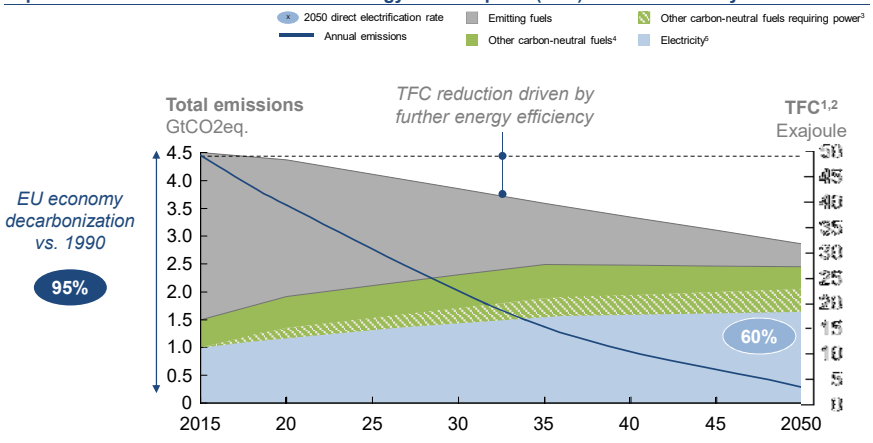
SOURCE: Energy Insights, EuroStat

Energy efficiency drives down final energy consumption significantly, while yearly direct electricity consumption increases by 1.0 to 1.5%



1 Includes 32 countries in scope: EU28 + EEA; ENTSOE report additionally includes Turkey and other Eastern European countries adding up to a total of ~3,300 TWh
2 Annual YoY TFC reduction adjusted to total GDP growth (as a proxy for increase in energy productivity) varies between 2% and 2.8% depending on scenarios

95% decarbonization through strong electrification, energy efficiency, and support from other non-emitting fuels



1 Includes 32 countries in scope: EU28 + EEA; ENTSOE report additionally includes Turkey and other Eastern European countries adding up to a total of ~3,300 TWh
2 Electricity consumption from transformation sectors not included; 3 Includes non-emitting fuels that trigger indirect electrification through power-to-X (H2, synth fuels) as well as non-emitting fuels that trigger increased electricity demand to be produced such as biofuels; 4 Includes all other non-emitting fuels/sources such as geothermal, solar thermal, and others; 5 Direct electricity consumption

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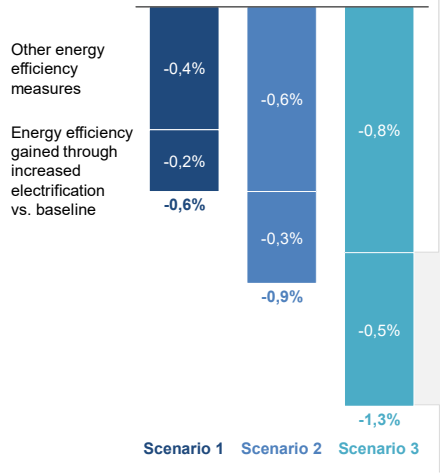
NOT EXHAUSTIVE

Deploying electric solutions is strongly contributing to the total energy efficiency gains

Drivers of energy efficiency gains
2015-2050 YoY reduction in TFC



Illustrations by sector

Transport

- In passenger cars, EVs consume 25% of ICE vehicles' energy consumption
- For trucks, e-trucks consume ~50% of their diesel equivalents' own energy consumption

Buildings

- In space heating, heat pumps' coefficient of performance (COP[1]) is 4-5x higher than the COP for typical gas boilers
- In cooking, the energy intensity of electric solutions is 10% lower than for gas and down to 1/5 of the energy intensity of charcoal and wood

Industry

- For steel, electric arc furnace route using recycled steel is 5-6x less energy intense than traditional coal-based (blast furnace) production routes
- In other industry, electric solutions (e.g., heat pumps, hybrid boilers) can be between 100-300% more energy efficient for low temperature grades then their gas equivalents

1 Coefficient of performance (COP) = ratio of heat delivered vs energy needed as input

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Resulting electrification of road transport

		2015 Baseline	2050 Scenario 1	2050 Scenario 2	2050 Scenario 3
Passenger cars	Direct electrification rate	0%	42%	66%	94%
	Share in new sales	1%	75%	100%	100%
	Share in fleet	<1%	65%	80%	96%
Trucks	Direct electrification rate	0%	24%	29%	48%
Buses	Direct electrification rate	0%	29%	39%	58%

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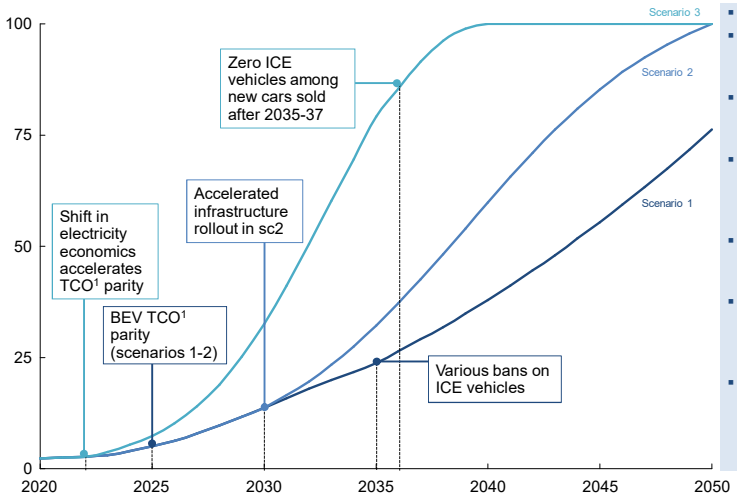
Favorable TCO[1] and regulatory push drive up-take of electric vehicles in passenger cars across our 3 scenarios

Share of battery electric vehicles (BEVs) in new sales in the EU

Percent



Key drivers of BEVs sales

- Current fleet
- Macro-economic drivers: GDP, population growth
- Scrap rates, especially of internal-combustion-engine (ICE) vehicles
- TCO of BEVs relative to other competing technologies, driven by decreasing battery cost
- Demand for shared mobility and autonomous driving
- Infrastructure deployment and innovation *(i.e. wireless charging)*
- Non-economic drivers for BEV acquisition (*i.e. regulation, environmental awareness)*

1 TCO: total cost of ownership

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Resulting electrification of residential heating

		2015 Baseline	2050 Scenario 1	2050 Scenario 2	2050 Scenario 3
Space heating	Direct electrification rate	**8%**	21%	32%	44%
Water heating	Direct electrification rate	**11%**	22%	32%	44%
Cooking	Direct electrification rate	**26%**	75%	90%	95%
Total buildings	Direct electrification rate	**34%**	45%	54%	63%
	Total electricity demand as part of TFC[1]	**34%**	45%	56%	64%

1 Includes direct electrification, indirect electrification and electricity demand driven by production of CCS and biofuels

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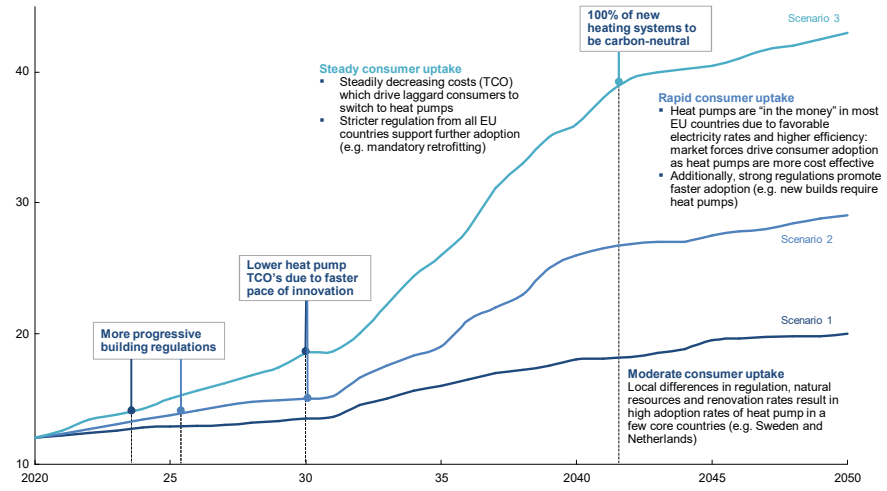
Changes in heat pump economics are driving adoption of electrification in space heating for buildings

Heat pump market share of space heating
Percent of total TFC electrified



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Resulting electrification of industrial sectors

		2015 Baseline	2050 Scenario 1	2050 Scenario 2	2050 Scenario 3
Chemicals	Direct electrification rate	30%	35%	36%	39%
Iron & Steel	Direct electrification rate	32%	38%	39%	42%
Other industries	Direct electrification rate	35%	39%	47%	55%
Total industries	Direct electrification rate	33%	38%	44%	50%
	Total electricity demand as part of TFC[1]	33%	45%	53%	60%

1 Includes direct electrification, indirect electrification and electricity demand driven by production of CCS and biofuels

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Electrification is expected to play a major role, as part of the 'menu' of options that could address the industry CO_2 emission

Demand side measures

Lower the demand for virgin products by increasing reuse and recycling of the materials, or by replacing it by another material

Energy efficiency

Adapting the production equipment to lower energy use per production volume

Electrification of heat

Replace fossil fuel for heating with electricity in e.g., ethylene production

Hydrogen as fuel or feedstock

Replace the feedstock or fuel with carbon neutral hydrogen e.g., in ammonia production

Biomass as fuel or feedstock

Replace the feedstock or fuel with sustainably produced biomass to reduce CO_2 emissions, e.g., use bio-based feedstock in chemicals production

CCS / CCU

Capture the CO_2 emitted and store (CCS) or use (CCU)

Other innovation

- Innovative processes e.g., electrochemical production process
- Non-fossil fuel feedstock change e.g., change in cement feedstock

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Direct electrification results by scenario

		2015 Baseline	2050 Scenario 1	2050 Scenario 2	2050 Scenario 3
Total EU economy	EU economy decarbonization vs 1990	22%	80%	90%	95%
	Direct electrification rate	22%	38%	48%	60%
Total transport	Direct electrification rate	1%	29%	43%	63%
Total buildings	Direct electrification rate	34%	45%	54%	63%
Total industries	Direct electrification rate	33%	38%	44%	50%