Industry decarbonisation progress to achieve the Paris Agreement objectives

2040 pathway through the Paris Agreement Compatible (PAC) 2.0 scenario

Joni Karjalainen, Energy Transition Analyst
Dimitris Tsekeris, Energy Scenarios Project Manager
Climate Action Network (CAN) Europe
RGI Expert Workshop
8th November 2023

PAC Paris Agreement Compatible Scenarios for Energy Infrastructure

CAN CLIMATE ACTION NETWORK Europe

Contact us:
joni.karjalainen@caneurope.org
dimitris.tsekeris@caneurope.org

CAN
CLIMATE ACTION NETWORK
Europe

PAC Paris Agreement Compatible Scenarios for Energy Infrastructure

We are fighting dangerous climate change, following scientific findings

CAN Europe promotes sustainable climate, energy and development policies throughout Europe, with over 180 member organisations active in 38 European countries, representing over 1.700 NGOs and more than 40 million citizens.

National and EU27 pathway(s) to meet +1.5 C

What is the PAC project?

The Paris Agreement Compatible (PAC) scenario project aims to construct a European-wide energy scenario aligned with the objective to limit global warming to 1.5°C, which embodies the policy demands of civil society.

2nd phase of the PAC scenario modelling

The PAC 2.0 project (by CAN Europe, Renewables Grid Initiative, European Environmental Bureau, REN21 - Renewable Energy Policy Network for the 21st Century) **creates the EU27 scenario and disaggregates it into the national level of each member-state** with member organisations and national experts, by using open source software ([1].

The PAC scenario is guided by the overall goals:

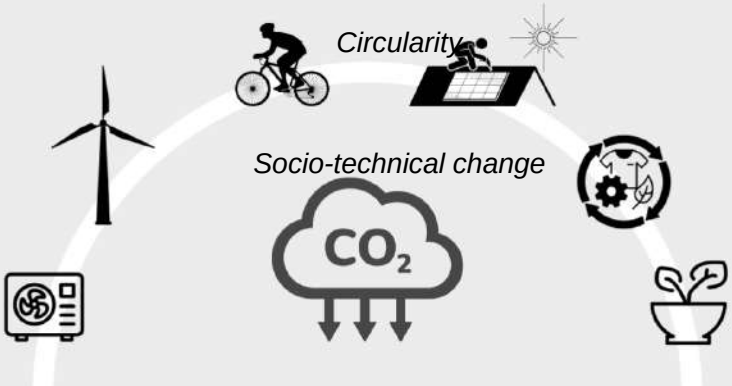
1. At least 65% reduction in greenhouse gas emissions by 2030
2. Net-zero greenhouse gas emissions by 2040
3. 100% renewables in Europe by 2040 in all sectors

[1]) Tools: Pathways Explorer, Python for Power Systems Analysis

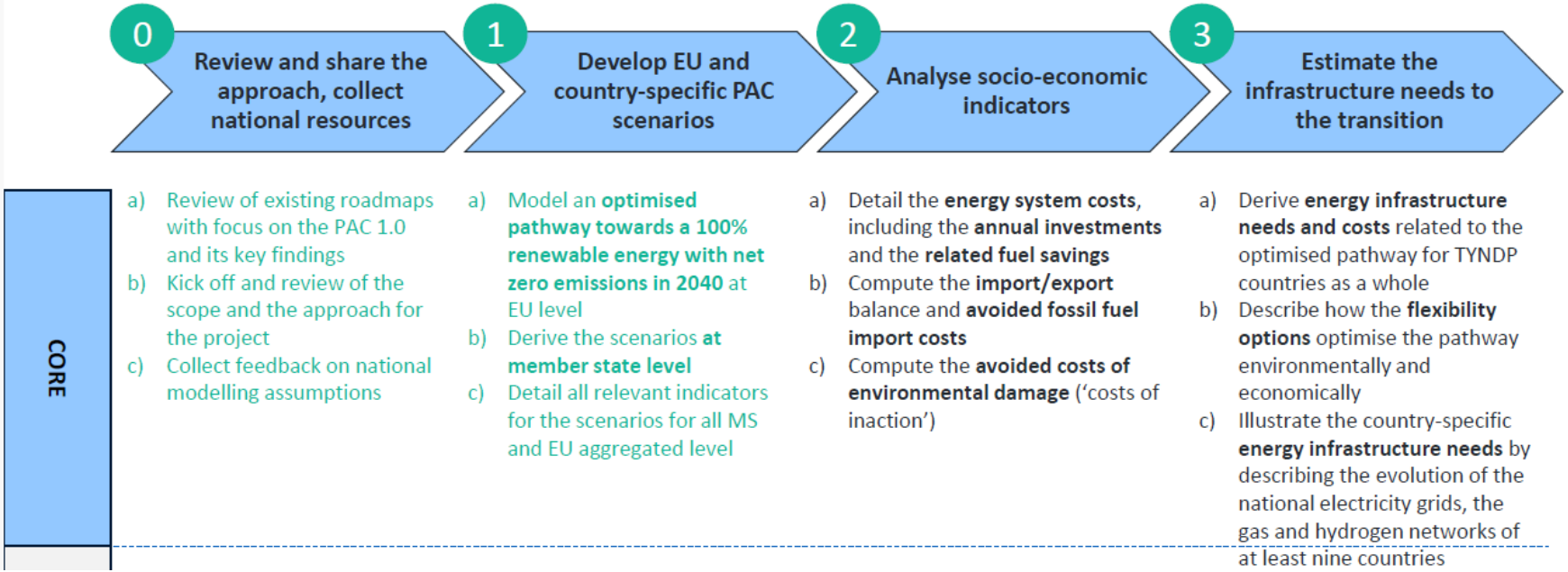
Aiming for climate neutrality by 2040

- At least 65% GHG emissions reductions by 2030 (from 1990 levels)
- A 2030 renewable energy target of 50% in final energy consumption
- A 2030 energy efficiency target of at least 20% for 2030 (compared to the 2020 Reference Scenario)

- An EU-wide coal phase out by 2030
- An EU-wide gas phase out by 2035
- An EU-wide phase out of fossil oil products by 2040
- Nuclear phase-out gradually
- An EU-wide phase out for sale of Internal Combustion Engine (ICE) cars, not later than 2035



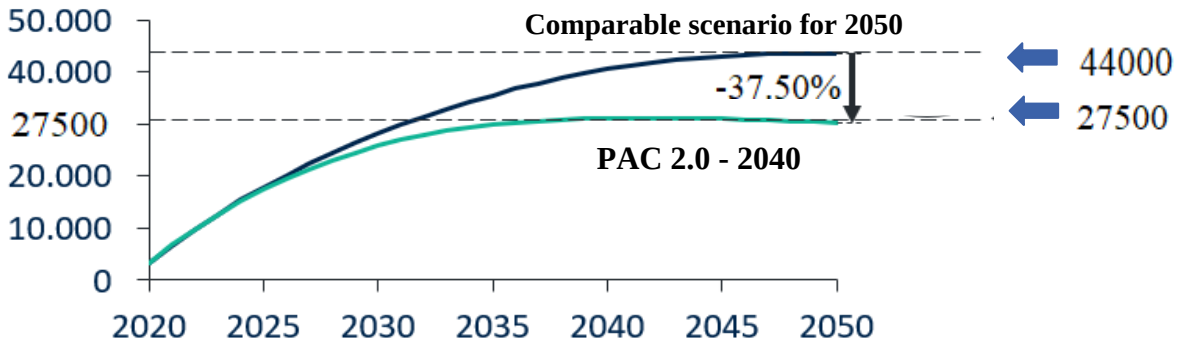
The project phases for PAC 2.0 scenario



Advancing the target by 10 years has a big impact on EU's GHG budget

2020-2050 EU domestic GHG budget aligned with 1.5°C	27.5 Gt CO_{2eq}
PAC 2.0 GHG budget	27.46 Gt CO_{2eq}

Cumulative GHG emissions (2020-2050) [$MtCO_2e$]



As a historical emitter and a technologically advanced continent, EU has a responsibility and a strategic interest to set a credible path to 1.5 C, also for the rest of the world.

<u>This requires:</u>

- To **advance the net zero target to 2040**
- A fast and ambitious ramp-up in a range of measures

PAC 2.0 scenario

Europe's actions to reach climate neutrality in 2040

Triggering change, with lifestyle changes

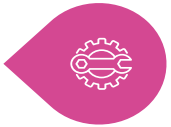
- Achieving net zero requires a **drastic reduction of the energy demand**, through important **changes in social patterns and societal organization**, towards **more sobriety, frugality and circularity**.

Process improvements and energy efficiency

- **Energy efficiency measures, with technological progress and process improvements** will allow to reduce energy demand and lean **towards a more sustainable economy.**

Electrification coupled with renewable power production

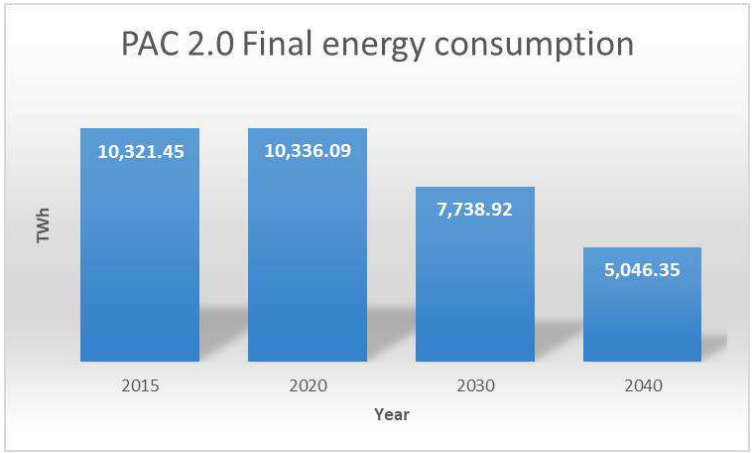
- **Electrification of the processes across all sectors** is necessary and needs to be **coupled with renewable power production (100% RES)**

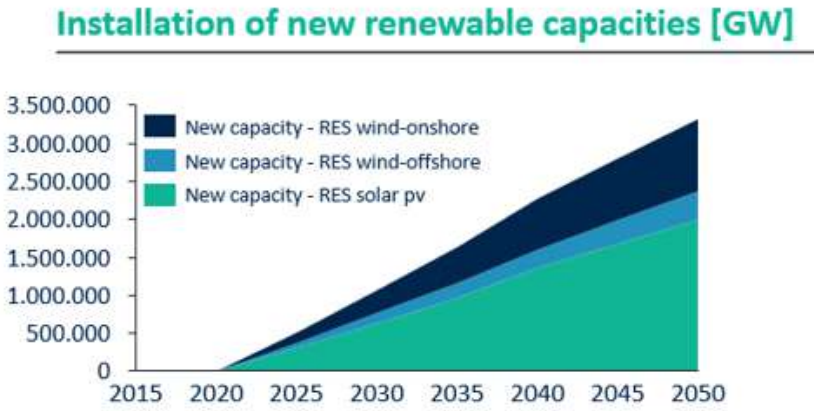


Decarbonizing what is left

- Fuel switch (bio or e-fuels): **for those processes that cannot be electrified**
- Carbon capture: only for remaining industrial process emissions (cement,...)
- Land-Use: Natural carbon removal potential (limited)

Halving energy consumption * Tripling RES deployment are necessary to allow for a phase-out of fossil fuels



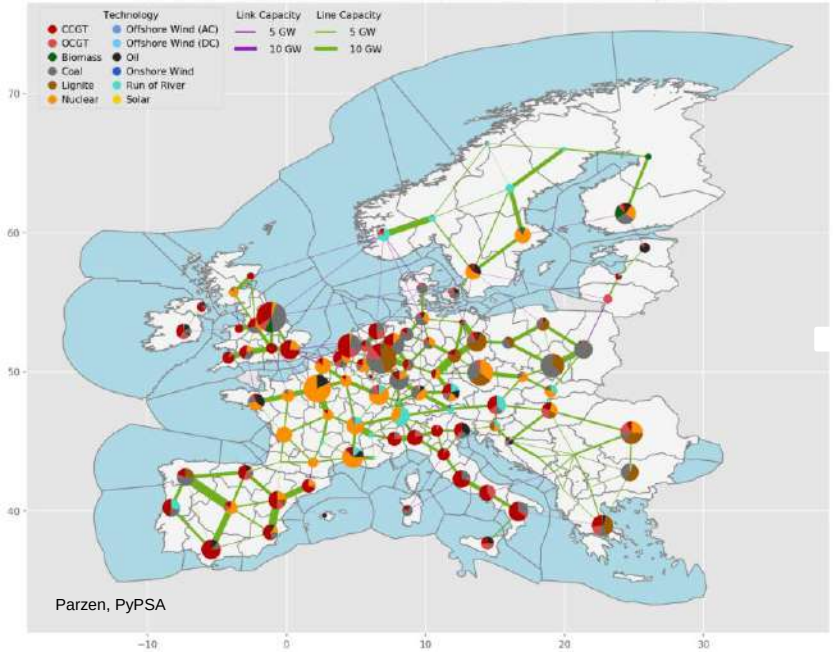


2015-2030 reduction: -25.0%
2015-2040 reduction: -51.1%
2020-2030 reduction: -25.1%
2030-2040 reduction: -34.8%
2020-2040 reduction: -51.2%

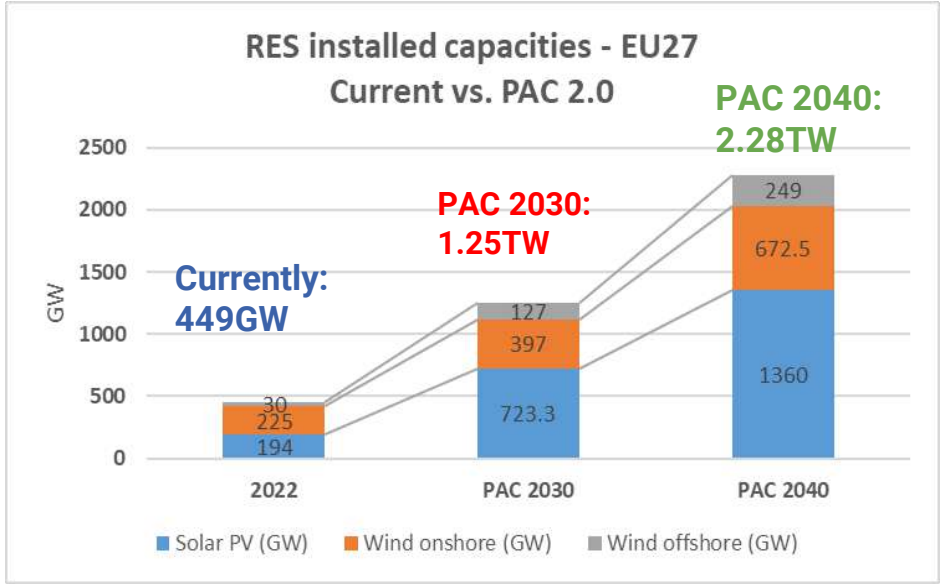
Annual rate of installation for renewables needs to be close to 3 times higher than in the 2020-2022 period (35GW/y➔105GW/y)

100% renewable energy based system in 2040 and its infrastructure for Europe's industry

Our analysis will provide figures for 2030, 2035 and 2040



Pedersen, Tim & Victoria, Marta & Rasmussen, Morten & Andresen, Gorm. (2021). Modeling all alternative solutions for highly renewable energy systems. Energy. 234. 121294. 10.1016/j.energy.2021.121294.



The above values are to be taken into account ONLY when the final energy consumption is reduced by at least 50%

PAC 2.0 scenario

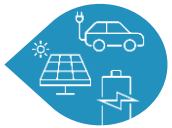
The necessary actions for the net zero industry in Europe 2040

Triggering change, with lifestyle changes

- Reduce, Reuse & Recycle - the evolution of frugal and circular behaviors
- Sharing economy for goods assumed, as a Europe-wide shift

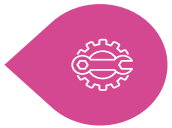
Process improvements and energy efficiency

- Switch to **less energy-intensive materials (cement ⇒ wood,...)**, and **less use (when possible)**
- Develop and deepen the patterns for **reduce, reuse and recycling**, longer lifetime for products



Electrification coupled with renewable power production

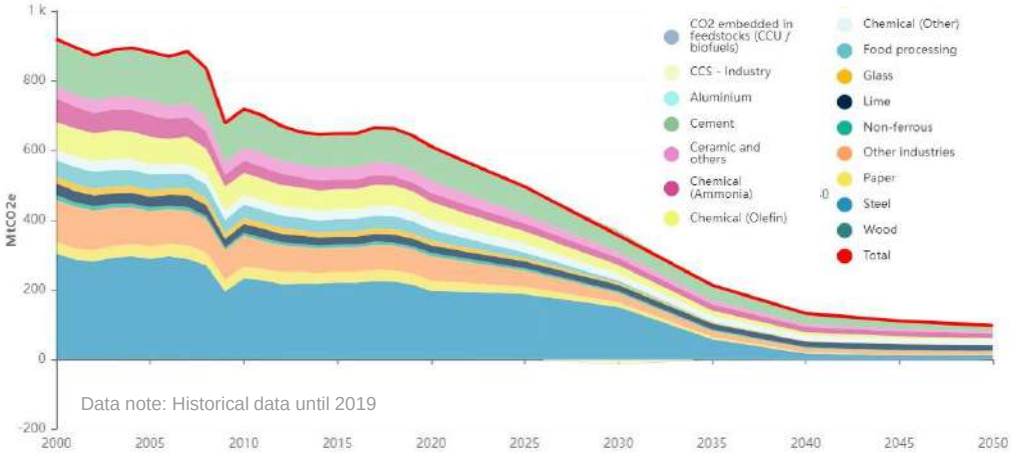
- Massive investment in **electrification of low temperature heat processes** (food, paper, pulp..).
- Renewable Hydrogen, **for some energy-intensive industries** (steel,…), with domestic RE H2



Decarbonizing what is left

- **Alternative fuels (biofuels, hydrogen and e-fuels) for some heavy industry**
- Carbon capture only for industries with high process emissions (cement,…)
- CO2 either stored (CCS) or used in building material CCU products

Paris Agreement compatible industry pathway for Europe: 2030, 2040



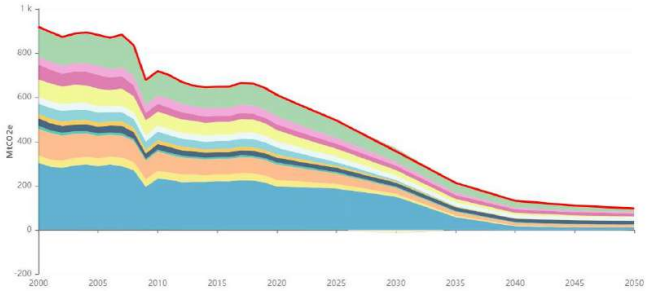
Industry KPI	Pathway in PAC 2.0		
	2015	2030	2040
Total net GHG (incl. Sequestration)	647.6	370.5 -43%	133.9 -79%
Production volume [Mt]	1176.5	1125.8 -4.3%	1040.3 -11.6%
Technology [% electric in final energy excl feedstocks]	31	51	75

Note: Almost 2.5 times more electrified energy mix for the industry in 2040.

- High energy and feedstock costs, with some supply chain interruptions reduce material demand faster **towards a circular economy**.
- Demand for energy-intensive raw materials cut **thanks to substitutes** (e.g. wood replacing steel, aluminium and cement in construction; biomass replacing fossil oil as plastics feedstock), immediately sourced in the EU.
- **Electrification**, recycling and modernised processes for **industries' efficiency gains**.
- Steel industry prepares **for leapfrogging to RE hydrogen** as soon as possible.

- ➢ Circularity at the heart, secondary materials
- ➢ Less materials, less resources
- ➢ CCS/CCU only in cement, high process emissions
- ➢ Minor production volume drop - Not necessarily less jobs

Paris Agreement compatible industry pathway for Europe: 2030, 2040 per sub-sector: data view



GHG emissions per sector in Industry (MtCO2e)	2015	2030	2040
CO2 embedded in feedstocks (CCU / biofuels)	/	-1.29	-2.41
CCS - Industry	/	-13.72	/
Aluminium	3.92	2.23	1.48
Cement	91.95	60.96	31.47
Ceramic and others	35.98	17.12	7.95
Chemical (Ammonia)	27.27	19.95	15.77
Chemical (Olefin)	57.96	24.6	9.42
Chemical (Other)	27.96	20.23	15.46
Food processing	35.41	6.58	/
Glass	14.98	5.67	1.65
Lime	22.69	17.78	15.97
Non-ferrous	8.25	5.2	2.69
Other industries	69.53	26.96	12.36
Paper	31.56	13.07	3.25
Steel	218.13	148.91	15.73
Wood	2.04	1.27	0.66
Total (MtCO2e)	**647.62**	**355.51**	**131.45**

- Major emission reductions across industry sub-sectors by 2030
- A prerequisite for achieving reductions by 2040

PAC 2.0 scenario

Circularity for the industry:

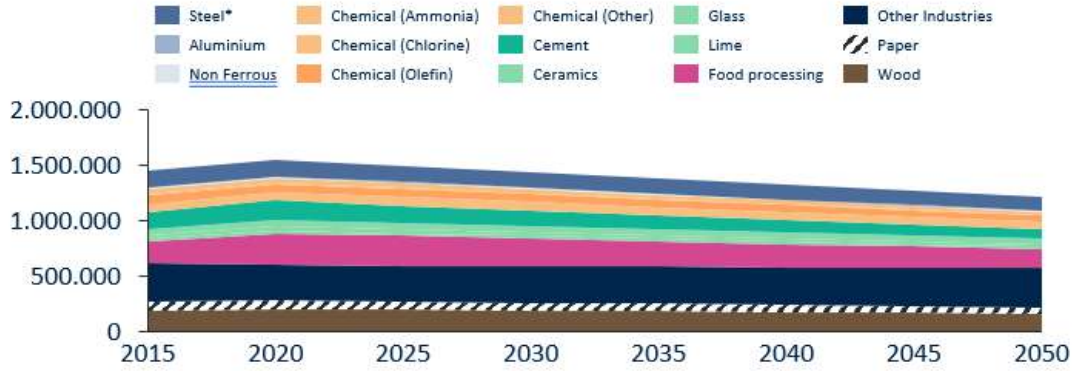
as transformative as possible, still feasible pathway

By the year 2050…	ambition level 1	ambition level 2	ambition level 3	ambition level 4	PAC assumption	Comment
How will aluminium production evolve compared to 2015?	1.35	1.15	1	0.5	-50%	
What is the share of recycled aluminium?	0.2	0.3	0.85	1	95.50%	vs. 42.7% in 2015
How will cement production evolve compared to 2015?	1.35	0.79	0.73	0.52	-48%	
What is the share of geopolymers in primary cement production?	0	0	0.1	0.3	20%	
How will ceramics production evolve compared to 2015?	1.66	1.42	0.82	0.72	-18%	
How will ammonia production evolve compared to 2015?	1.04	0.86	0.58	0.43	-42%	
How will olefins production evolve compared to 2015?	1.2	1	0.59	0.5	-41%	
What is the share of recycled olefins?	0.1	0.2	0.5	0.63	63%	from only 6.0% in 2015
How will glass production evolve compared to 2015?	1.69	0.86	0.74	0.5	-26%	
What is the share of recycled glass?	0.385	0.45	0.65	0.9	77.5%	vs. 38.2% in 2015
How will non-ferrous metals production evolve compared to 2015?	1.3	0.95	0.69	0.5	-31%	
What is the share of recycled non-ferrous metals?	0.176	0.35	0.45	0.7	60%	vs 31.0% in 2015
How will paper production evolve compared to 2015?	1.52	0.95	0.69	0.41	-31%	
What is the share of recycled paper in 2040?	0.448	0.54	0.6	0.8	70%	vs 55.8% in 2015
How will steel production evolve compared to 2015?	1.33	1.11	0.83	0.49	-17%	
What is the share of recycled steel?	0.273	0.35	0.5	0.9	68%	vs. 42.6% in 2015
What is the share of blast oxygen furnaces in primary steel production?	1	0.9	0.6	0	0%	vs. 100% in 2015
What is the share of Hydrogen Direct Reduction of Iron (H-DRI) technology in primary steel production?	0	0.1	0.4	1	100%	vs. 0% in 2015
What is the share of Electric Arc Furnaces (EAF) in secondary steel production?	1	1	1	1	100%	vs. 100% in 2015

In actually modelling the role of the industry, it was possible to refine the level of ambition (1, 2, 3 or 4) for each lever.

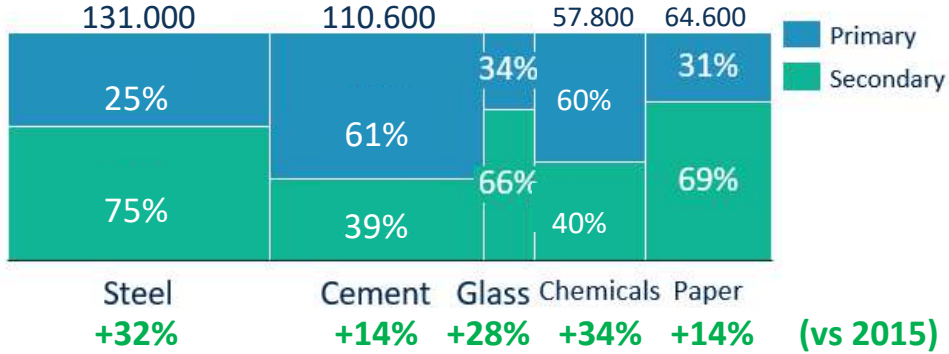
Circularity for the industry

Evolution of material production [Mt]



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

Slightly lower volumes, much more from secondary sources



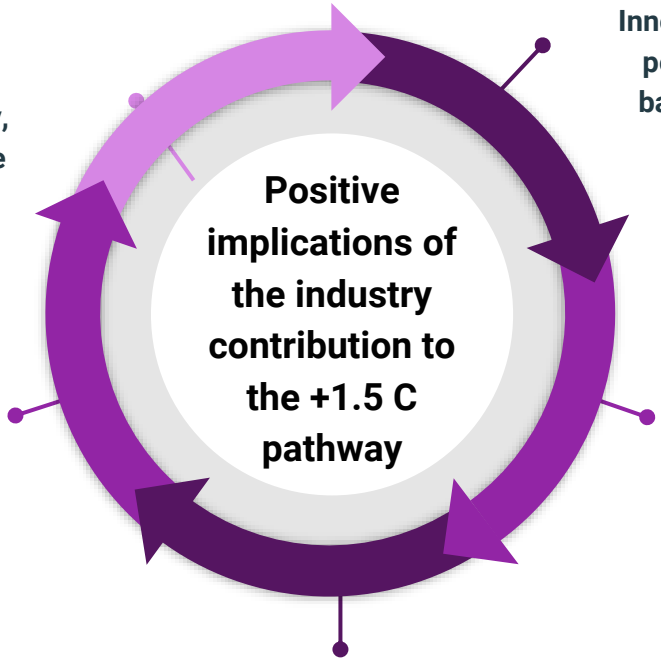
	NUMBER OF PRODUCTS	MATERIAL USE AND COSTS
TREND	Fewer new products	Less material per product
RATIONALE	Changes in social patterns and the impact of the functional economy	Better product design, less waste Less factory capacity required

	EMISSIONS AND ENVIRONMENTAL COSTS & RISKS	VALUE PER PRODUCT	MAINTENANCE & SERVICES
	Lower emissions and waste costs per product	More value per product (last longer, better utilisation)	More revenues
	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

CAN CLIMATE ACTION NETWORK Europe

CLIMACT

Implications of our 2040 pathway



Economic value will be generated, gradually with less materials. Quality, long-lasting products of higher value create more revenues, and also generate more maintenance revenue.

Innovating around a flexible enough power system, as a renewables-based ecosystem, as a source of new services, products, as well as business models.

Fewer new products and less material used per product will imply lower emissions and waste costs per product.

Circular behaviours assumed as a source of competitive advantage for a range of EU's key industries.

Pathway dramatically reduces industry GHG emissions. Achieving climate neutrality by 2040 a huge impact on EU's carbon budget.

CAN
CLIMATE ACTION NETWORK
Europe

Key industry assumptions

✔ **High energy and feedstock costs along with supply chain interruptions for certain materials favour an accelerated reduction of material demand towards a circular economy approach.**

? The strong material demand reductions rely on questionable behavioural changes of consumers (e.g. switch to car sharing and public transport instead of individual car ownership reduces steel and aluminium demand).

✔ **Demand for energy-intensive raw materials will be cut because there are substitutes (e.g. wood replacing steel, aluminium and cement in construction; e.g. biomass replacing fossil oil as feedstock for plastics). They can be immediately sourced in the EU.**

? Substitutes for energy-intensive raw materials are limited and expensive. Their market introduction mostly requires structural changes in industries. Increased biomass demand can conflict with biodiversity and undermine the carbon storage function of forests.

✔ **Electrification, recycling and modernised processes increase industries' efficiency gains.**

? Energy and material savings from efficiency gains might be jeopardised by rebound effects such as increased consumer demand and exports. The economic and regulatory conditions for sufficiency are still too weak. Extracting and importing might be cheaper than recycling.

✔ **The steel industry prepares for leapfrogging to renewable hydrogen as soon as possible.**

? The steep increase of hydrogen demand might not be covered by electrolysers using domestic renewable electricity but through imports. Sustainability and climate benefits of hydrogen imports of whatever origin remain questionable.

Thank you!

Do not hesitate to contact us for specific questions

Joni Karjalainen and Dimitris Tsekeris
Climate Action Network (CAN) Europe
The Paris Agreement Compatible (PAC) scenario team

Contacts:
joni.karjalainen@caneurope.org
dimitris.tsekeris@caneurope.org