CLIMACT | Empowering **you** to act on **climate change**

2040 Targets

Analytical base for upcoming Strategic Perspectives report on pathways towards 2040 targets

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STRATEGIC PERSPECTIVES

Introduction

- Strategic Perspectives seeks to inform the policy debate on the new EU post-2030 climate targets and what it means for the mandate of the next Commission.
- Climact has modelled -85%, -90% and -95% net emission reduction scenarios for 2040 and deducted a net-target for 2035 for each of them. The scope includes all emission reductions from aviation and maritime sectors, going beyond the current ETS scope(1).
- Strategic Perspectives considers the -90% scenario a feasible pathway that provides a strong effort of the European Union in the global effort to fight climate change. It would require the EU to slightly increase the pace of decarbonisation after 2030 compared to the trajectory to reach the 2030 target. This scenario maximises the electrification potential across sectors, sets clear phase out milestones for gas consumption and endorses circularity. It relies on technological innovation driven through policies while keeping a relatively conservative approach on societal choices. Today we discuss the sector findings related to these scenarios
- Based on the modelling and analysis, Strategic Perspectives will publish a full report on the priorities for the next European Commission mandate (2024-2029) in July. The results and conclusions derived in this report are those of Strategic Perspectives and do not necessarily represent those of Climact or the organisations that supported this research. Based on the modelling and analysis, Strategic Perspectives will write a report that also includes policy recommendations for the next Commission. The report will cover fact sheets for all sectors of the economy. We will not include all sectors in our narrative, analysis and policy recommendations though.

NOTE: (1) International aviation (outside EU) is included in this tool, but is not in the ETS scope

We design the scenarios using the open source Pathways Explorer

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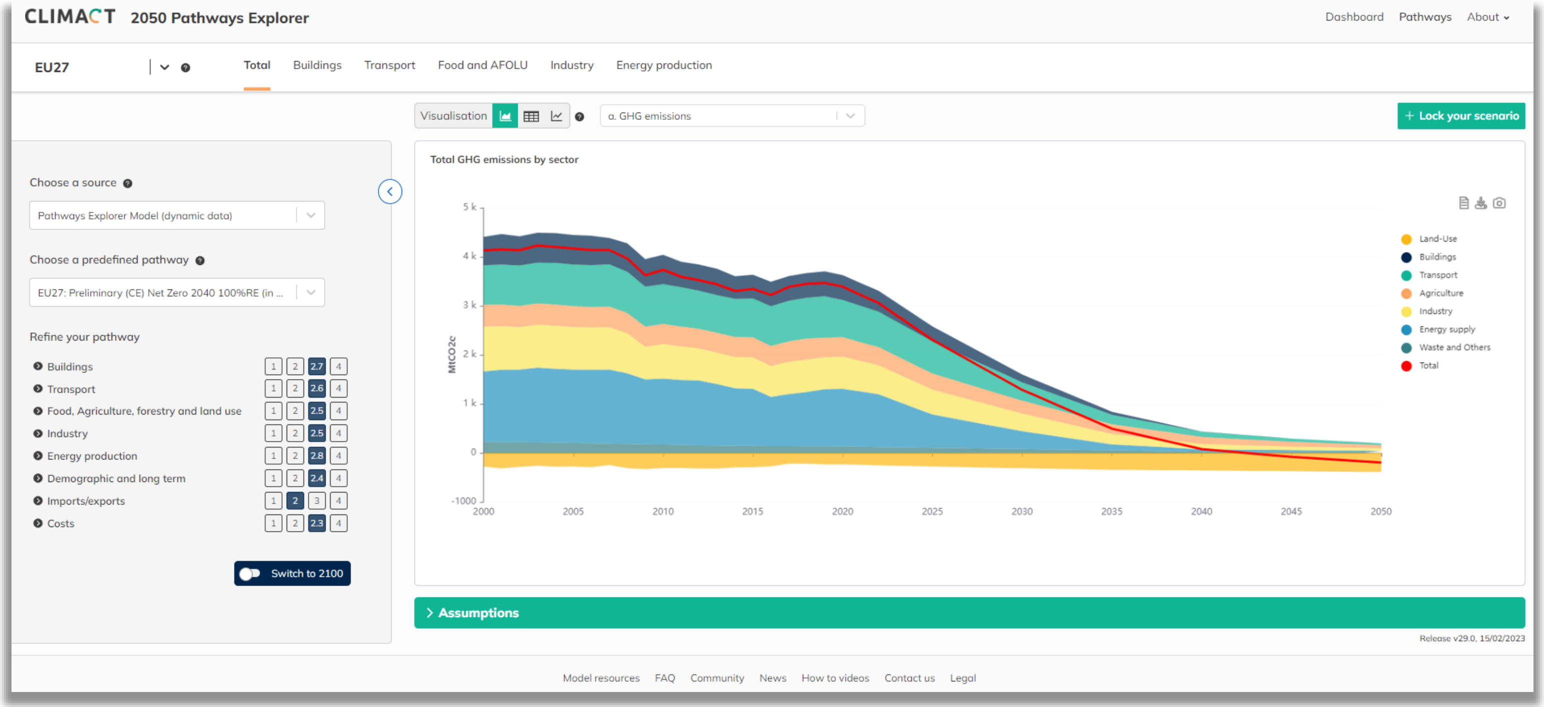

[Link to the Pathways Explorer]

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Overview

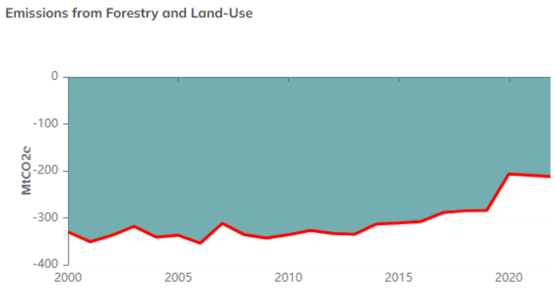
Cross-sector overview

- 1) Buildings
- 2) Transport
- 3) Industry
- 4) Energy supply
- 5) AFOLU

Three separate targets are specified for each scenario

Net emissions	• This emissions scope is most aligned with the upcoming policies [1] • The net includes removals (both natural sinks and technical removals) and international bunkers • The international bunkers include an approximation of the allocable emissions from international aviation & maritime, based on a departure-based logic.
Net emissions excluding bunkers	• This emissions scope is aligned with historical emissions reporting • Compared to the previous, it excludes international bunkers and is therefore less ambitious for a same reduction percentage
Excluding Natural sinks	• This emission scope enables not to overly bet on the natural carbon sink • In addition, these are provided because the carbon sink is harder to predict. LULUCF emissions are modelled with less precision (across all models and even with strong yearly variability in the historical accounting, see image to the right).
Excluding all removals	• This emission scope enables not to overly bet on all the removals (both the natural carbon sinks and the technology removals)

Historical LULUCF emissions



NOTES: (1) International aviation (outside EU) is included in this tool, but is not in the ETS scope
CO_2, CH_4 and NO_2, 2-4% of other gases are outside the scope of the Pathways Explorer model, they however are expected to follow the same trends

The following 2040 scenarios are being specified with indications for 2035

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Name		Net emissions 2040	Excluding			Milestone 2035	Description	Links
				Removals				
		Base scope (1)	International bunkers	Natural sinks	Tech. (2)	Base scope (3)		
-95% net	%	-95.5%	-96.9%	-85.7%	-84.9%	-82.2%	*Based on the balanced scenario, with more ambition on societal changes and some technology breakthrough*	Link
	Mt CO_2e	210.4	97.3	-471.0	-35.51	843.17		
-90% net	%	-90.2%	-92.8%	-81.8%	-80.6%	-79.2%	*Balanced scenario reaching -90% of emission reduction*	Link
	Mt CO_2e	462.5	155.4	-412.5	-61.35	1031.78		
-85% net	%	-85.4%	-88.3%	-78.2%	-77.0%	-73.2%	*Based on the balanced scenario, with lower ambition on societal changes and technology breakthrough*	Link
	Mt CO_2e	690.9	176.3	-369.3	-59.37	1270.14		

NOTES:

(1) Percent reductions are expressed in 2040 vs 1990, on the net GHG emissions
The net includes removals (both natural sinks and technical removals) and international bunkers
The international bunkers include an approximation of the allocable emissions from international aviation & maritime, based on a departure-based logic.
1990 baseline is 4727 Mt net, 4940Mt excluding natural sinks, and 4940Mt excluding all sinks

(2) Includes biogenic CO_2 from the upgrade of biogas to biomethane (assuming 60% of biogas upgrade to biomethane for scenario -95% (27.6Mt), 50% for scenario -90%(23Mt) and 40% for scenario -85%(18.4Mt) ➔ Not modelled in the online webtool

(3) The indicative target for 2035 is extracted as the interim point of the respective pathways

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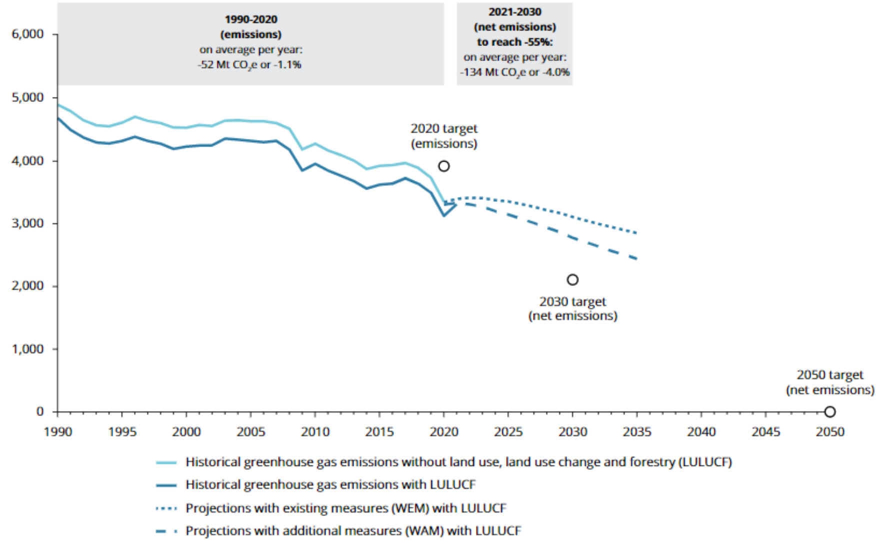
When comparing to Pathways Explorer results, The EU27 1990 baseline is 4728 $MtCO_2e$ (1)

EU 27 Historical trends and future projections for GHG emissions ($MtCO_2e$, including F-gases, aviation and maritime)



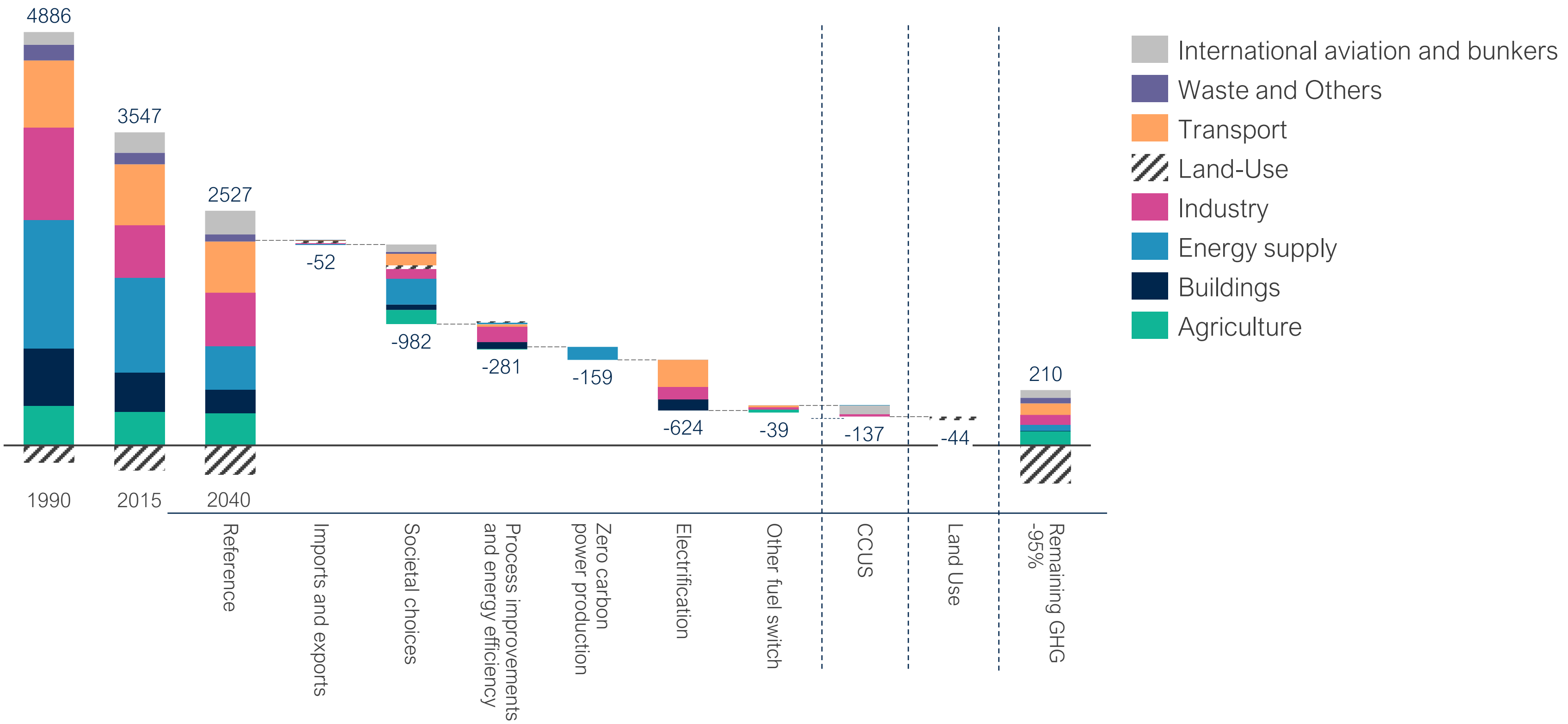
$MtCO_2e$ (1)		Main 3 gases (CO_2, CH_4, N_2O)	All gases (CO_2, CH_4, N_2O, F-gases)
Net excl. Land use excl. bunkers		4 784	4 839
Land use		-213	
International bunkers	Aviation	54	
	Maritime	103	
Total	incl. LULUCF incl. bunkers	4 728	4 782
Total	excl. LULUCF incl. bunkers	4 941	4 995

These categories are not included in the first graph, they are in transport bunkers

SOURCE: (1) 1990 UNFCCC NIR v2022 for EU 28 of which is substracted UK

-95% waterfall by themes

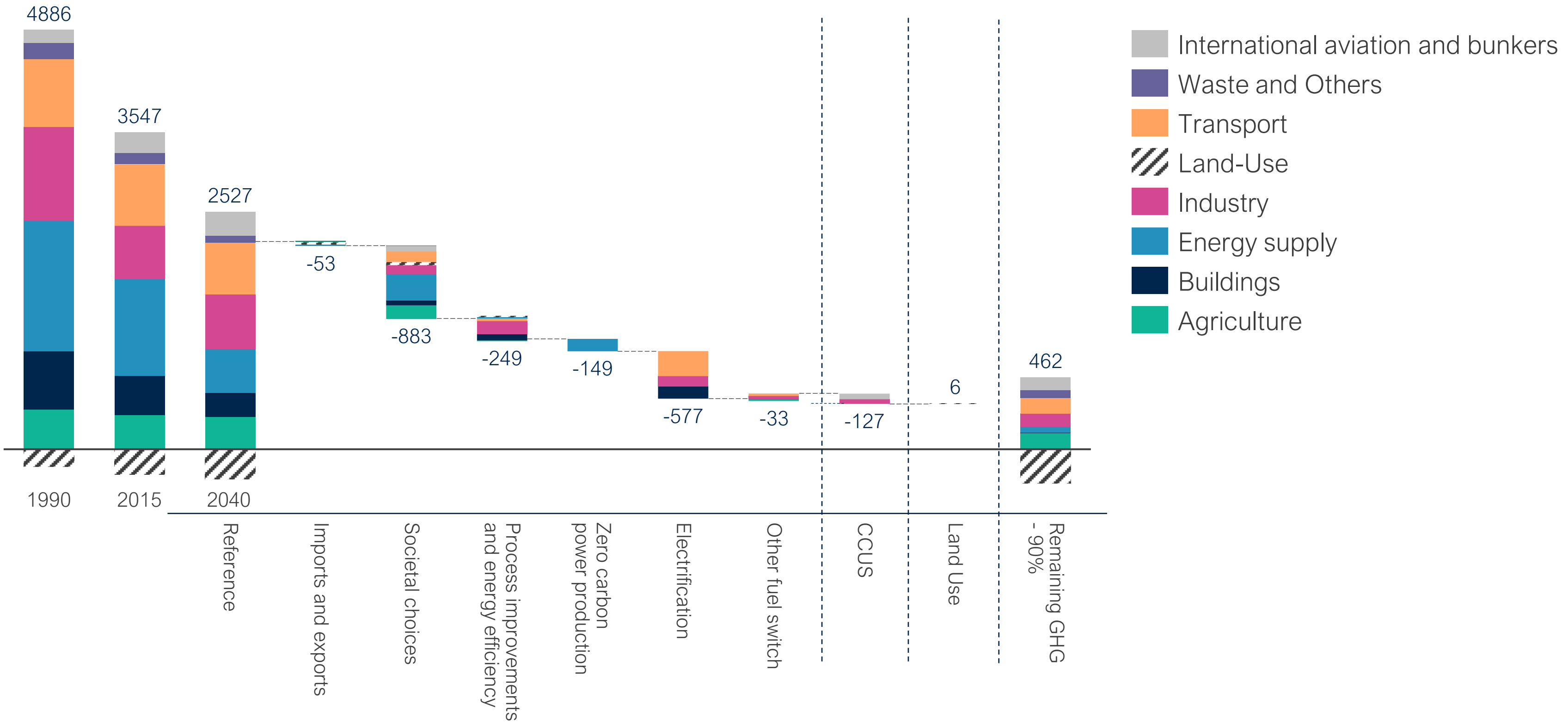
GHG emissions trajectory [$MtCO_2e$]



NOTES: (1) The reference scenario mimics the EU 27 WEM scenario (scenario with existing measures), as published by the EEA in October 2022
(2) CCUS includes all levers related to carbon capture (end-of-pipe, DAC, biogenic…), usage and storage

-90% waterfall by themes

GHG emissions trajectory [$MtCO_2e$]



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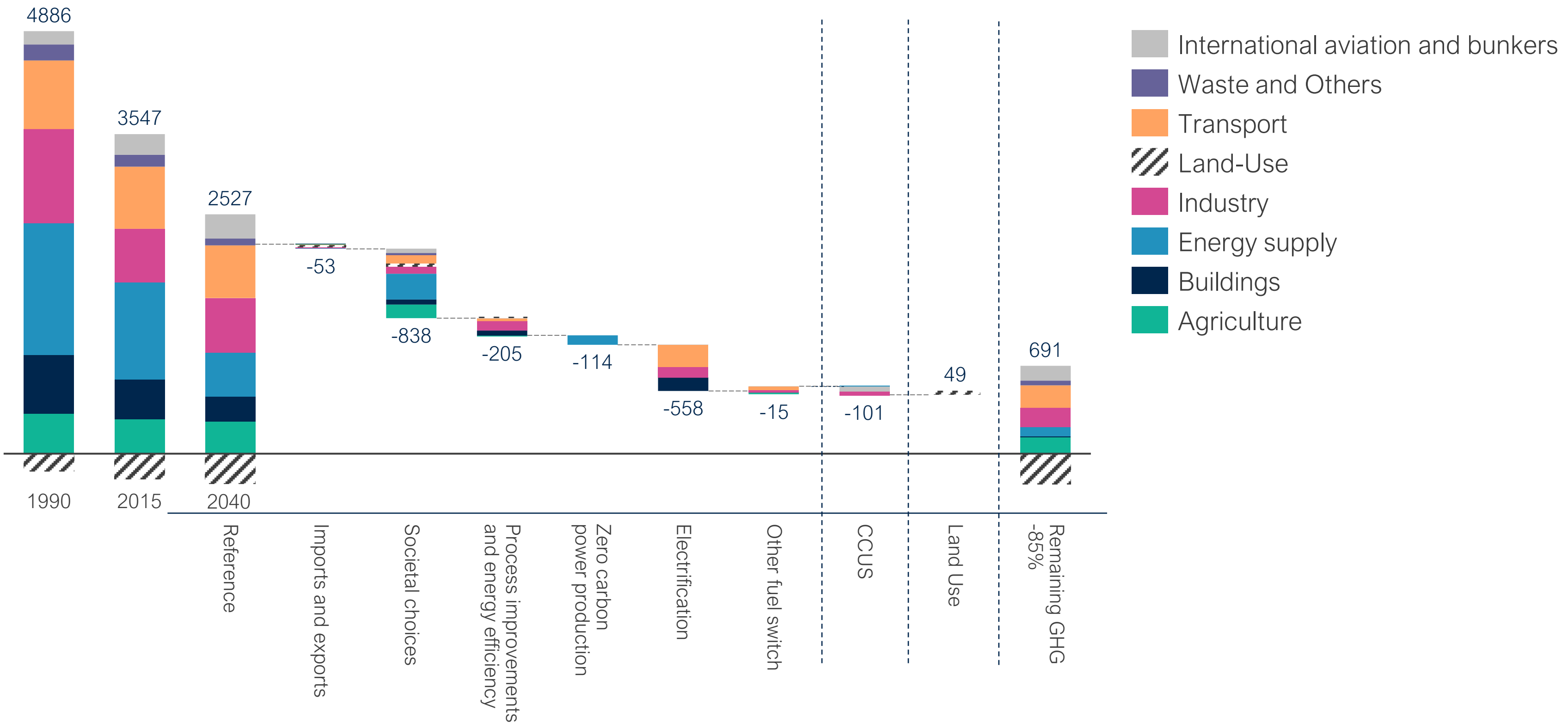
-85% waterfall by themes

GHG emissions trajectory [$MtCO_2e$]



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Key indicators are provided for each scenario

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Indicator			2015	2040 net REF	2040 net -95%	2040 net -90%	2040 net -85%
FF share (of final sector energy demand)	Total [%]		/	/	22.5% of total	28.9%	33.8%
	Buildings	Gas [%]	32%	21.9%	0%	0%	0%
		Oil [%]	13.6%	9%	0%	0%	0%
		Coal [%]	2.8%	0%	0%	0%	0%
	Transport, excluding ETS bunkers	Gas [%]	~0%	/	0.3%	0.5%	0.8%
		Oil [%]	92.7%	65%	37%	48%	53%
	Industry, excluding feedstocks	Coal [%]	12.8%	12.8%	1.1%	2.6%	4.4%
		Gas [%]	32.2%	29.9%	4.6%	8.9%	14%
		Oil [%]	9.3%	8.4%	1.4%	2.5%	3.7%
	Industry, including feedstocks	Coal [%]	9.3%	9.6%	0.9%	1.9%	3.3%
		Gas [%]	27.4%	25.6%	5.8%	9.8%	13%
		Oil [%]	28.8%	27.9%	20%	21.7%	22.6%
Renewable energy	RES incl. biomass [%]		20%	40%	67.06%	59.46%	54.87%
	RES excl. biomass [%]		10%	18%	47.54%	42.11%	36.47%
Share of efficient buildings	Zero emission buildings [%] (< 85kWh/m²)		0%	8%	39.4%	37.4%	32.2%
	Zero +energy plus buildings [%] (< 15kWh/m²)		0%	2%	7.8%	7.4%	6.5%
	Average final energy consumption for space heating [kWh/m²]		95	67	45.87	48.6	51
Green hydrogen	local demand [TWh]		0%	116.4	460.5	482.31	512.55
	local production [TWh]		0	126.32	307.4	321.54	341.7
	imports [TWh]		0	22.29	154.1	160.77	170.85
Carbon capture and sinks	CC & DAC, excluding LULUCF [MtCO2e]		0	75	73.75	80.75	79.26
	Net land sink from LULUCF [MtCO2e] (includes sinks and sources)		-311	-146	-470.9	-412.5	-369.29
Energy demand	Primary [PWh]		13.4	13.6	8.877	8983.28	10.04
	Final [PWh]		12.25	13.08	7.209	7.671	8.308
	Final electricity consumption [PWh]		2.65	3.55	3.82	3.74	3.84
	Share of electrification of the economy		21.63	27.14	53%	48.8%	46.2%

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EU Low carbon scenario exploration : Buildings sector

The buildings module applies the following technical and behavioral levers to assess the energy and emissions

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1 **Societal choices calculations**

2 Buildings envelope efficiency
[kWh/m²/y]

These levers determine the **rate and depth of renovation** of the existing building area and the energy performance of **new constructions**

3 Demand for energy services
[kWh/m²/y]

These levers determine the **energy demand** for space heating, cooling, cooking, appliances, lighting

4 Technology share per services
[%]

Define the **mix of technologies** and fuels used to provide space heating, cooling or cooking demand

5 Fuel switch
[%]

For remaining fossil fuels demand, switch to **green fuels** (either bio or synthetic)

Those levers are broken down by types of building, end-uses, technologies and fuels

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Building usage

Residential

- Single family homes
- Multiple family homes (apartments)

Non-residential

- Education
- Health
- Offices-all
- Trade
- Others

Building state

New buildings

Renovated (since base year)

Non-renovated

Energy end-uses

Space heating

Water heating

Space cooling

Lighting

Cooking (residential)

Appliances
(fridges, washing machines, dryer, dishwasher, TV, DVD, computer, tablets, mobiles)

Other

Heating/Cooling technologies (1)

10 **heating technologies**

- Boilers (solid, gas, liquid)
- CHP (gas, solid, liquid),
- Heat pump (hybrid & full electric)
- Solar thermal
- District heating (covered by heat supply module)

1 **cooling technology**

- Electric cooling

Fuels

Electricity : local, grid

Fossil : coal, oil, natural gas

Biomass: solid, liquid, gaseous

Hydrogen

Heat: local (solar thermal, envir. heat from heat pumps), grid

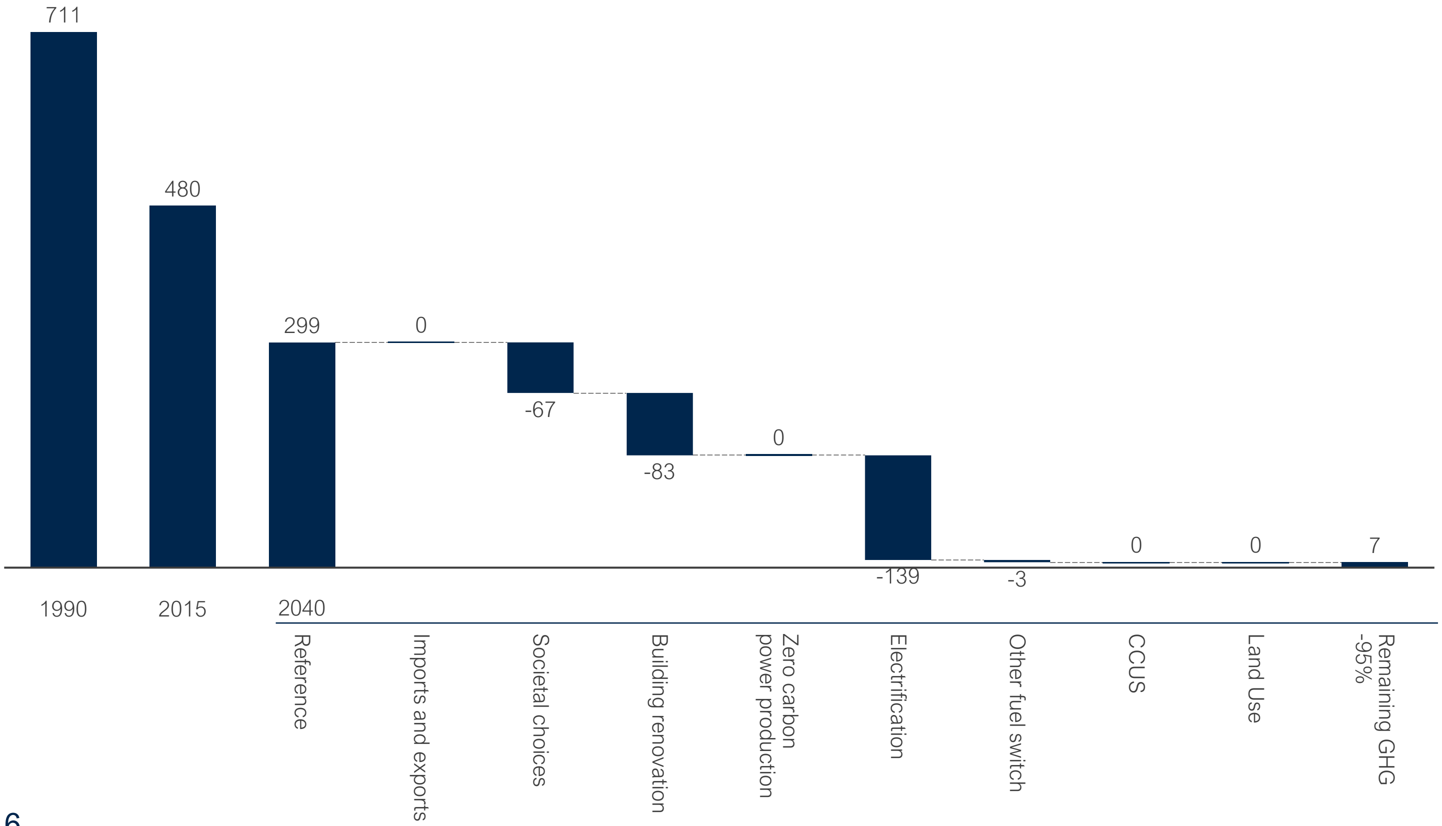
Synfuels: liquid, gaseous

Building module takes into account materials needed for building (cement, steel, bricks, chemicals, timber) to make the link on the impact for industrial sectors

NOTE: (1) The technologies are currently modelled based on their fuel consumption

-95% Buildings waterfall by themes

GHG emissions trajectory [$MtCO_2e$]



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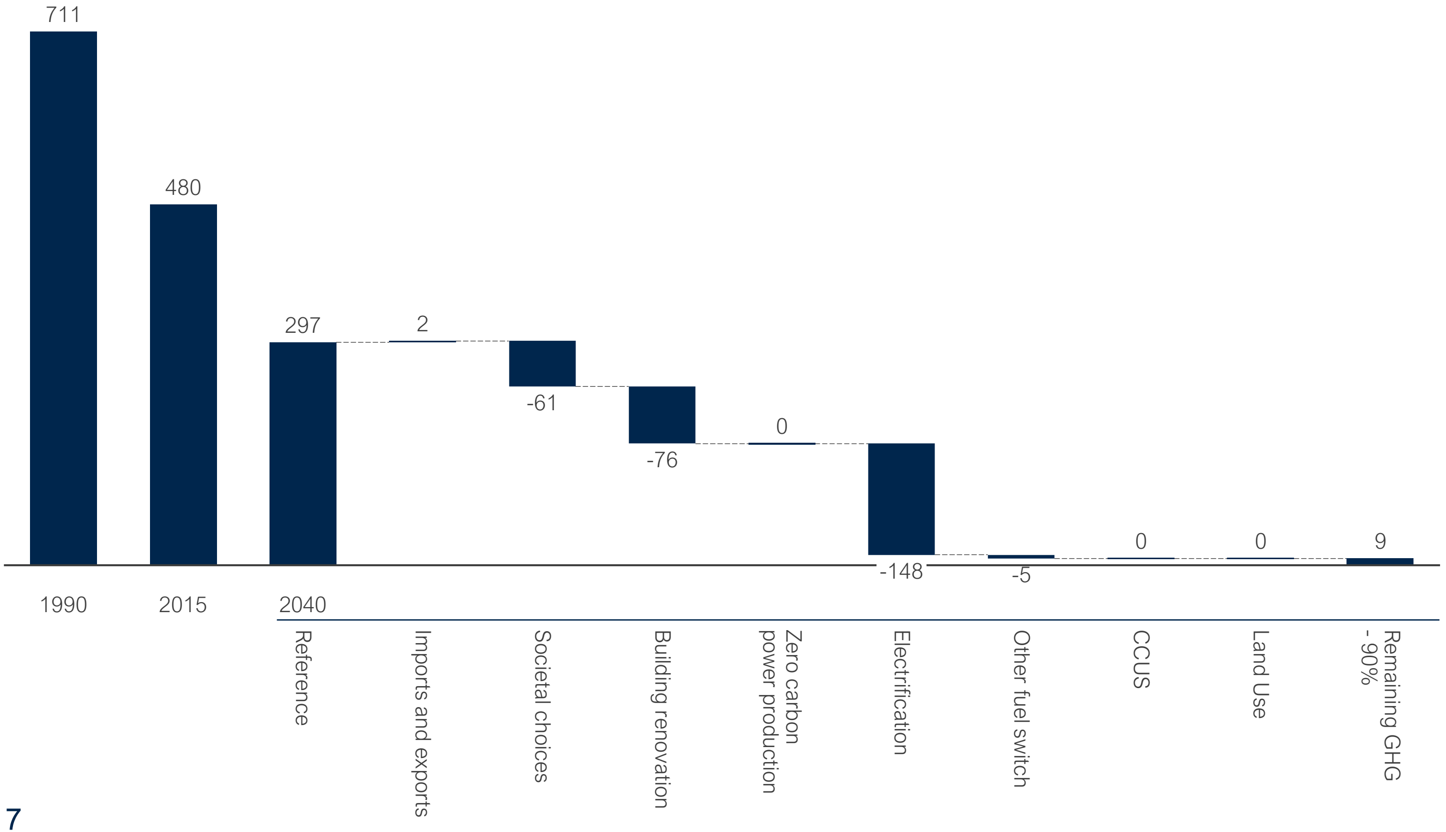

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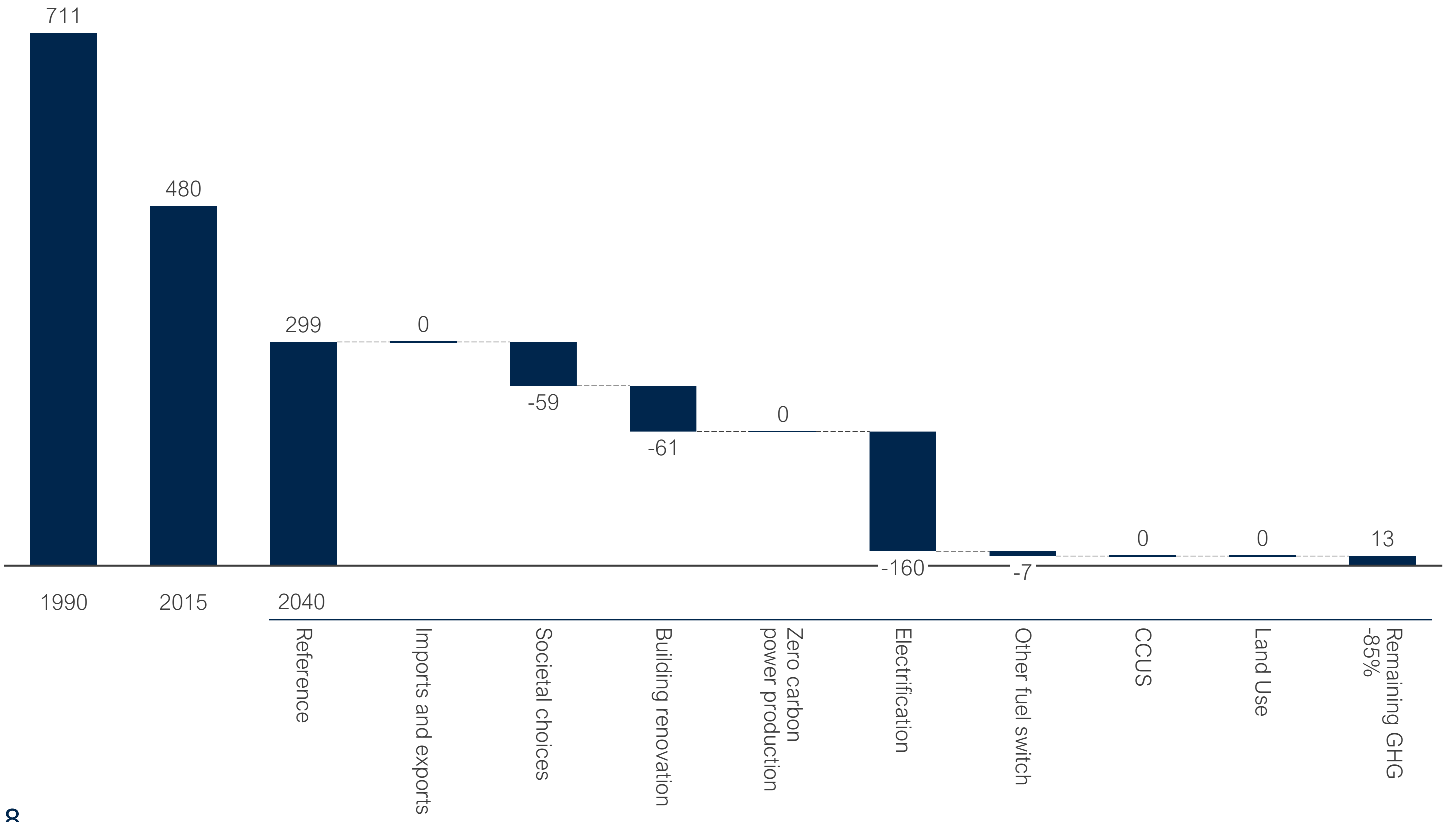

Buildings

Five key take aways

1. The pathways presented in this analysis are in line with an overall phase out of fossil fuels in the building sector by 2040 as envisaged in the **Energy Performance of Buildings Directive.** The energy **renovation rate of building stocks needs to increase significantly to 3% from 2030 to 2040.**

2. Most of these renovations should be **energy+ or 0-emissions buildings**, respectively defined as an energy requirement below 85kWh/ m^2 and below 15kWh/m^2.

3. All **new constructions should be 0-emission buildings from 2030**. Deep renovation of buildings and a significant deployment of low-carbon heating systems go hand in hand.

4. For the renewable share for heating to reach 100% in 2040, 1/2 of the energy demand will be covered by heat pumps and a1/3 by district heating. **The heat pump installation rate thus also increases to 3% in line with the building renovation rate.**

5. **Society can contribute to the efforts** in the sector also by maintaining efforts to reduce energy demand as effectively implemented in response to the Russian war

Buildings

Necessary actions

-90% scenario

Societal choices

- As seen in response to the energy crisis, reduce energy demand for space heating (comfort temperature)
- Improve insulation to limit need of additional air conditioning(below 5%) and heating
- Maintain the per capita use of residential area

Building renovation and energy efficiency

- 75% of the building stock renovated between now and 2050
- Scale up deep renovation (18% of energy+ buildings, 70% of 0-emission buildings)
- All new housing with passive standards from 2030

Electrification coupled with zero carbon power production

- Massive deployment in heat pumps
- Development of district heating networks

Decarbonizing what is left

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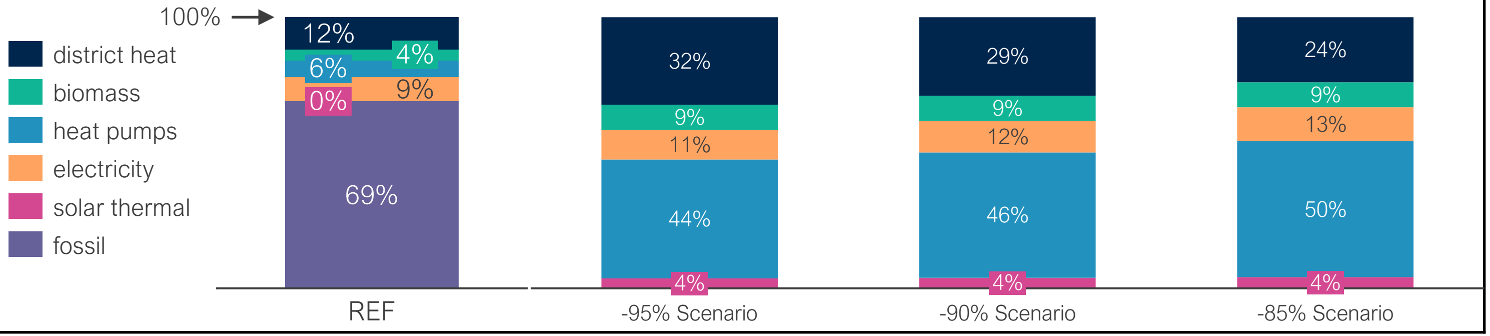
Key assumptions for the building sector

Evolution to 2040 (vs 2015 for relative)		2019	-95% net	-90%	-85%
Floor areas	residential	▪ 40 m²/cap	▪ +10% to 44m²/cap	▪ +16% to 46 m2/cap	
	services	▪ 1370 billion m²	▪ Keep floor area stable		
New construction		▪ /	▪ 0-emission buildings[1] from 2030		
Renovations	rate	▪ 1.3% (residential) & 2.4% (services)	▪ Renovation rate: 3% by 2030		
	Depth	▪ 80% of shallow (<25% energy savings vs average of the stock)	▪ 70% of 0-emission buildings[0,1] ▪ 18% of energy+ buildings[0,2]	▪ 65% of 0-emission buildings ▪ 16% of energy+ buildings	▪ 55% of 0-emission buildings ▪ 15% of energy+ buildings

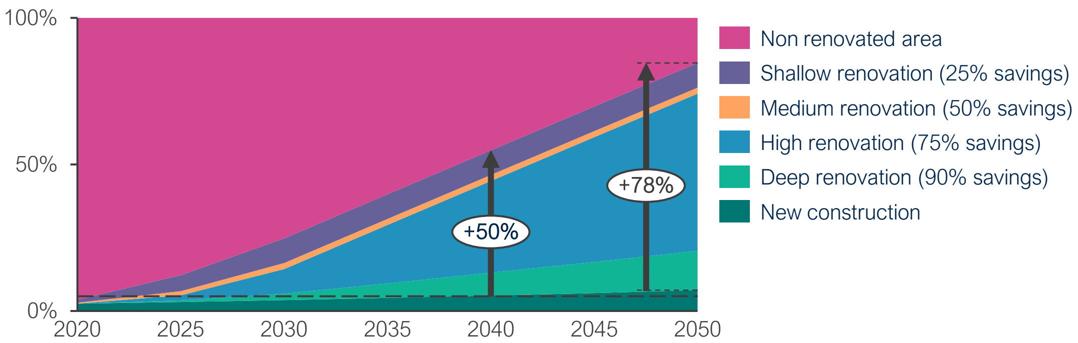
Technological mix of residential space heating



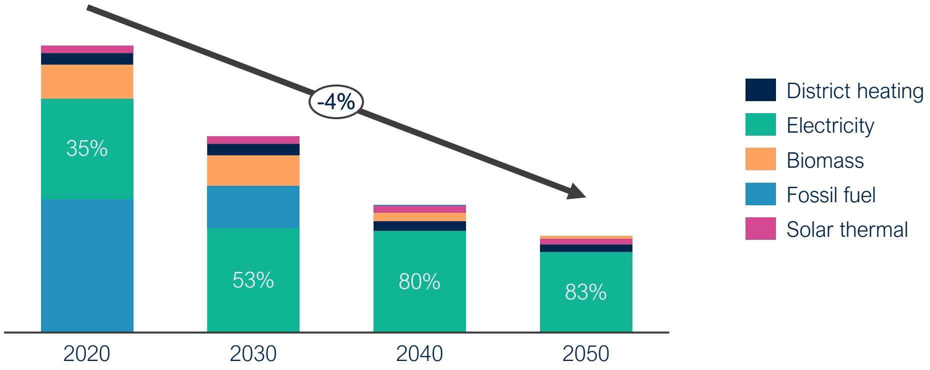
NOTES: 0. Renovation depths are constant between 2030 and 2040
1. energy+ buildings are defined as <15kWh/m²
2. 0-emission buildings are defined as <85kWh/m²

Energy efficiency and electrification of buildings (scenario -90%)

Building area evolution [%][1]



Energy consumption evolution [TWh/m²]



3% renovation rate would allow to reach around 50% of buildings renovated/build by 2040 and 78% by 2050

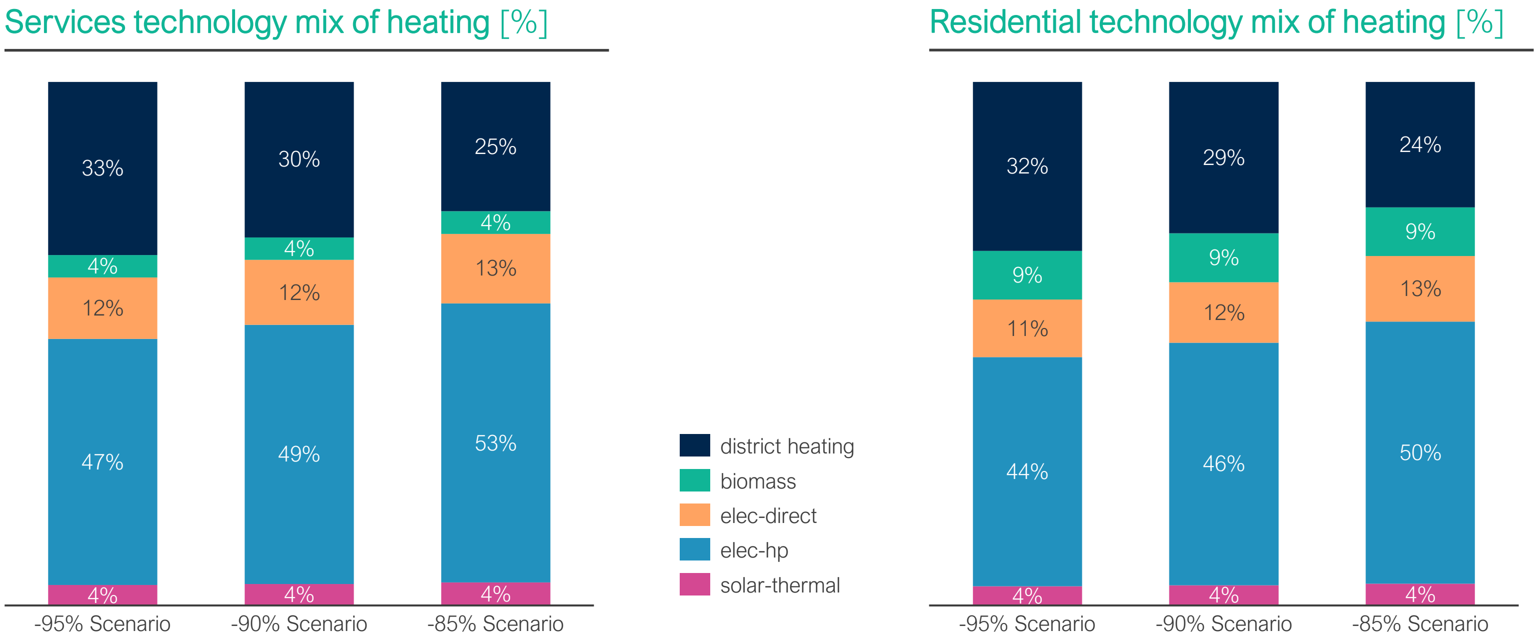
Along with the development of district heat, installing heat pumps in renovated projects at a **similar 3% rate** would allow a complete phase out of fossil fuels for 2040

Combined with societal choices, those measures allow for an **annual decrease of 4%** of energy consumption

Note: 1. energy savings: shallow = 25%; medium = 50%; high = 75%; deep= 90%
2. solar thermal demand given as equivalent TWh if heating was provided by electricity

Overview or the technology mixes

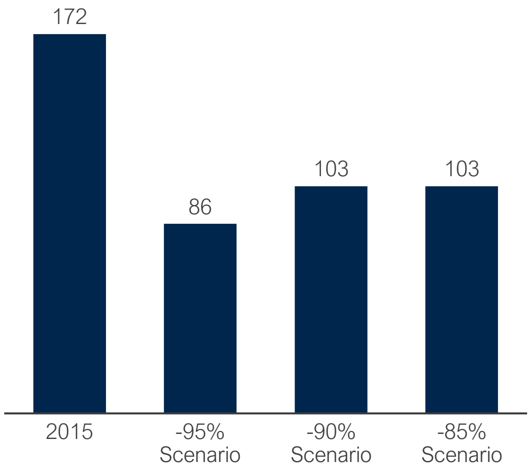
- Technology mixes of heating **is fully decarbonized by 2040** (EPBD - Energy performance of building directive)
- The three scenarios are contrasted regarding the **district heating** share and the amount of **heat pumps**



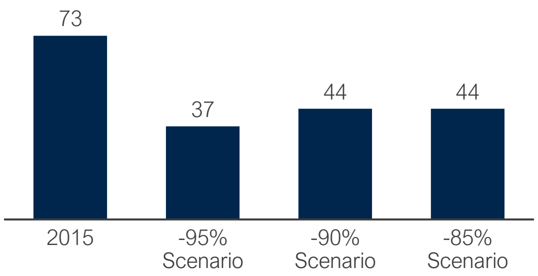
Cooling demand increases to reflect trends in South Europe

- This specific energy consumption only applies **to buildings equipped with a cooling system**

Energy need of residential [kWh/m²]



Energy need of non-residential [kWh/m²]



Overview

Cross-sector overview

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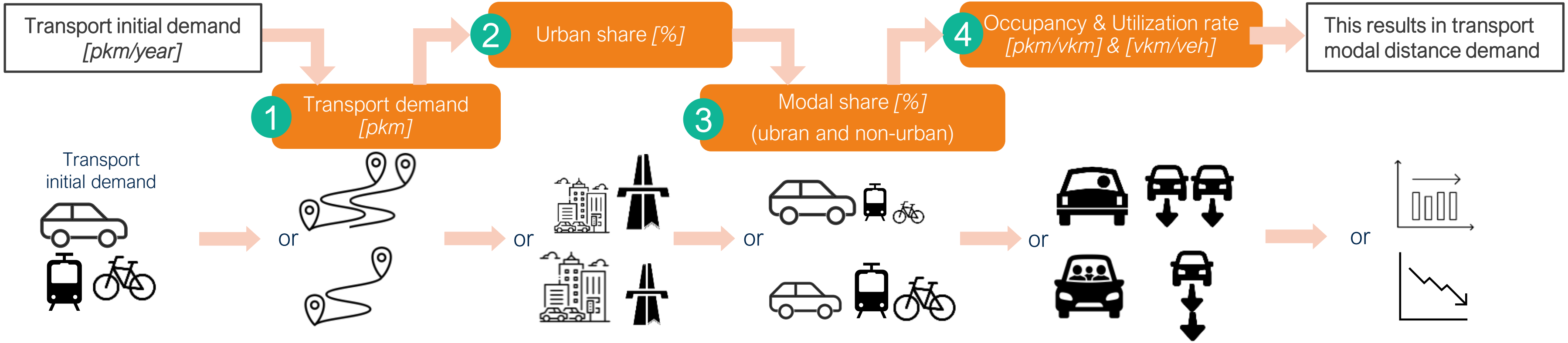
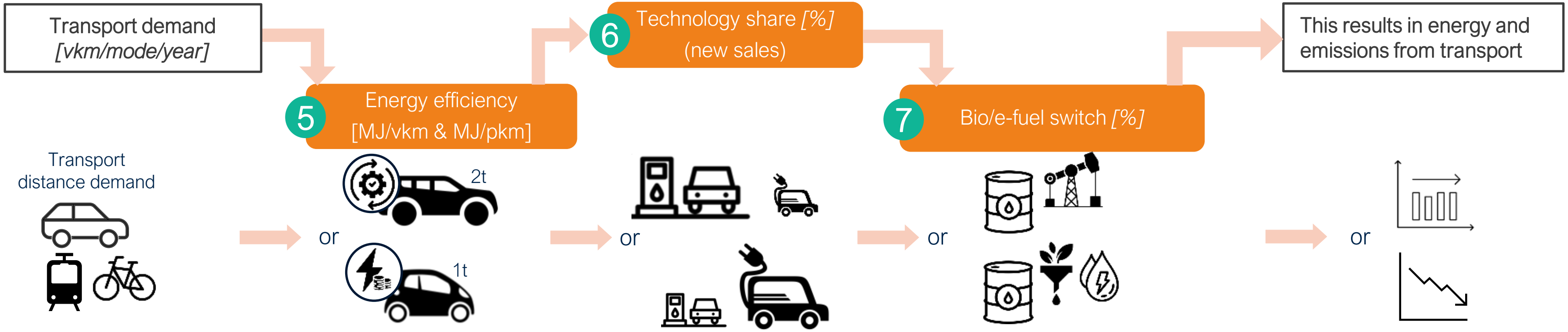
EU Low carbon scenario exploration : Transport sector

A glimpse at how our model works (1/2)



 SOURCE: Climact analysis

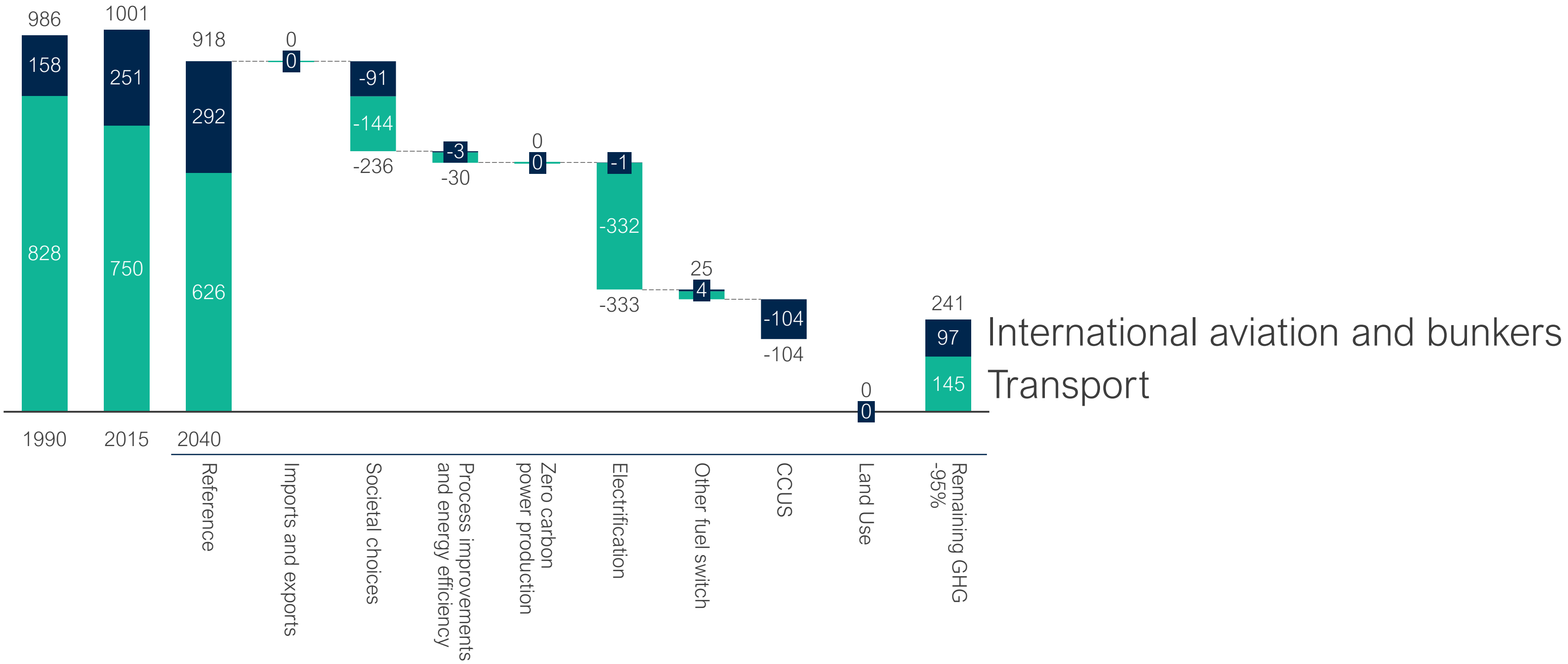
A glimpse at how our model works (2/2)



 SOURCE: Climact analysis

-95% Transport waterfall by themes

GHG emissions trajectory [$MtCO_2e$]



-90% Transport waterfall by themes

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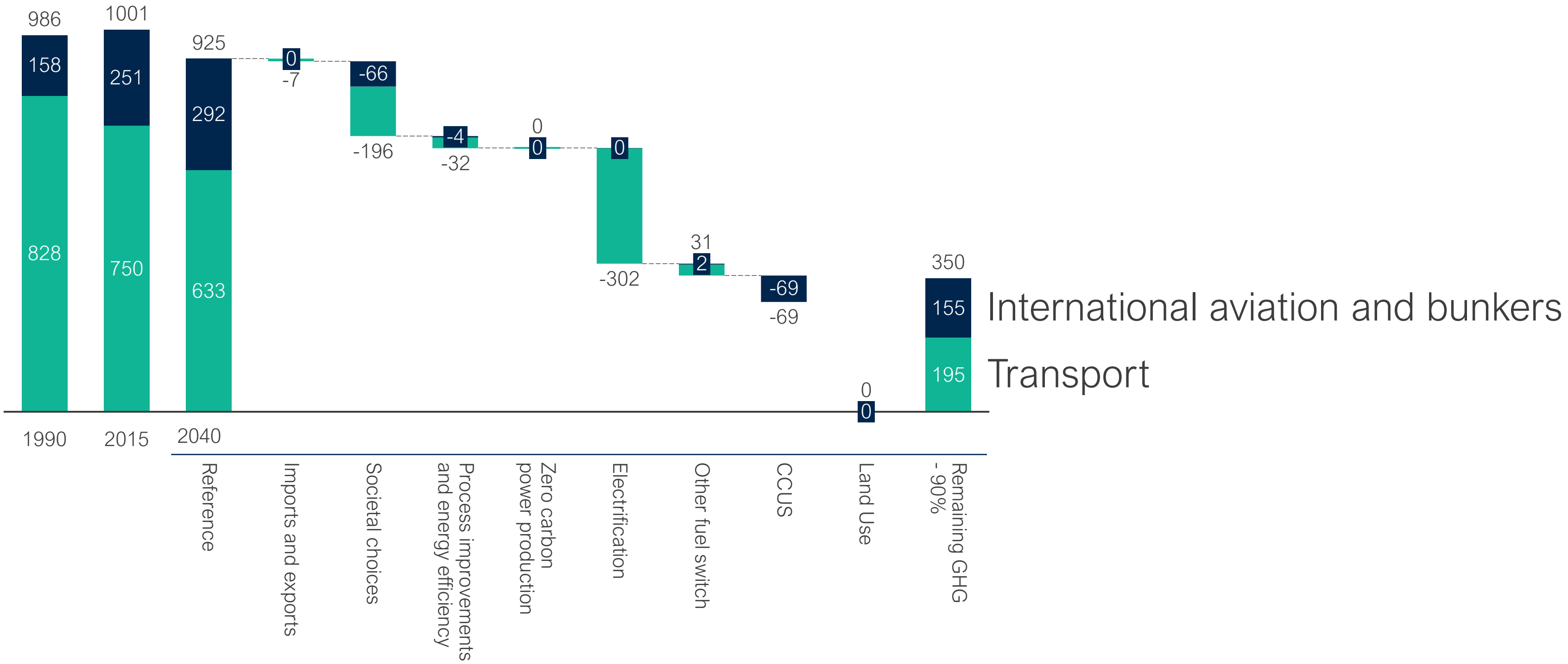
GHG emissions trajectory [$MtCO_2e$]



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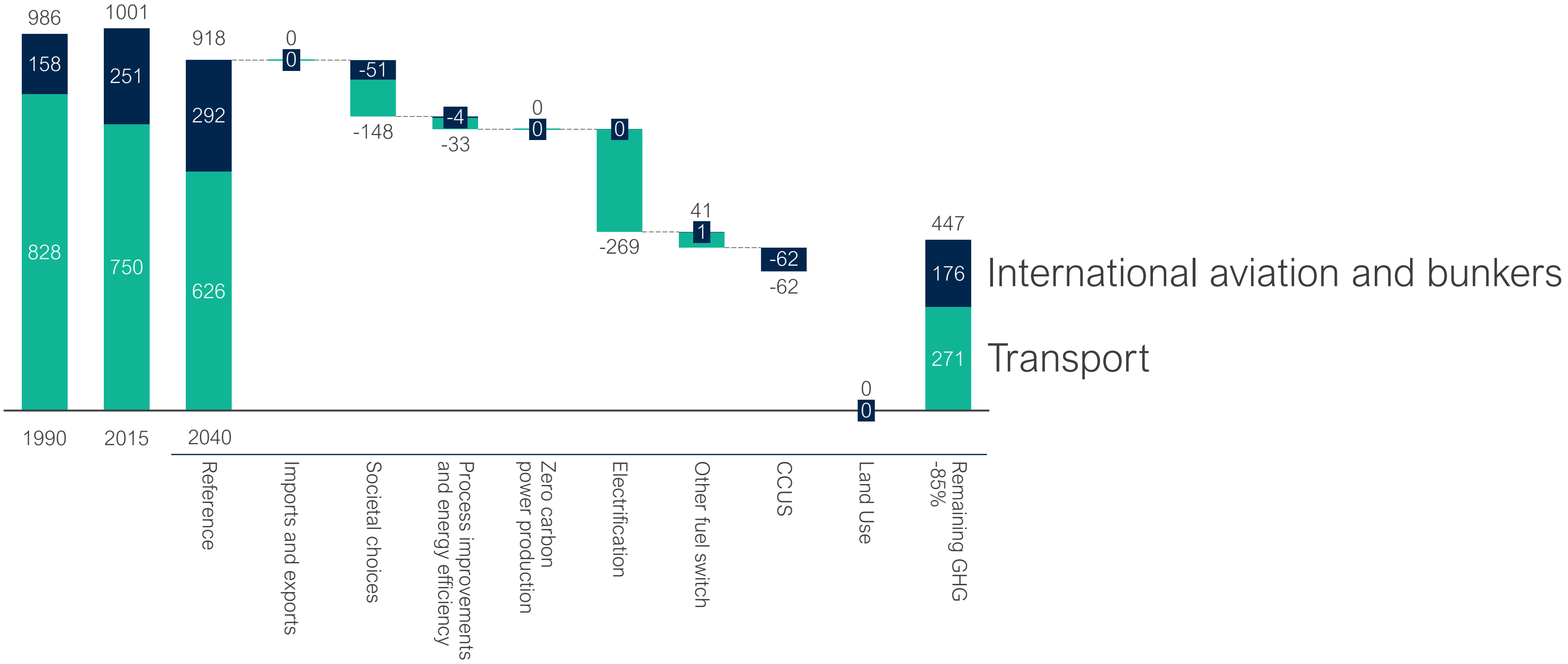
-85% Transport waterfall by themes

GHG emissions trajectory [$MtCO_2e$]



Transport

Five key take aways

1. **Electrification of car and truck fleets has the potential to cut domestic transport emissions by 50%** and significantly reduce oil consumption. By 2040, at least 84% of the total car fleet will be electric and 46% of the truck fleet.

2. **Emissions gains will be maximised if new cars, trucks and their batteries are designed to be more efficient, lighter and smaller.** For instance, eco-design measures for batteries can increase efficiency, limit its weight and ensure a sustainable use of minerals.

3. **Shifting to other modes of transport, with public transport and "mobility as a service" can reduce the car fleet by 20% while increasing mobility options.** This requires the implementation of new infrastructures in urban and rural areas, such as cycle paths, railways, intermodal connections and a system of shared cars. For international travel, air travel will be slightly reduced and replaced by trains, local tourism, or remote meetings for example.

4. **Increasing the freight modal shift of railways and waterways will contribute to reducing the number of trucks by 30%** while maintaining the objectives of European reindustrialisation.

5. **Switching to alternative fuels is the solution to decarbonise the remaining 50% of international transport emissions.** As biofuel and e-fuel supplies are limited, safeguards and priorities could be established to ensure a sustainable use.

Transport

Necessary actions

STRATEGIC PERSPECTIVES

-90% scenario

Societal choices

- Shift towards more active transport (urban) and public transportations
- High increase of the car sharing economy (shared vehicles, self-driving…)
- Significant reduction of air transport with the increase of rail (night trains,…)

Process improvements and energy efficiency

- Increased energy efficiency for vehicles
  - lighter
  - more efficient power train

Electrification coupled with zero carbon power production

- Electrification of the road transport fleet:
  - All new vehicles are EV's as of 2030
  - retrofitting of remaining park of trucks
  - H2 or alternative fuels for some heavy transport

Decarbonizing what is left

Alternative fuels (biofuels, hydrogen and e-fuels) for aviation and marine sectors

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Key assumptions for the transport sector

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Evolution to 2040 (vs 2015 for relative)				**2019**	**-95%**	**-90%**	**-85%**
Passenger	Car usage	car occupancy		1.6 people by car	1.72	1.72	1.72
		car utilization		11200 vkm/veh/y	+25%	+25%	+25%
	Transport demand	inland		12000 pkm/cap/y	+20%	+20%	+35%
		aviation		3325 pkm/cap/y	-20%	-1%	+10%
	Modal share	urban	car & 2wheels	65% & 6%	54% 7%	58% 6.5%	58% 6.5%
			public	14%	20%	18.5%	18.5%
			bike & walk	4% & 11%	7% & 12%	5.5% & 11.5%	5.5% & 11.5%
		Non-urban	car	80%	76%	77.5%	77.5%
			rail	11%	13%	12.5%	12.5%
			bus	9%	11%	10%	10%
	Technology share	BEV cars	New sales	12% (2022)	98% (2030)	95%	86%
			Fleet	3M (2022) (1%)	166M (90%)	162M (84%)	162M (75%)

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Key assumptions for the transport sector

STRATEGIC PERSPECTIVES

Evolution to 2040 (vs 2015 for relative)				2019	-95%	-90%	-85%
Freight	Demand	inland		2390 billion tkm	-20%	-10%	-5%
		Intern. bunkers		13180 billion tkm	-13%	-6%	-4%
	Territory Modal share	road		71%	61%	63%	66%
		rail		17%	23%	22%	20%
		IWW		12%	16%	15%	14%
	Technology share (road)	diesel		100%	39% (1.47M)	48% (2M)	55% (2.4M)
		electric		0%	54% (2.07M)	46% (1.92M)	39% (1.7M)
		hydrogen		0%	6% (0.27M)	6% (0.27M)	7% (0.3M)
Freight & passenger	Fuel switch	aviation	biofuel	0%	22%	22%	22%
			e-fuel	0%	41%	24%	24%
		marine	biofuel	0%	0%	0%	0%
			e-fuel	0%	50%	30%	20%

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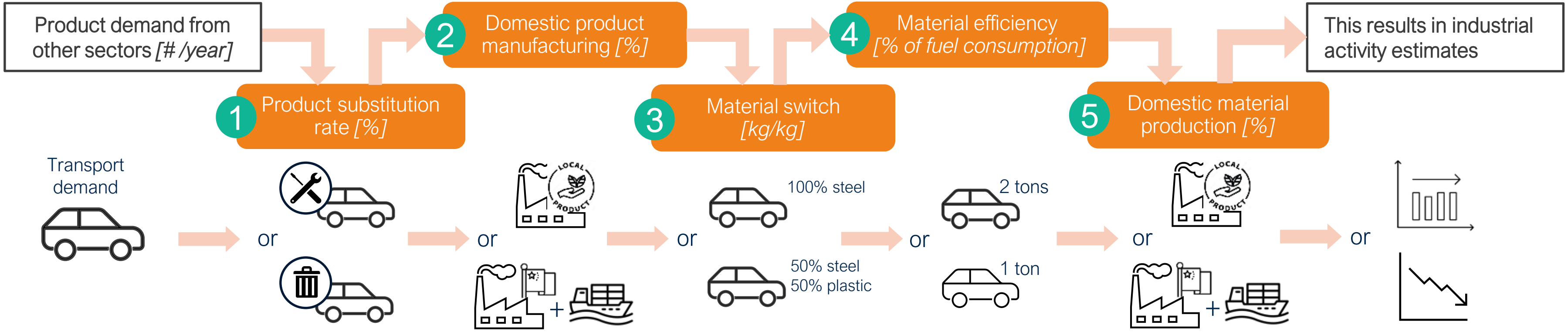
- 2) Transport
- **3) Industry**
- 4) Energy supply
- 5) AFOLU

EU Low carbon scenario exploration : Industry sector

A glimpse at how our model works : Example of steel demand from cars (1/2)



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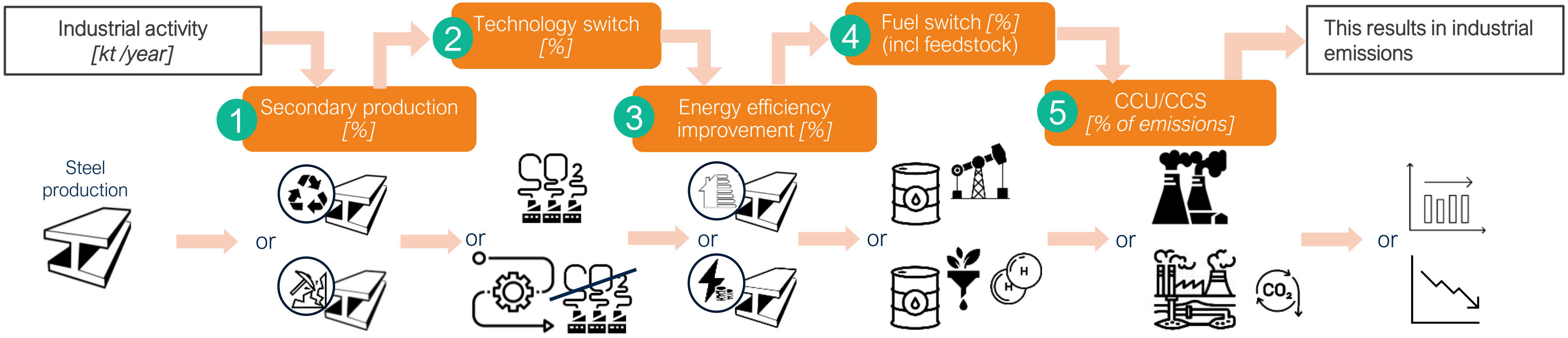
 SOURCE: Climact analysis

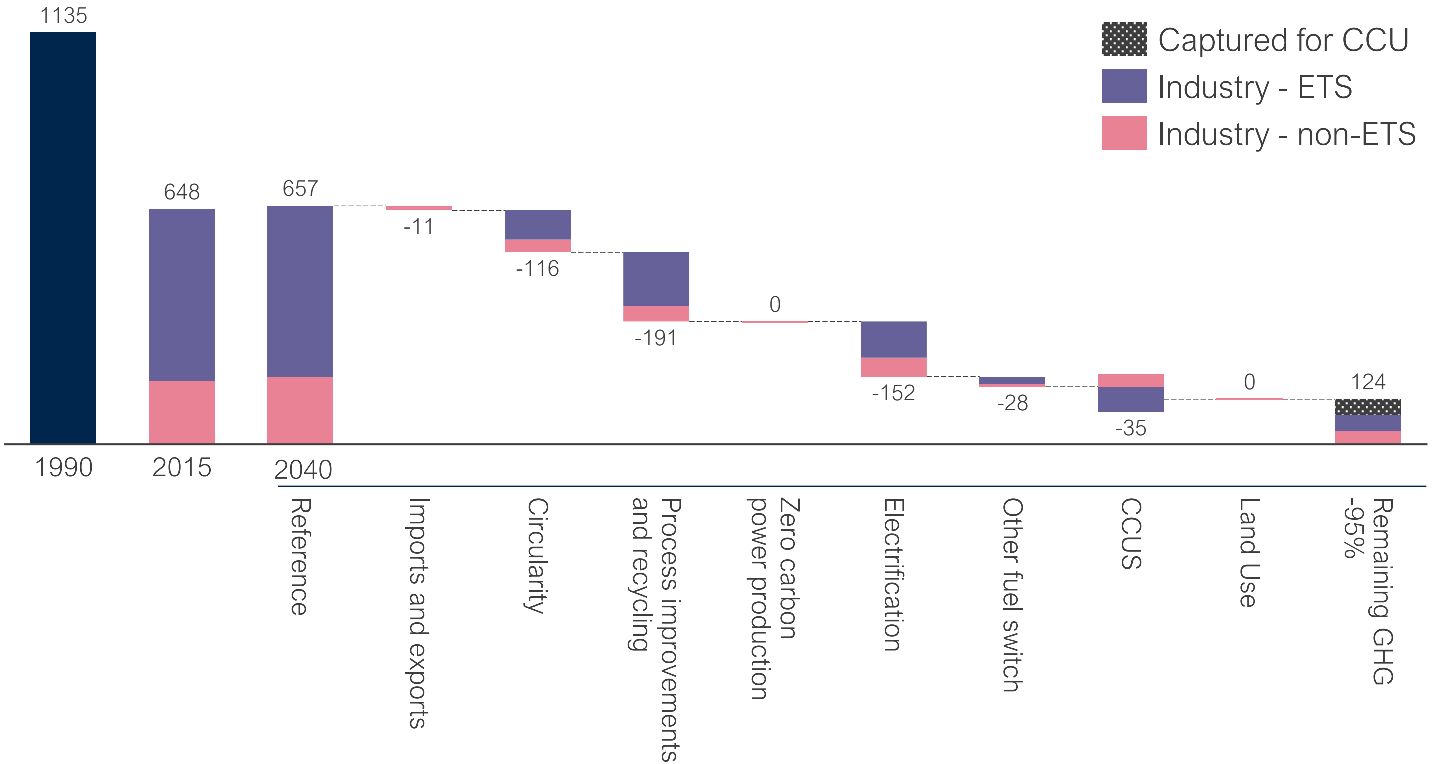
4 levers specify the industrial activity : Example with cars



 SOURCE: Climact analysis

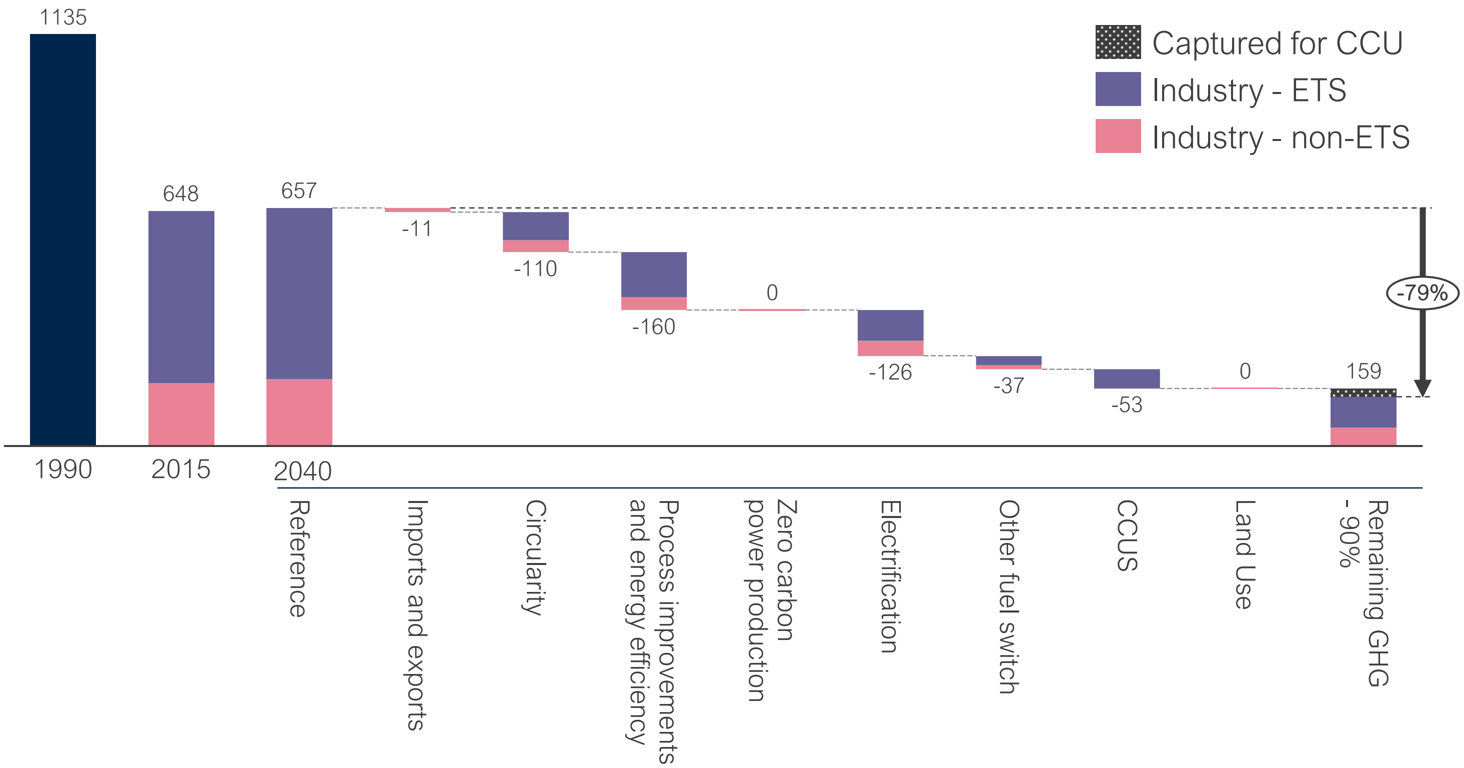
-95% Industry waterfall by themes

GHG emissions trajectory [$MtCO_2e$]



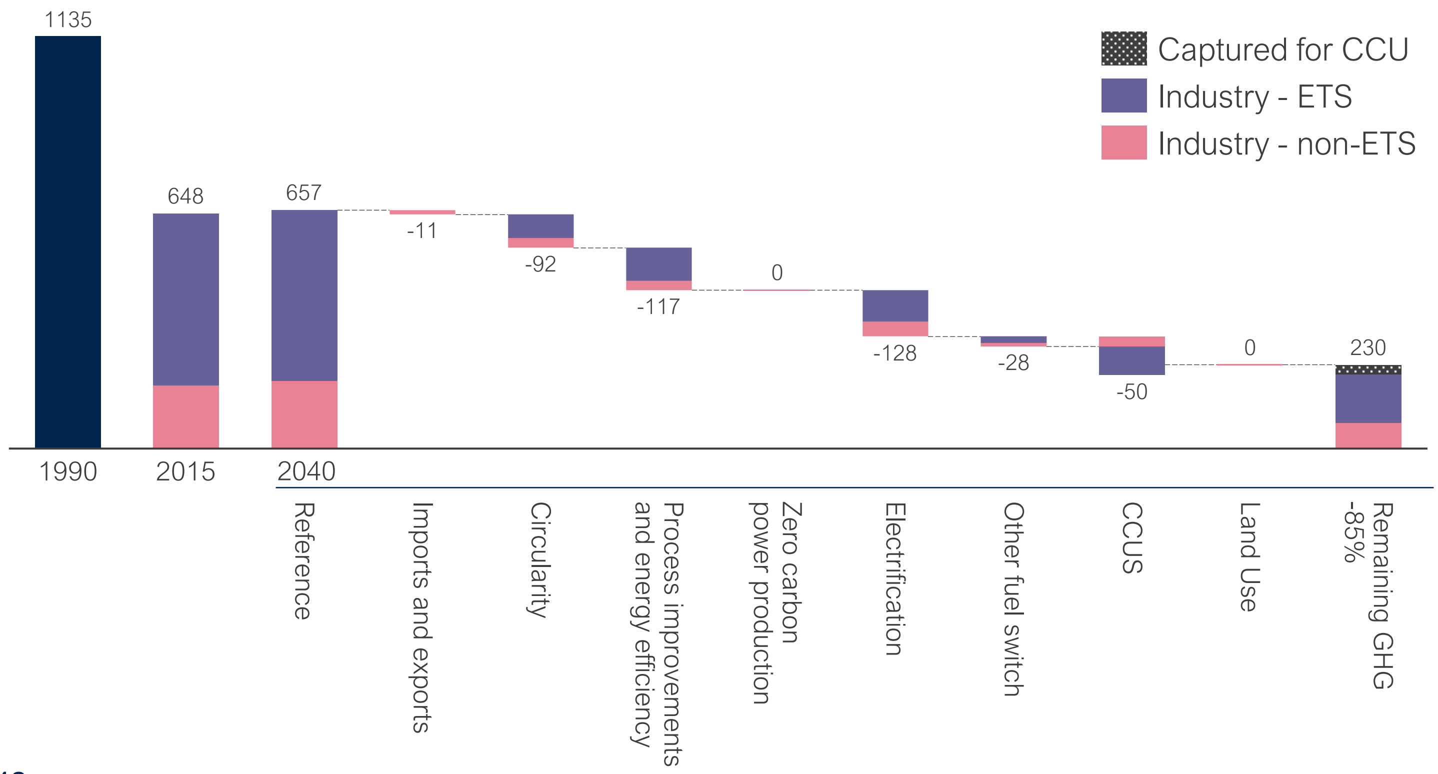
-90% Industry waterfall by themes

GHG emissions trajectory [$MtCO_2e$]



-85% Industry waterfall by themes

GHG emissions trajectory [$MtCO_2e$]



Industry

Five key take aways

1. **Emissions in the industry sector can be substantially reduced by using raw materials with efficiency and promoting circularity. The lower material production can reduce emissions by 20%.** In addition, material efficiency (less cement for the same building, lighter cars, etc.), material longevity (reuse and repair) and material switch to sustainable alternatives (clay instead of cement, wood instead of steel) are key measures to be implemented in this regard.

2. **Increase in recycling completes the industrial circularity and allows for an additional 25% of emissions reduction**, thus resulting in almost 50% emissions reductions through the “reduce-reuse-recycle” scheme. A potential driver for the scheme is to switch from an economy of goods to an economy of services as it pushes companies to produce long-lasting and reparable products. Indirect and direct electrification of industrial processes is key and enables the industry to reach an additional 25% emissions reduction. Low- and mid-temperature heat demand can promptly be supplied by heat pumps (i.e. for the food industry), so can some high temperature demand via electric heating (i.e. glass). When direct electrification is not possible, green hydrogen and low-carbon technologies can be deployed (i.e. for steel, green ammonia).

3. **Alternative fuels will likely be used for feedstock production and limited for energy supply.** Decarbonisation through bio and e-fuel energy switch is prioritised for feedstock production (i.e. plastic) and this substitution allows to compensate downstream emissions in waste treatment.

4. **Carbon capture is only applied to the remaining process emissions,** sequestering 56 million tonnes and utilising 35 million tonnes for e-fuel production (i.e. for maritime and aviation). The necessary infrastructure can already be planned now. The narrow application of carbon capture ensures that the main efforts and investments go into emission reductions.

Industry

Necessary actions

-90% scenario

Circularity

- Shift towards a sharing economy for goods
- Development of circular behaviors (Reduce, Reuse & Recycle)

Process improvements and energy efficiency

- Switch to more sustainable materials (and less primary raw materials) when possible
- …and products ready for recycling

Electrification coupled with zero carbon power production

- Massive investment in electrification of low- and mid-temperature processes.
- H_2 for some heavy industries (steel,…) and ammonia

Decarbonizing what is left

- Alternative fuels (biofuels, hydrogen and e-fuels) for remaining high-temperature processes
- Carbon capture only applied for industries with high process emissions (cement,…) and limited in industries where full decarbonization technologies are possible, to avoid lock-in effects (steel,…)
- CO_2 either stored (CCS) or used in building material CCU products

Key assumptions for the industry sector

Evolution to 2040			2019	-95%	-90%	-85%
Production level*	Steel		150 Mt	-17%	-17%	-15%
	Aluminium		5Mt	maintained	maintained	+2%
	Cement		173 Mt	-25%	-22%	-17%
	Chemicals olefin & ammonia		80Mt & 47Mt	-28%	-28%	-25%
Secondary share	Steel		41%	76%	68%	60%
	Aluminium		46%	81%	75.4%	72.4%
	Cement non-clinker		25%	39%	36%	34%
	Chemicals olefin		6%	47%	41%	35%
Technology and fuels	Primary steel	H2-DRI	0%	82%	65%	54%
		BF-BOF	100%	18%	35%	46%
	Industry electrification (excl. feedstock)		32%	75%	63%	57%
Carbon Capture	2030		0MtCO2	18Mt	18Mt	20Mt
	2040		0MtCO2	36Mt	36Mt	45Mt

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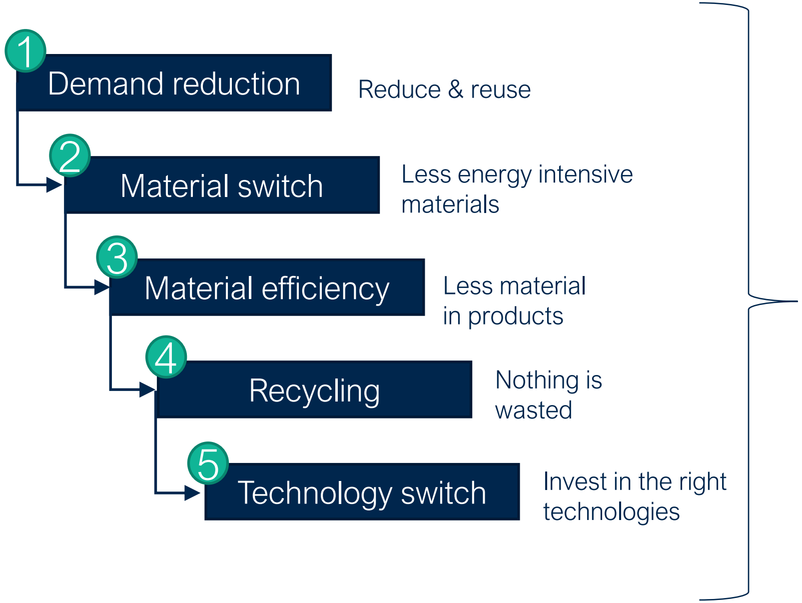
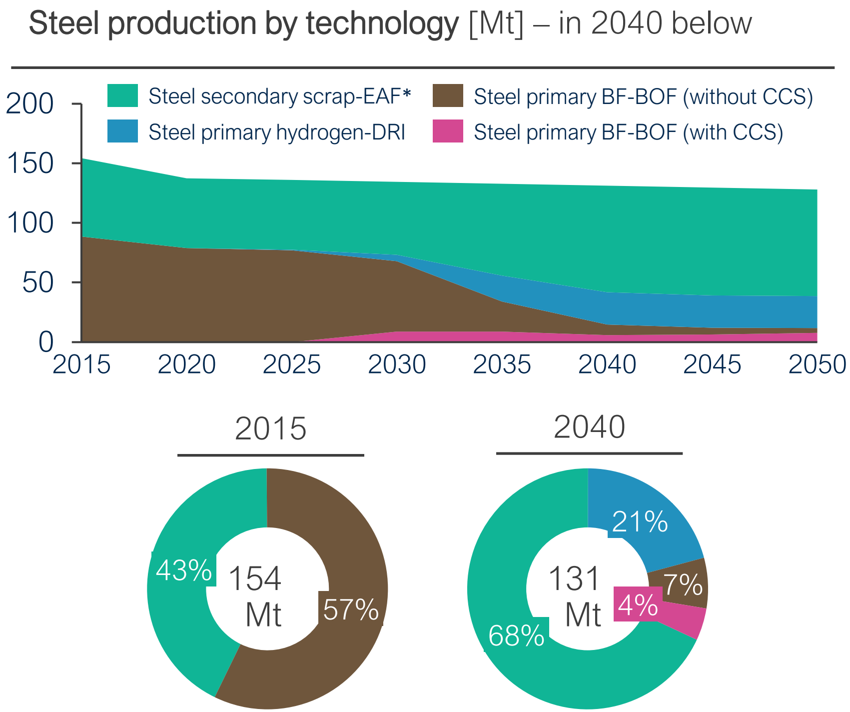
The steel example: The decarbonization of the steel industry results from a sequence of measures



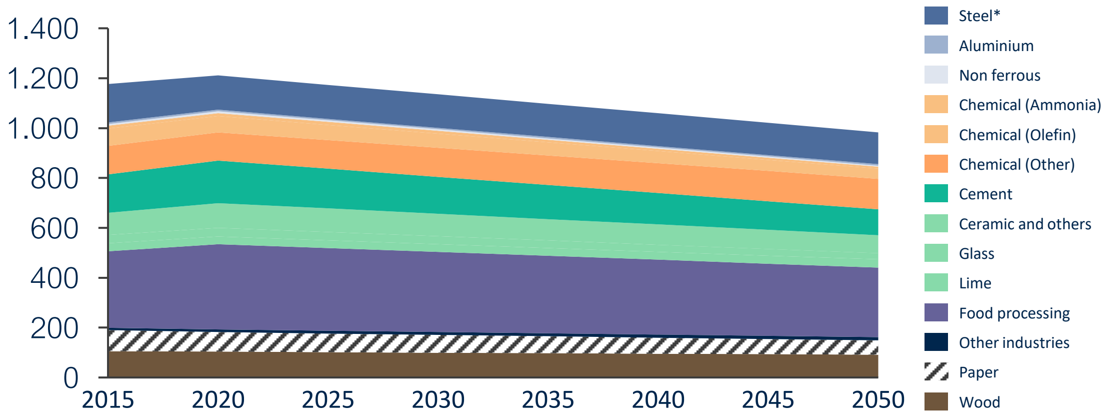


Note: 1. EAF: Electric arc furnaces route, often used to produce recycled steel nowadays
2. BF-BOF: Blast Furnace-Basic Oxygen Furnace, often used to produce primary steel nowadays

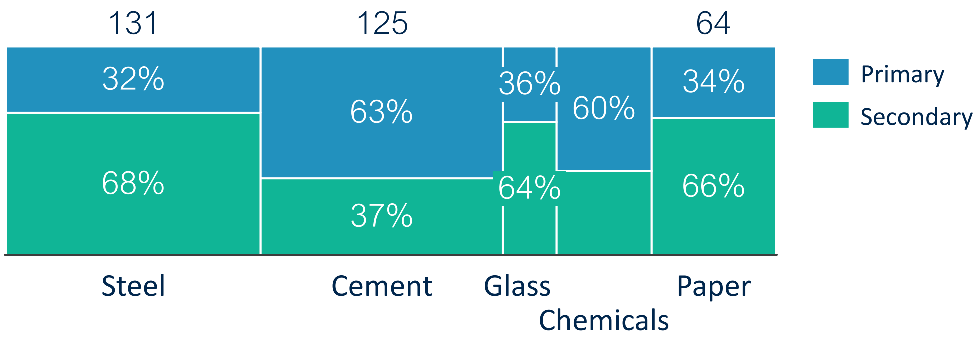
Circular economy is at the center of industrial transformation (-90%)

STRATEGIC PERSPECTIVES

Evolution of material production [Mt]



Share of primary and recycling in 2040 [Mt - %]



	NUMBER OF PRODUCTS	MATERIAL USE AND COSTS
TREND	Fewer new products	Less material per product
RATIONALE	Changes in social patterns and the impact of the functional economy	Better product design, less waste Less factory capacity required

	EMISSIONS AND ENVIRONMENTAL COSTS & RISKS	VALUE PER PRODUCT	MAINTENANCE & SERVICES
TREND	Lower emissions and waste costs per product	More value per product (last longer, better utilisation)	More revenues
RATIONALE	Less materials, less emitting materials, less emitting manufacturing technologies	More R&D investments per product Higher added value materials	More maintenance revenues More services to increase asset utilisation

Overview

Cross-sector overview

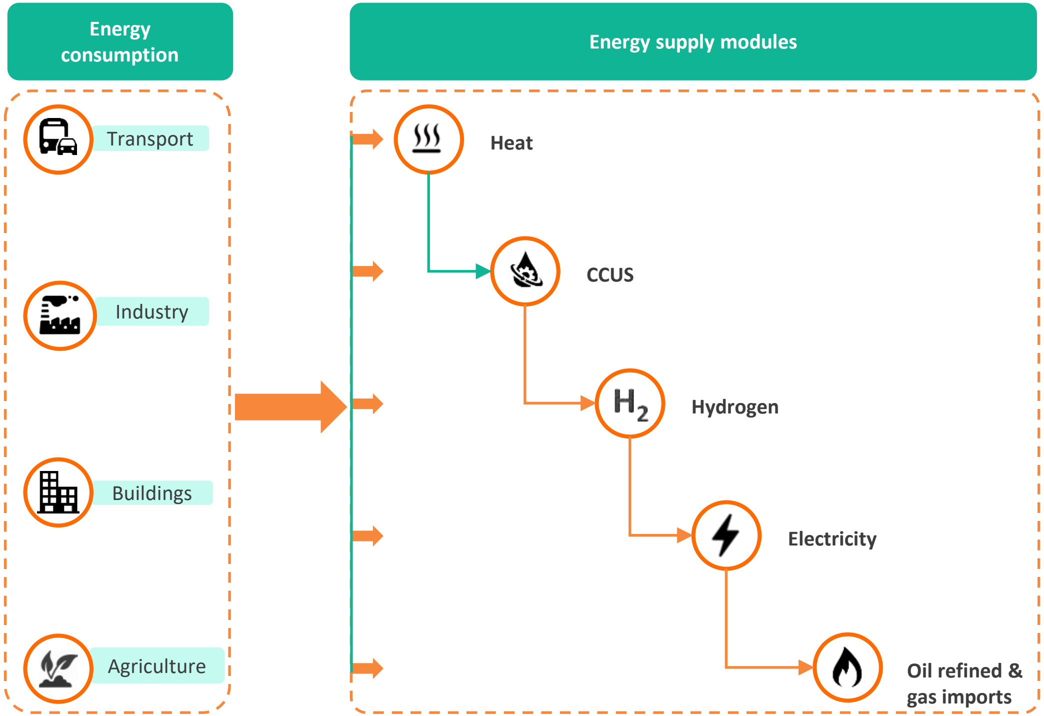
- 1) Buildings
- 2) Transport
- 3) Industry
- **4) Energy supply**
- 5) AFOLU

EU Low carbon scenario exploration : Energy supply sector

A glimpse at how our model works (1/2)

STRATEGIC PERSPECTIVES

Energy consumption is addressed by the energy supply sector, through 5 supply modules, each using a mix of technologies



Production technologies

- Thermal power plants
  (coal, gas, oil, nuclear, biomass)
- Fischer-Tropsch process (with Methanation)[1]
- • Electrolysis
  • (Steam reforming not modelled yet)
- • Production
    - Fossil Power plants (Coal , Natural gas, Oil)
    - Nuclear power plant,
    - RES plants :
      - Biomass (gas, solid),
      - Sun (PV, and CSP),
      - Wind (On-shore, Off-shore)
      - Marine,
      - Geothermal,
      - Hydro, and
      - Waste
  • Distribution and transmission losses
- Fossil : oil refinery

Note: 1. Fischer-Tropsch process: Process to produce a variety of hydrocarbons based on H_2 and Carbon monoxyde

SOURCE: Climact analysis

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A glimpse at how our model works (2/2)

Within each module, the calculation logic is as follows

1 Energy demand from other sectors [GWh]

This is determined endogenously (through the model in the other sectors), unless a lever specifies exogenous demand [1]

2 Energy Imports & Exports [% demand addressed domestically]

This lever determines the share of energy produced domestically

What is produced domestically

3 Technology switch [% share of each technology]

This lever determines the share of each technology in the energy production mix

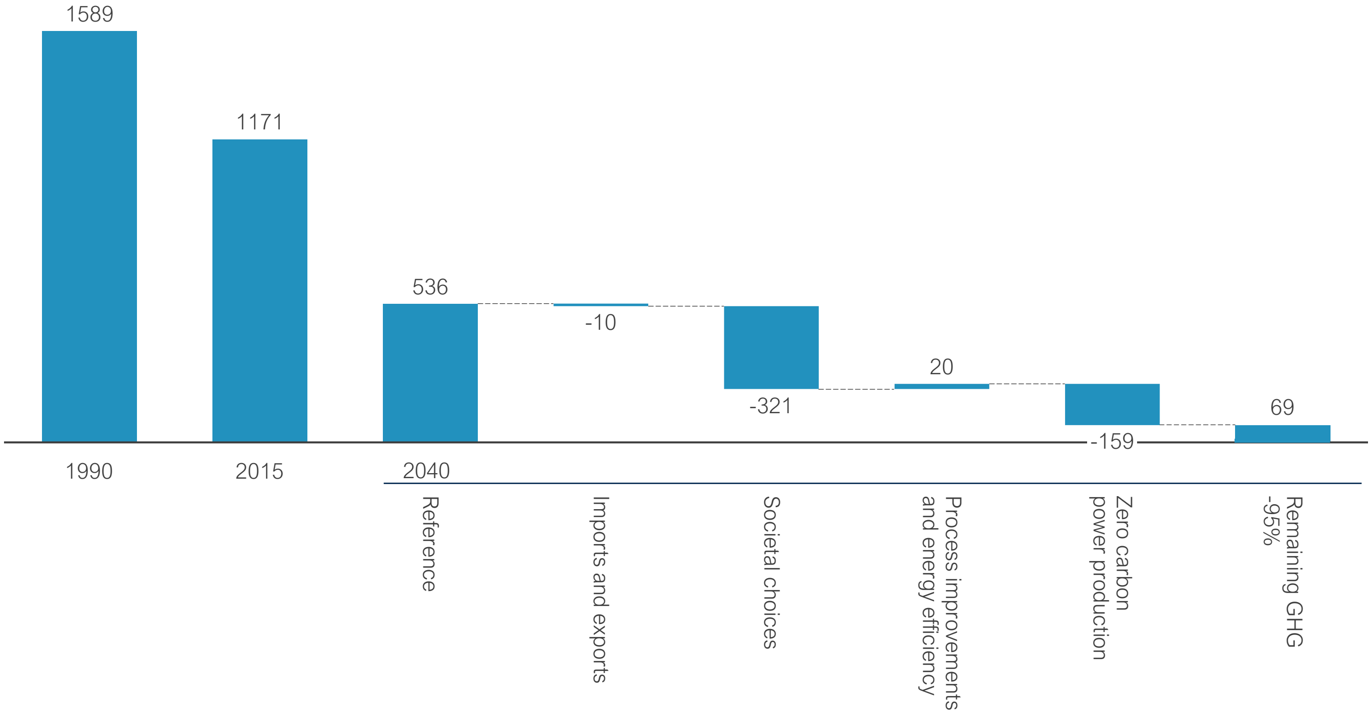
4 Energy efficiency [% reduction in energy consumption]

This lever determines the energy efficiency of each energy production technology

NOTE: (1) Refineries can specify an exogenous demand

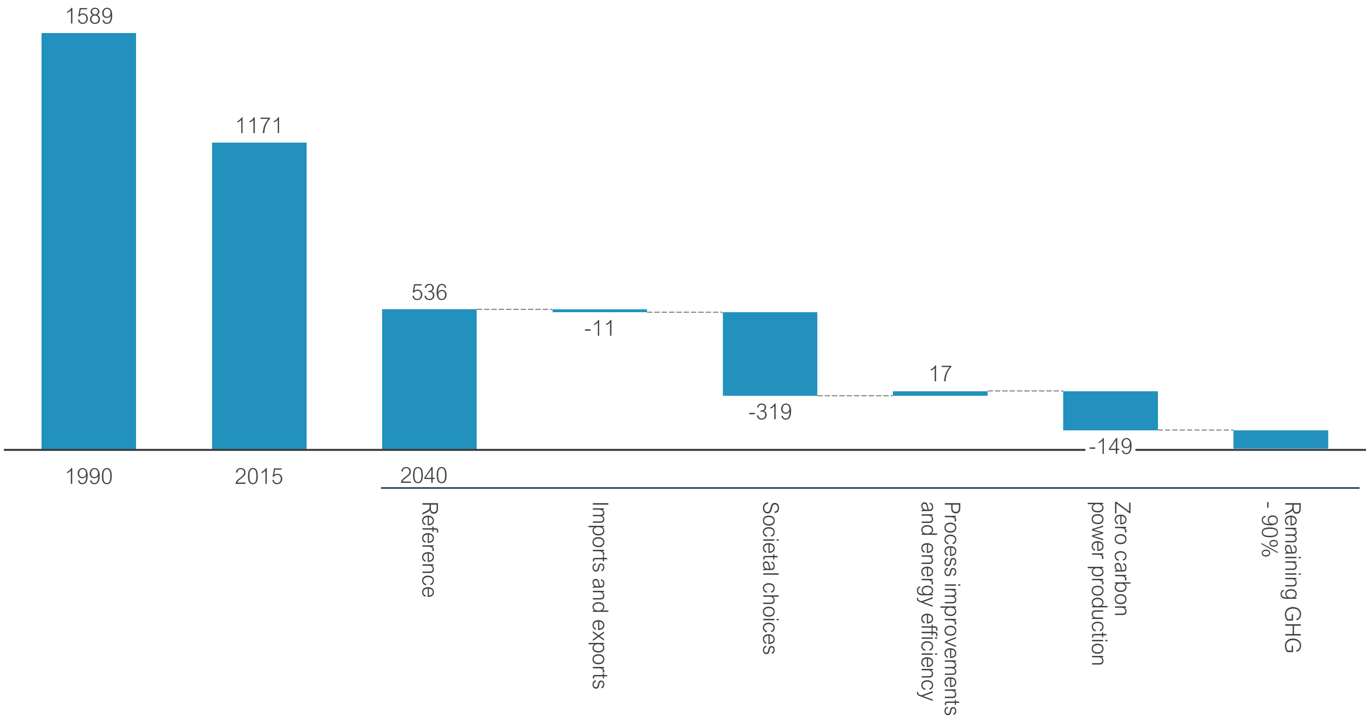
-95% Energy supply waterfall by themes

GHG emissions trajectory [$MtCO_2e$]



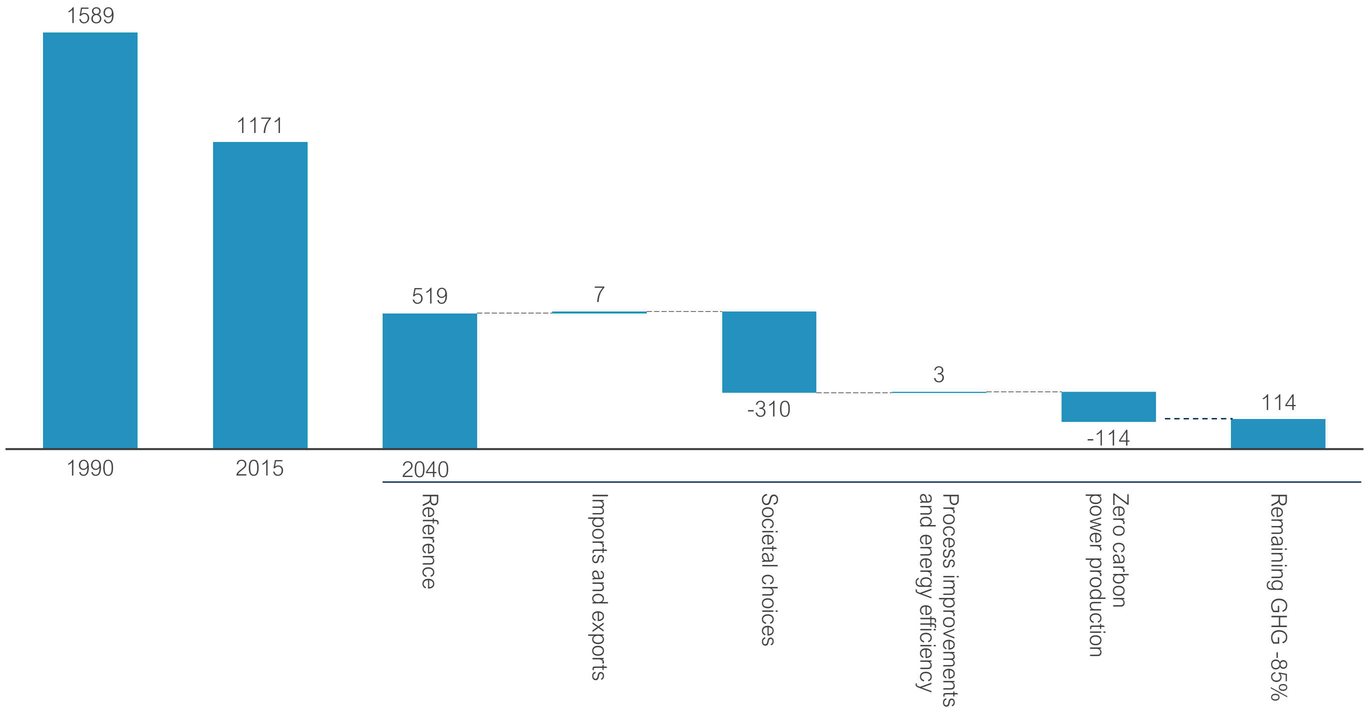
-90% Energy supply waterfall by themes

GHG emissions trajectory [$MtCO_2e$]



-85% Energy supply waterfall by themes

GHG emissions trajectory [$MtCO_2e$]



Five key take aways

1. **Demand reduction and energy efficiency** are the most impactful measures to reduce emissions in the energy sector and limit additional energy needs. A high degree of electrification across sectors leads to an overall increase in electricity demand. Only through adding zero-carbon energy can the decarbonisation of sectors succeed.

2. The installed capacity of **solar photovoltaics and wind energy** is envisaged to be nearly multiplied by a factor of 7 between 2020 and 2040, keeping almost trend as the deployment required for the 2030 renewable target. This rate allows for a full decarbonisation of the power sector as of 2035 in line with the G7 pledges and capping the use of biomass for power at current levels.

3. A key task for policymakers remains to design an orderly **phase down of coal and gas use with just transition efforts**. While the carbon market will reduce fossil fuel use for power substantially, accompanying measures are needed to secure job prospects for the workforce.

4. The main applications for **green hydrogen are ammonia, steel and e-fuel production** (for maritime and aviation sectors). The decarbonisation of the international transport sectors requires the biggest amount of hydrogen in 2040. The associate electricity demand is equivalent to 14% of total electricity demand in the -90% scenario.

5. **Careful policy choices are necessary between Carbon Capture and Storage (CCS) and e-fuels production** to avoid incentivizing CO2 capture when other decarbonisation routes are preferable (risk of lock-in effects). Direct Air Capture (DAC) is considered too energy-intensive and expensive until 2040 and thus plays an insignificant role in the present analysis.

NOTES:

(1) The model is mainly focused on base load capacities. It is not equipped to answer precise questions on the need to use fossil (or others fuels) for flexibility purposes

(2) The model doesn't take into account green H_2 to store electricity for the power sector. Additional H_2 production could be considered for this purpose

Energy supply

Necessary actions

-90% scenario

Societal choices

- /

Process improvements and energy efficiency

- growing deployment on renewables-based technologies (electrolysers, renewables,…)

Electrification coupled with zero carbon power production

- Significant investment in renewables from citizens, private and public sector
- Phase-out of fossil-fuel electricity generation capacities
- Massive investment in infrastructure and storage technologies

Decarbonizing what is left

- No carbon capture in the energy sector

Key assumptions for the energy supply sector

STRATEGIC PERSPECTIVES

Evolution to 2040		2019	-95%	-90%	-85%
Electricity demand		2.65 TWh	3.82 TWh	3.74 TWh	3.84 TWh
Phase-out Gas (excl. CHP)		123.38 GW	0% by 2034	0% by 2037	Out by 2040
Phase-out Coal		116.54 GW	Out by 2030[1]	Out by 2030[1]	Out by 2030[1]
CCS in electricity generation		None	None	None	None
Nuclear evolution		117.66 GW	Capacity decreases by 10% by 2040	Capacity decreases by 10% by 2040	Capacity decreases by 10% by 2040
Solar PV		85.15 GW	Increase to 1060 GW	Increase to 862 GW	Increase to 862 GW
Wind	On shore capacity	121.35 GW	Expand to 652 GW	Expand to 571 GW	Expand to 571 GW
	Off-shore capacity	5.9 GW	Expand to 195 GW	Expand to 195 GW	Expand to 195 GW
Green H2 production for sector demand		None	113 TWh	118 TWh	117 TWh
Green H_2 for e-fuels production		None	425 TWh	290 TWh	297 TWh
E-fuels production		None	351.53 TWh	245.32 TWh	250.93 TWh
Phase-out of Biomass (by 2050)		6.53 GW	67.7% decrease to 2.11 GW	67.7% decrease to 2.11 GW	67.7% decrease to 2.11 GW

NOTE: Minor coal left in the webtool, due to modelling limitations

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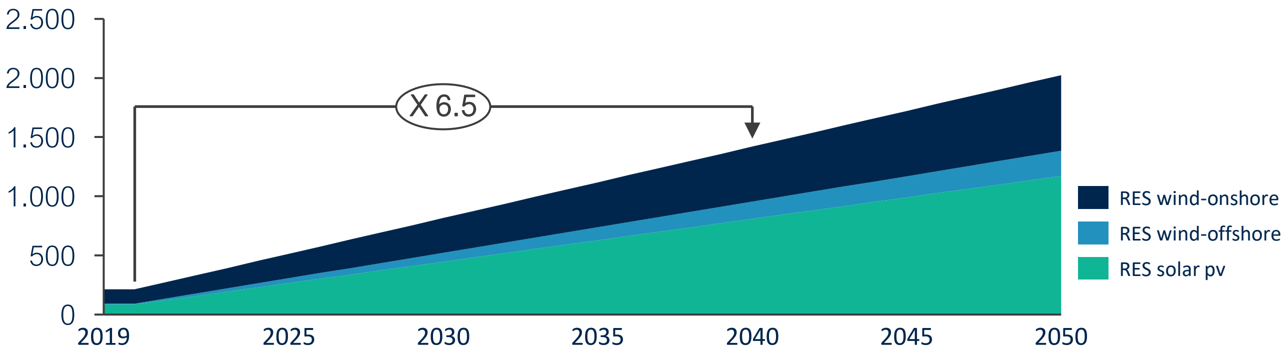
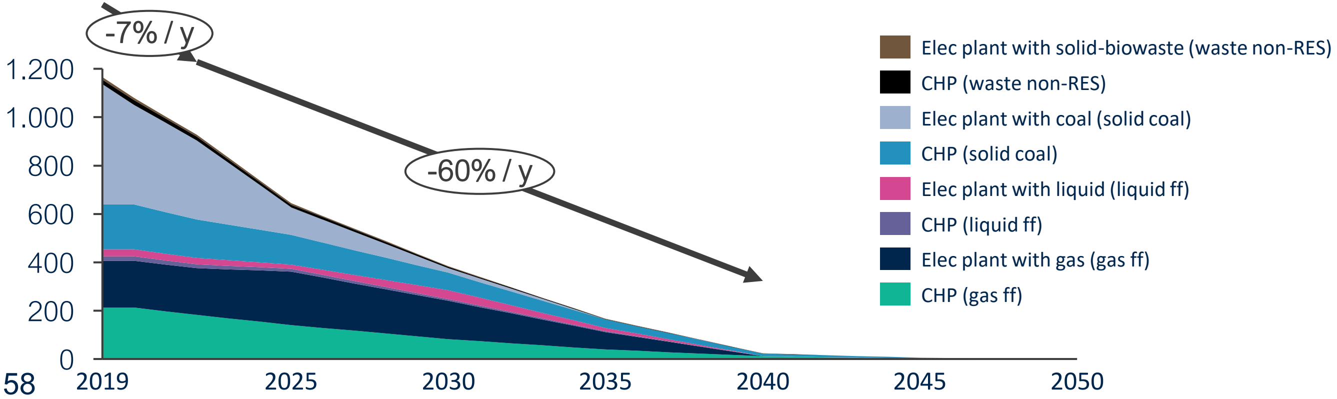
A fast ramp-up in RES is necessary to allow for a phase-out of fossil fuels

Installation of new renewable capacities, SP-90% scenario [GW]

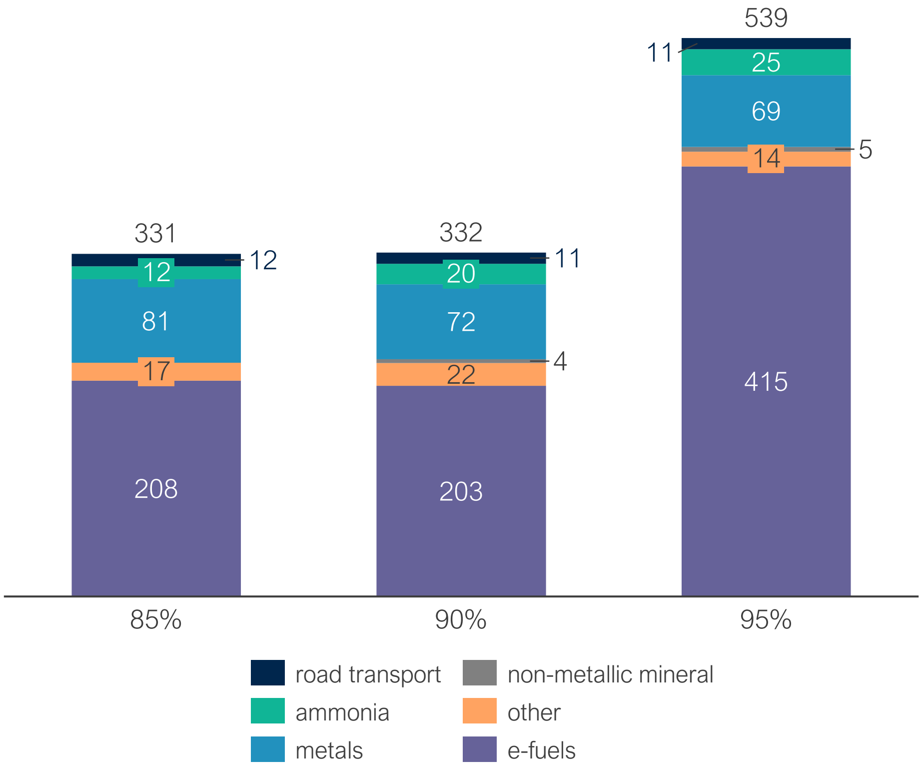


Fossil fuel phase-out in electricity generation [TWh]



H_2 and e-fuels

Hydrogen demand per end-use [MWh]



Most hydrogen is produced inside of the EU27. Some trade inside the EU27 is however necessary from countries with higher RES production to countries with lower RES potential

H_2 is fully green as of 2035

Overview

Cross-sector overview

- 1) Buildings
- 2) Transport
- 3) Industry
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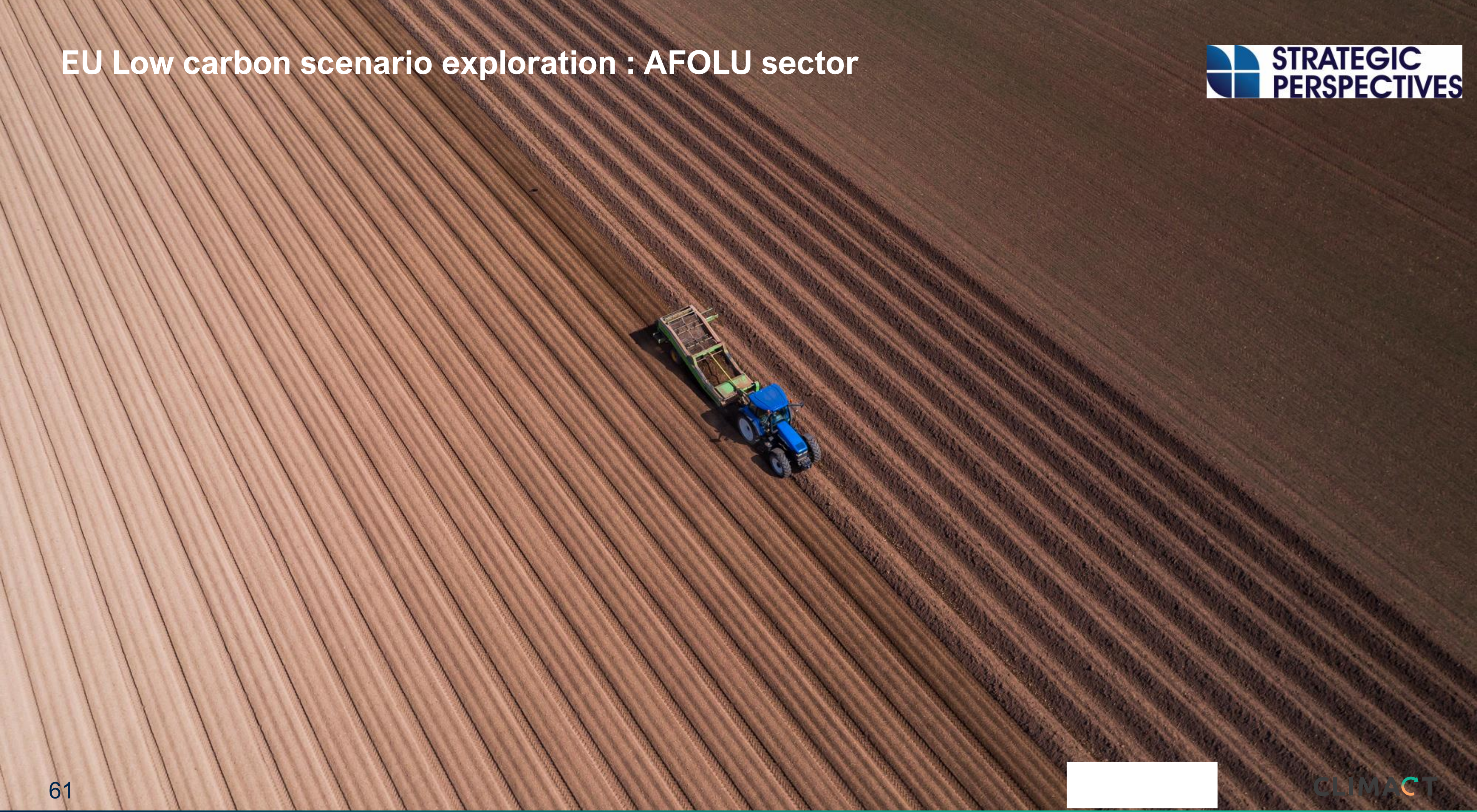
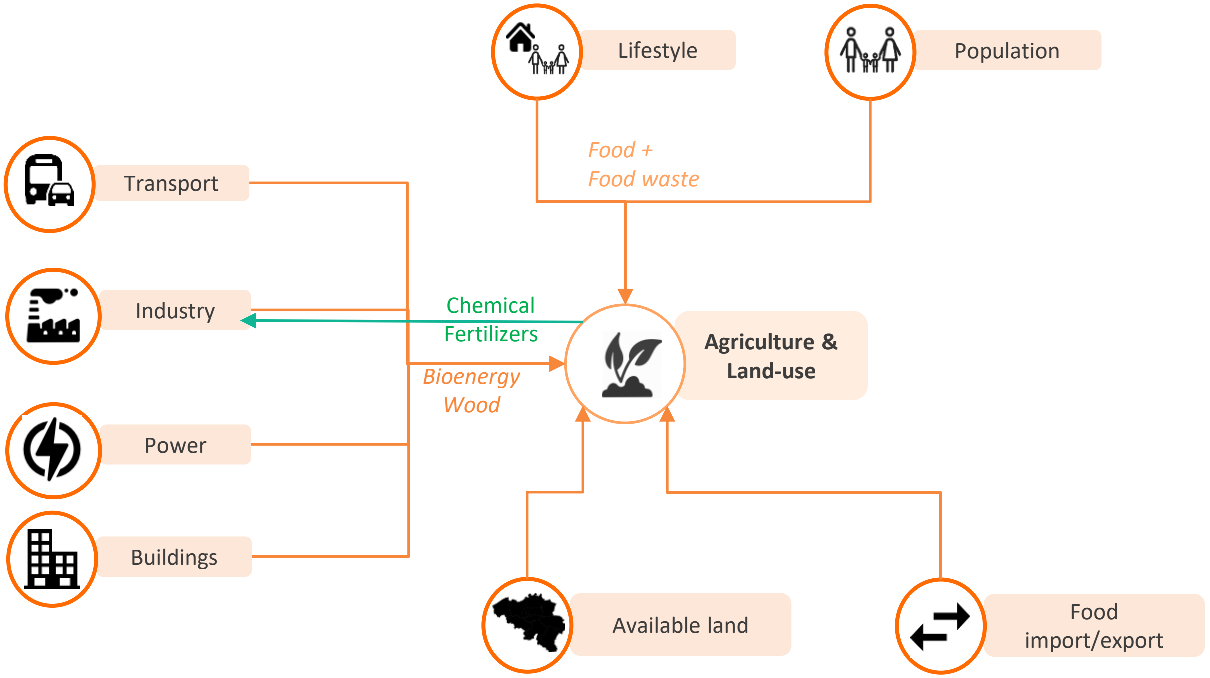
- 5) AFOLU

EU Low carbon scenario exploration : AFOLU sector



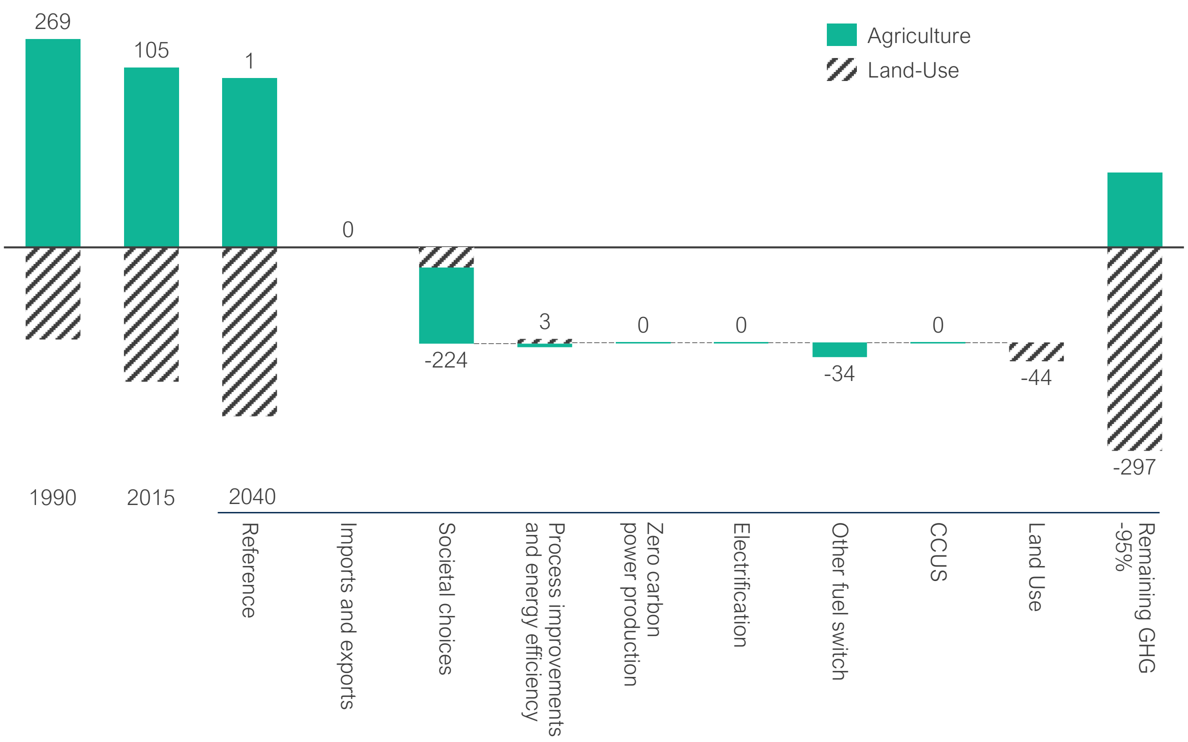
A glimpse at how our model works

The agriculture module answers the demand for food and bioenergy from other sectors



-95% AFOLU waterfall by themes

GHG emissions trajectory [$MtCO_2e$]



-90% AFOLU waterfall by themes

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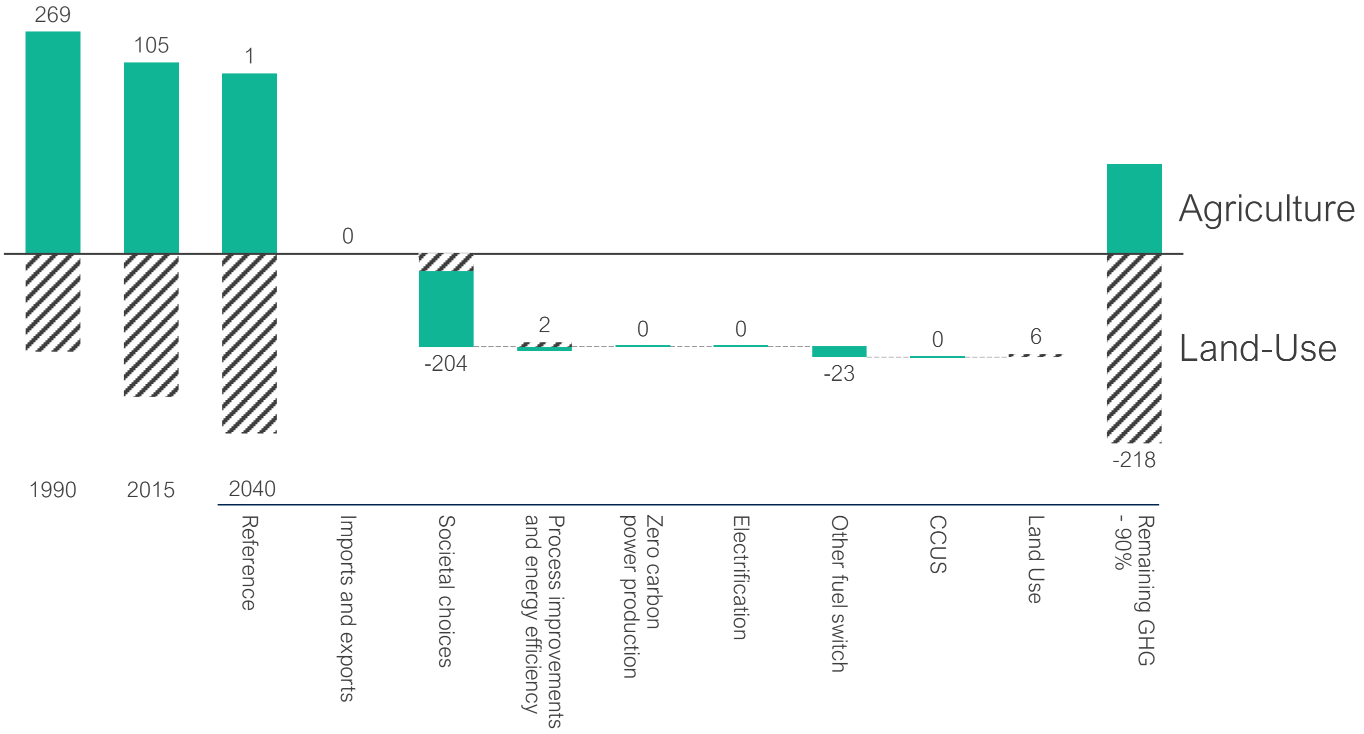

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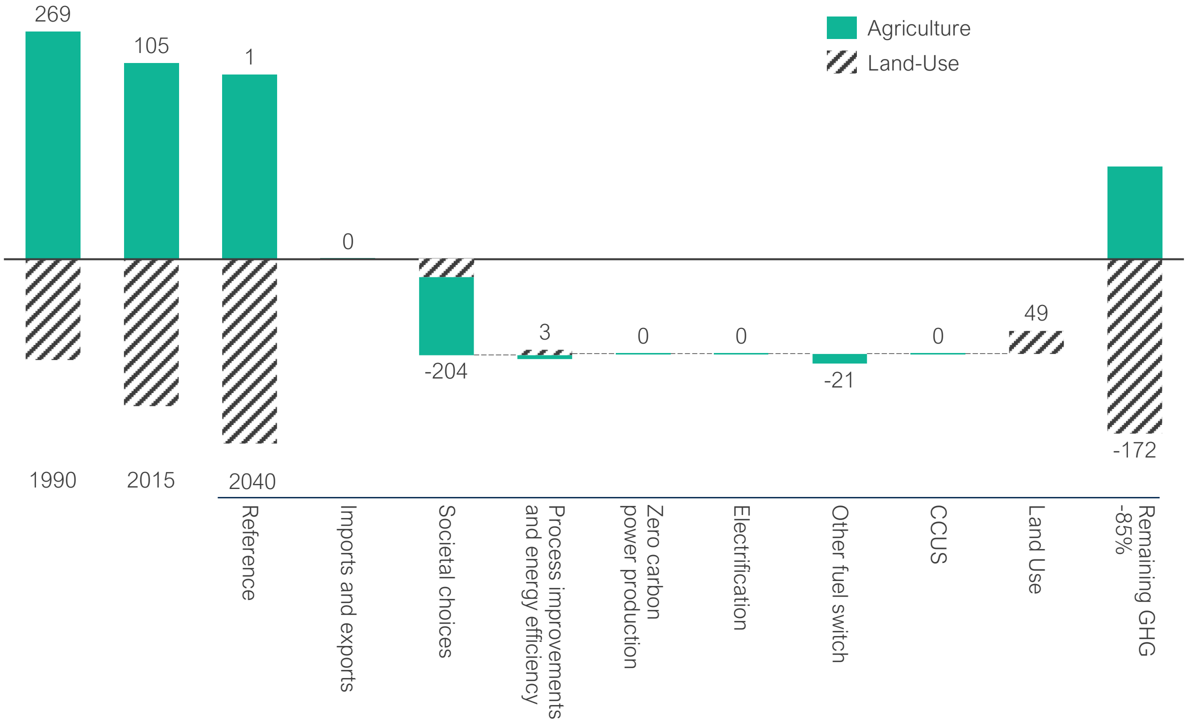
-85% AFOLU waterfall by themes

GHG emissions trajectory [$MtCO_2e$]



Five key take aways

1. **Reducing food waste by 35-40% can lower food production by 5% and thus reduce emissions and pressure on land.**

2. **Shifting to a healthier and plant-based diet can contribute to reducing food demand by 12%.** Reducing meat consumption in line with recommendations of the World Health Organisation has a significant impact on direct emissions of methane and nitrous oxide emissions, but also indirectly on pressure for land and deforestation for feed imports. A growing number of citizens in fact turns vegetarian as a result of environmental concerns in addition to animal welfare.

3. **Agriculture and forestry-waste** can contribute to energy production and reduce reliance on fossil fuels

4. **Afforestation, better forest management and restoration of natural habitats, such as peatlands, bring many benefits.** They allow for an increased carbon sequestration and storage through natural sinks and provide a habitat for biodiversity and improve air quality.

Necessary actions

STRATEGIC PERSPECTIVES

-90% scenario

Societal choices

- Reduce daily calory uptake by 10%
- Dietary changes towards a more plant-based diet (20% less meat consumed)
- Improved food supply chains reduce waste by 35%

Process improvements

- Adapt farming practices to reduce fugitive emissions from crops and livestock

  * 25% less fertilizers, 25% less crops as fodder

  * Enteric fermentation reduced by 7% & manure emissions reduced by 20%

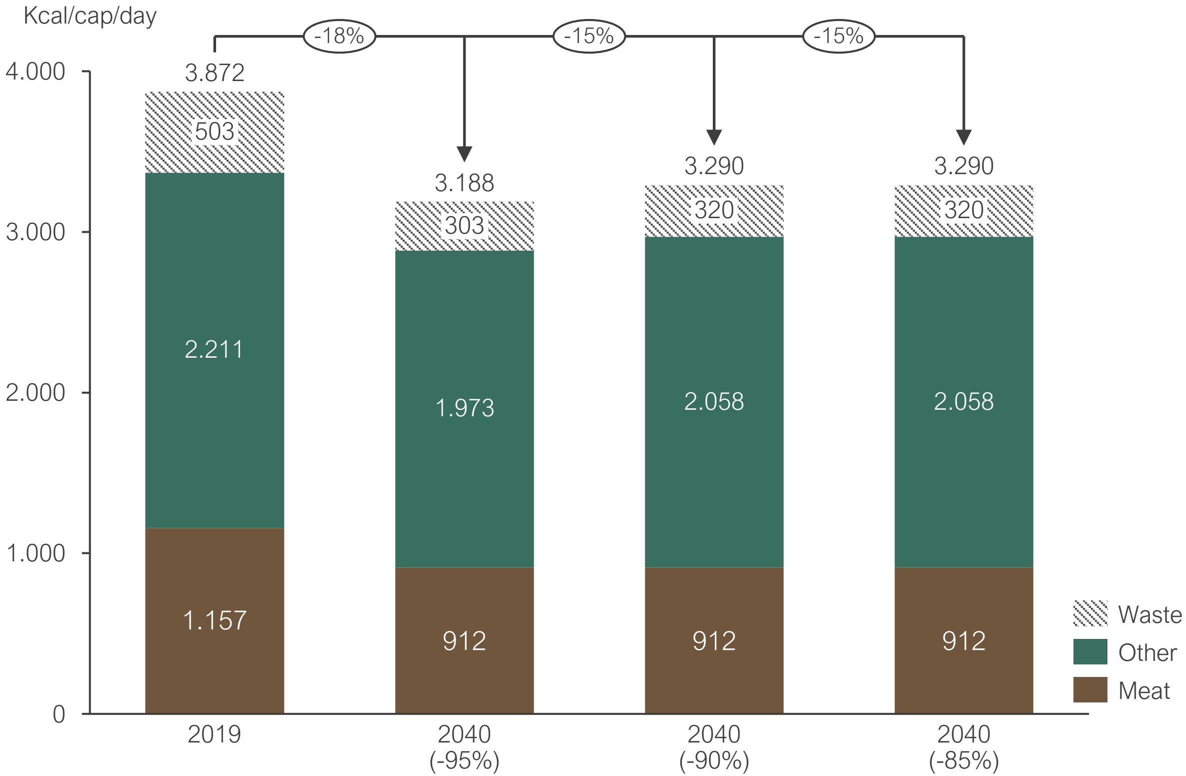
Switch away from fossil fuels to bioenergy

- Bioenergy makes up 25% of the sector’s energy mix
- Limited reliance on first generation biofuels following REDII guidelines

Convert freed up lands to maximize carbon sequestration

- 16 Mha of new forests, at the expense of grasslands and croplands
- Leads to co-benefits for biodiversity and water cycle

A more healthy diet and a drastic reduction of food waste can help reduce pressure on food demand



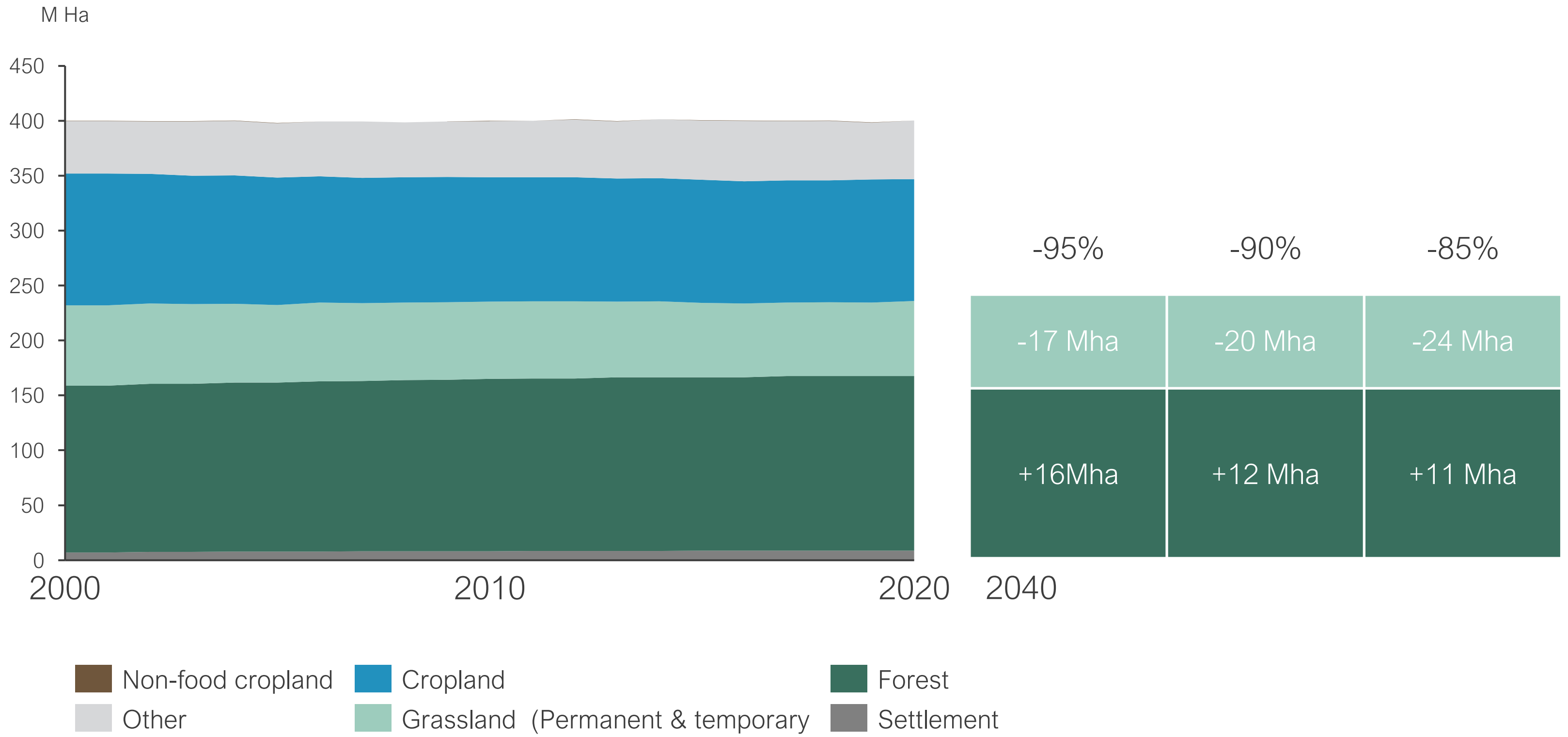
- Total food consumption reduces by 2040 (-14% in the 95% scenario, -10% in -90% & -85% scenarios)
- Meat consumption decreases even more by 2040 (-20% across all scenarios)
- Improved food chain efficiency reduces food waste by -40% to -35%

All in all, food production in the agricultural sector decreases by 15%-18%

Improved farming practices can reduce agricultural emissions

	-95%	-90%	-85%
Reduce food waste	Improved food chain efficiency -40%	-35%	-35%
Afforestation of freed up lands	Change in social patterns and agricultural practices can free-up land for carbon sequestration (reduced food waste and food consumption per capita, switched diet, land management…) +16 Mha	+12 Mha	+11Mha
Reduce fertilizer use	-24% N / -24% P / -24% K / -19% pesticides		
Reduce fodder needs of livestock	Traditional fodder is replaced by alternative proteins for 18%	17%	16%
	Traditional fodder is replaced by grazing for 9%	9%	9%
Reduce enteric fermentation	On average CH_4 emissions from enteric fermentation decreases by 7%	7%	6%
Reduce emissions from manure (CH_4 & N_2O)	On average CH_4 and N_2O emissions from manure management decreases by 22%	22%	21%

Lastly, freed up lands resulting from previous measures should be converted in lands that are capable to sequester large quantities of CO_2



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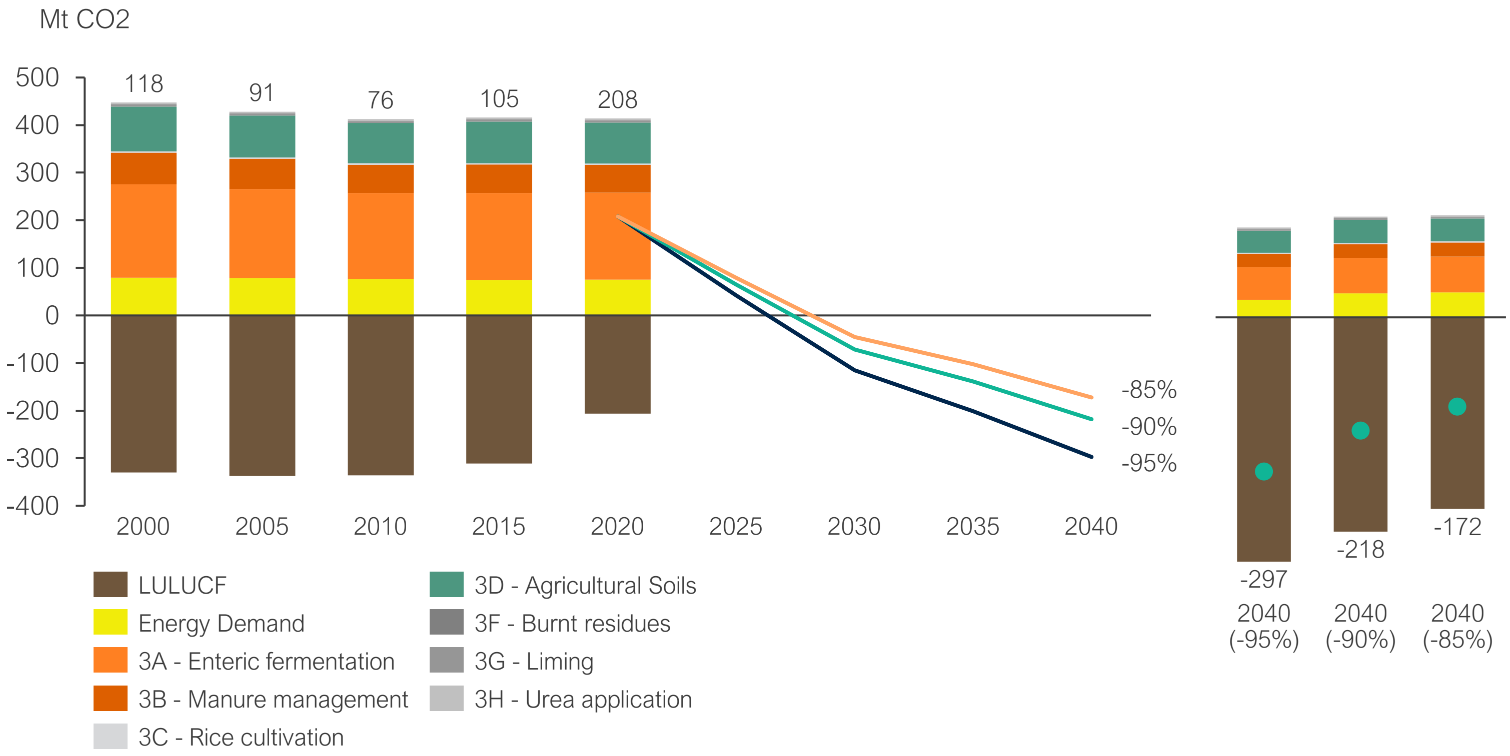
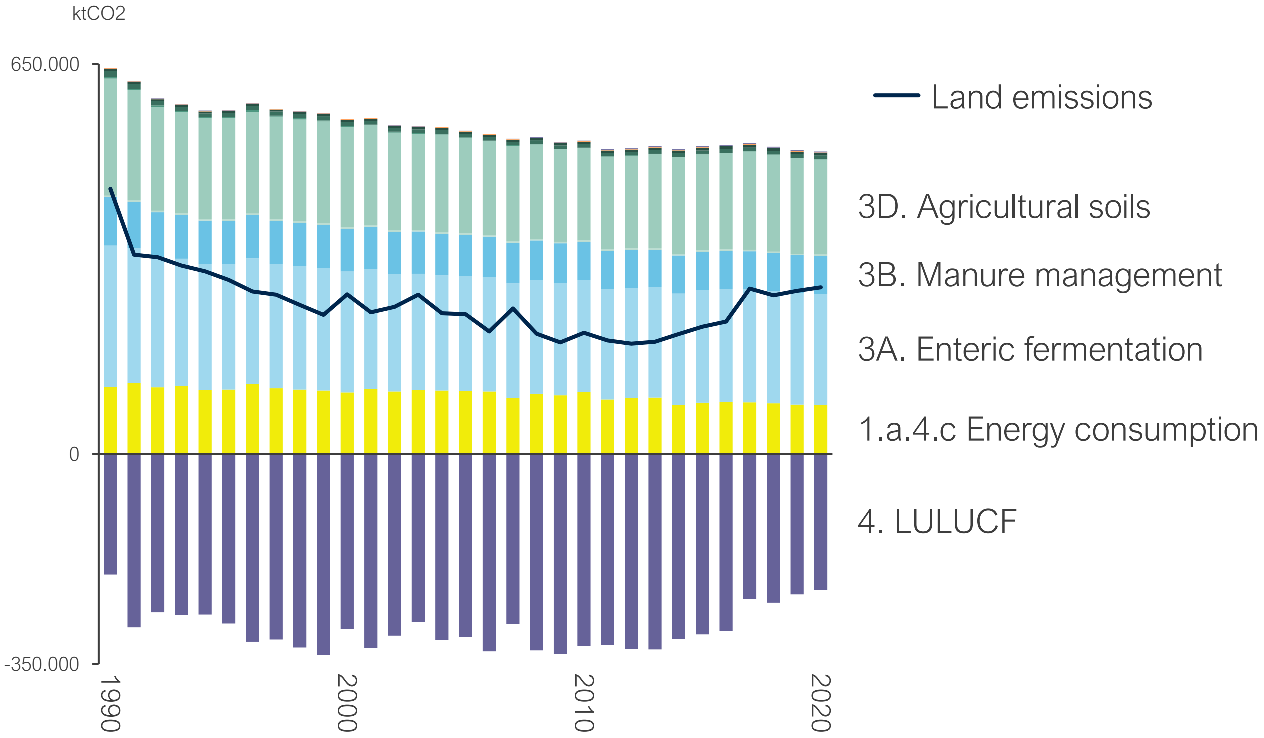
Implementation of the previous actions result in a net negative land sector



Schematic overview of AFOLU emissions



How to reduce LAND emissions

- Reduce overall food demand
- Improve farming practices
- Change energy mix
- Increase LULUCF sink

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STRATEGIC PERSPECTIVES

Thank you.

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