



European perspective:  
transform the European  
Process Industries,  
Activities and insights  
from the SPIRE network

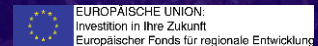
Ludo Diels, VITO, A.SPIRE, UA  
12 May 2022



**Process<sup>4</sup>  
Sustainability**

**Cluster for climate-neutral  
process industries in Hesse**

Supported by:

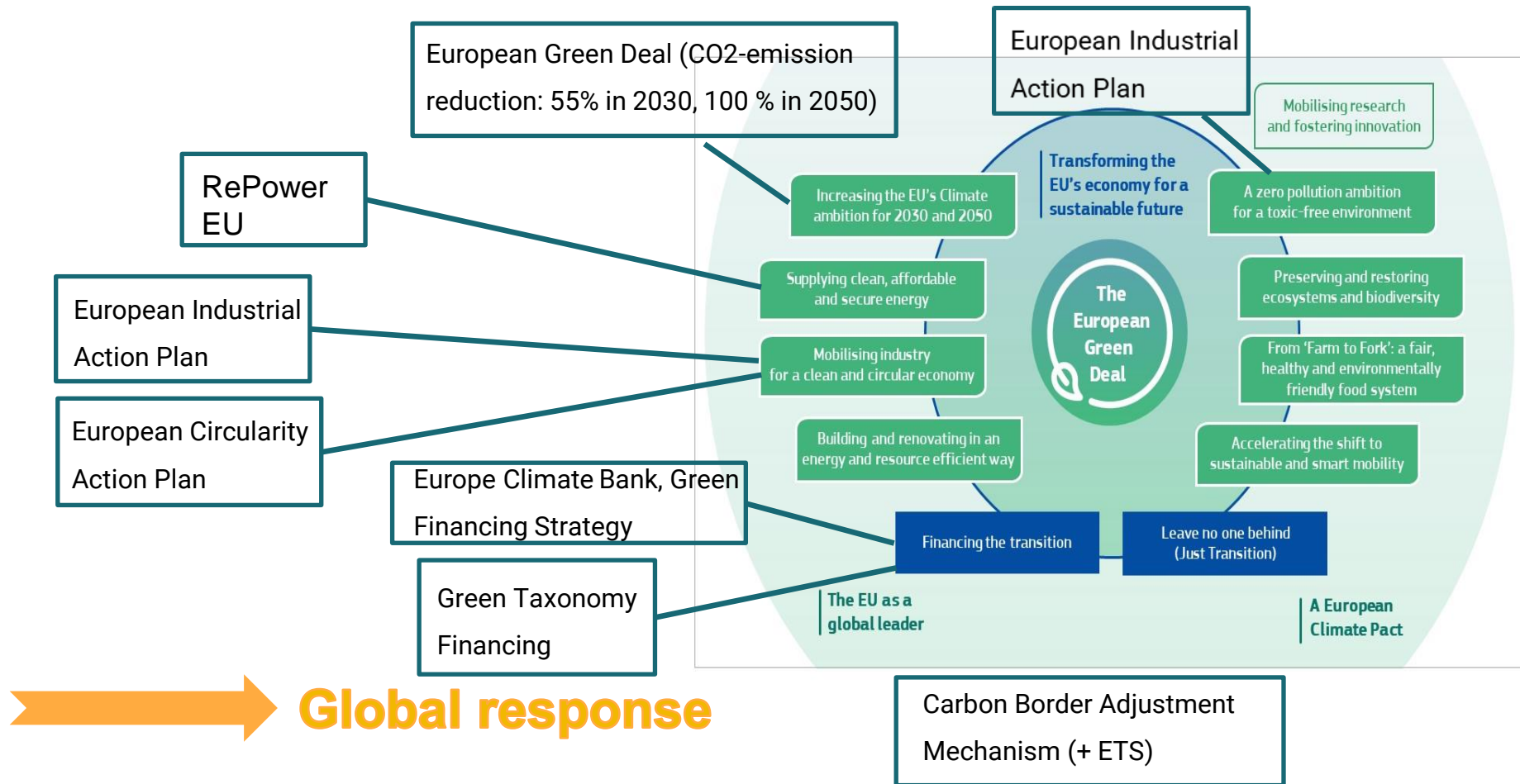


# 70 years ago

**9 May, 70 years from Schuman declaration**

“World peace cannot be safeguarded without the making of creative efforts proportionate to the dangers which threaten it.”





## A.SPIRE: a vibrant community with a common strategic Vision

### A.SPIRE – European cross-sectorial association



DG R&I  
DG Grow



### PROCESSES4PLANET

2050  
Process  
Industries

- ✓ Develop & deploy climate-neutral solutions
- ✓ Closing the energy and feedstock loops
- ✓ Achieve global leadership of the Process Industry
- ✓ Accelerate innovation & unlock public-private investments

### OPEN APPROACH: inclusive of different stakeholders and welcoming Newcomers

- Industries, incl. SMEs
- Industrial Associations & Clusters
- Consultancies

- RTOs
- Higher Education Institutions
- NGOs

- Public institutions
- Innovation Agencies
- MS and Regional representatives

- Partnerships & EITs
- Financial parties
- New sectors





**Cement**



**Ceramics**



**Chemicals**



**Engineering**



**Non-ferrous  
metals**



**Minerals**



**Pulp & paper**



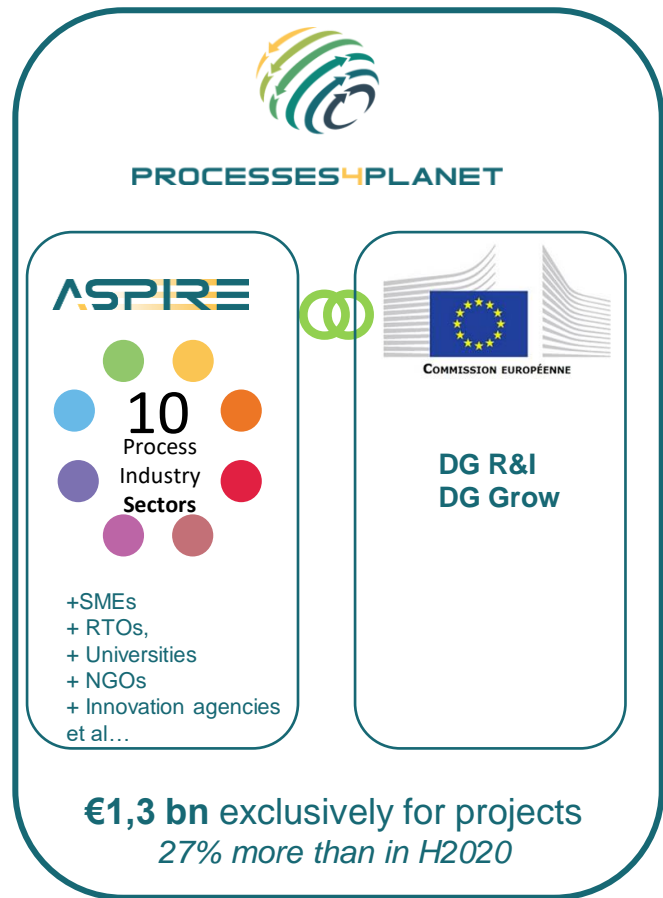
**Refining**



**Steel**



**Water**



## New approach to European Partnerships

New generation of objective-driven and more ambitious partnerships in support of agreed EU policy objectives

### Key features

- Simple architecture and toolbox
- Coherent life-cycle approach
- Strategic orientation

### Co-programmed

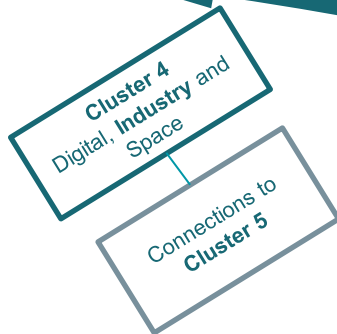
Based on Memoranda of Understanding / contractual arrangements; implemented independently by the partners and by Horizon Europe

### Co-funded

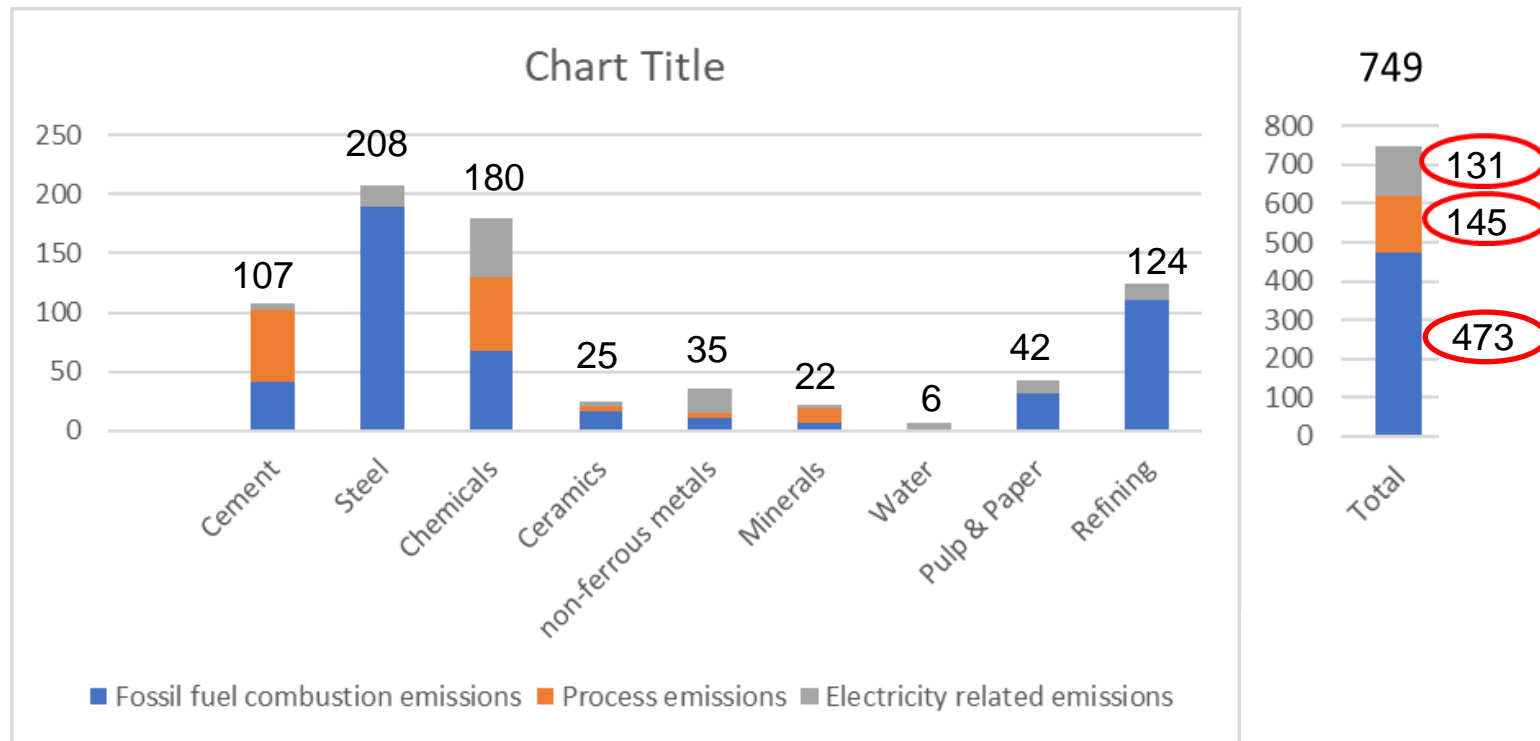
Based on a joint programme agreed and implemented by partners; commitment of partners for financial and in-kind contributions

### Institutionalised

Based on long-term dimension and need for high integration; partnerships based on Articles 185 / 187 of TFEU and the EIT-Regulation supported by Horizon Europe

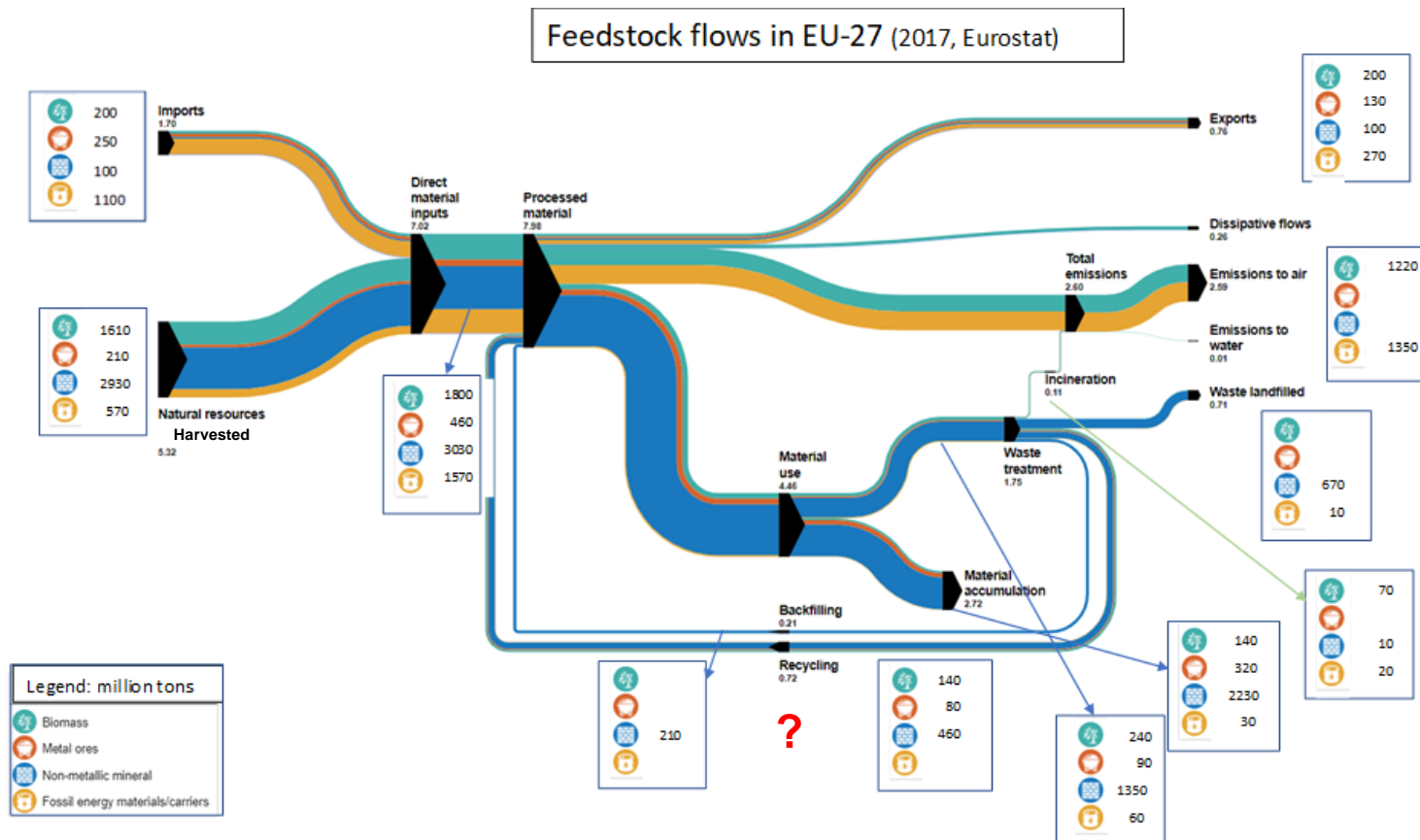


# High impact on climate > 700 Mtons CO2 emissions

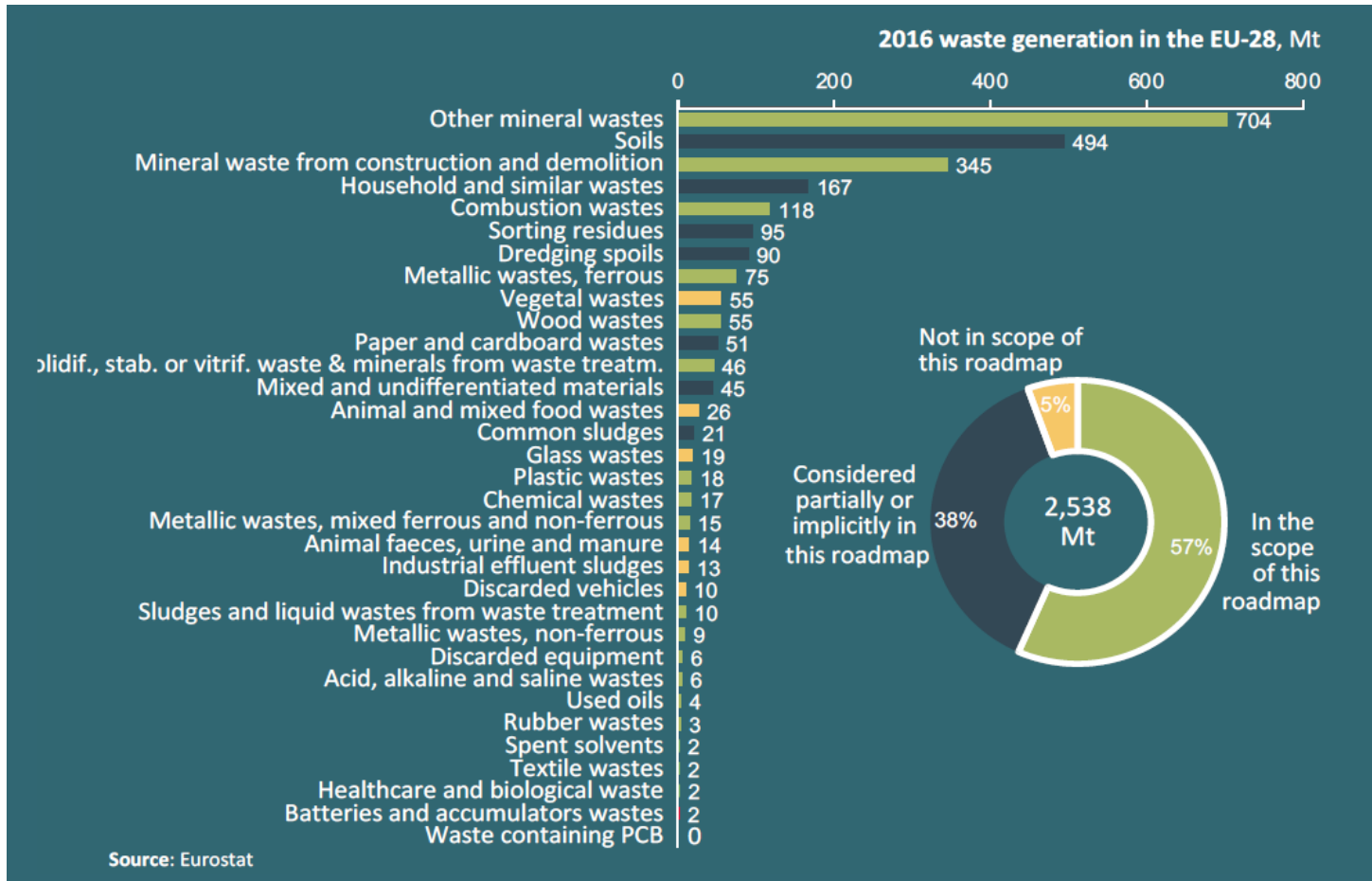


Sources: VUB/IES, Eurostat, EEA, Material Economics, Global Cement and Concrete Association, Cefic, Cerame-Unie & EuLA

Linear business models > 1500 Mtons wastes at the end of the value chains





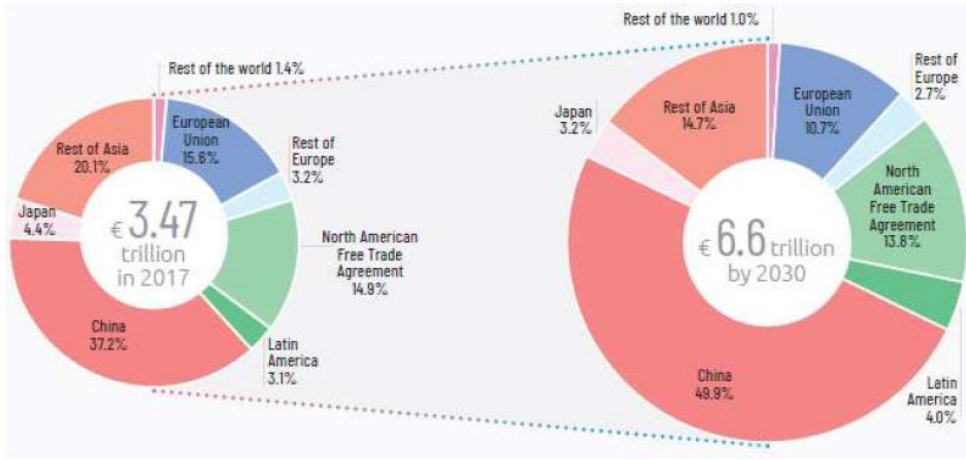


- > 2 trillion € turnover
- 8,5 Mln direct jobs
- 20 Mln indirect jobs
- 0,5 Mln enterprises
- 5% of the EU GDP



# Example: Global chemicals industry growth linked to global growth of need for materials ASPIRE

Global chemical industry projected to double by 2030



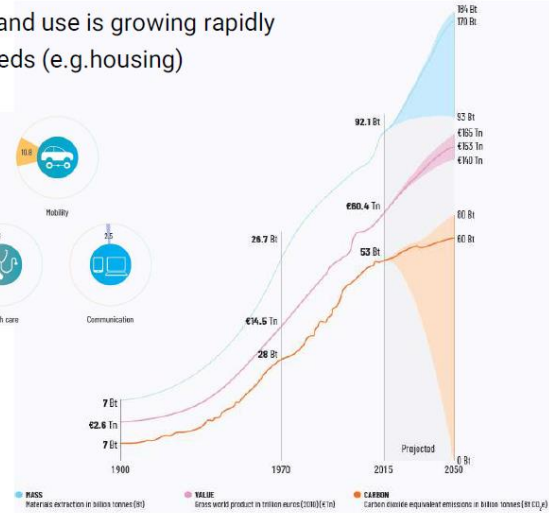
Projected growth in world chemical sales (excl. pharmaceuticals) (CEFIC)

- Materials extraction and use is growing rapidly
- Driven by societal needs (e.g. housing)



The global material footprint: extracted resources by key societal needs and consumables (billion tonnes) (based on de Wit et al. 2019)

Trends in materials extraction, financial value creation and greenhouse gas emissions (1900-2050) (adapted from de Wit et al. 2019)

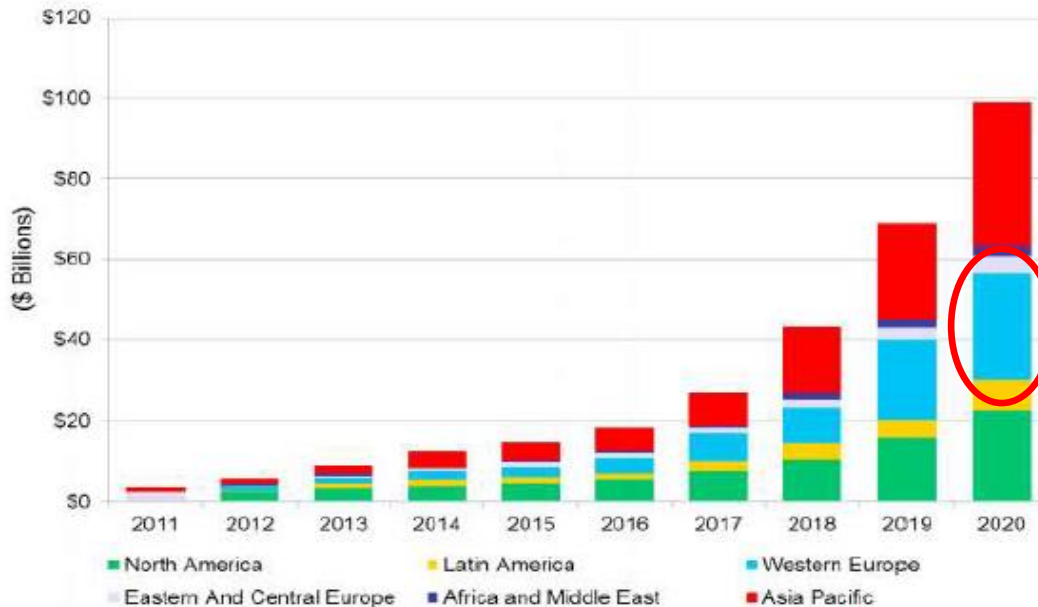


We don't have oil, shale, ...  
 But we have a strong bio-economy, biomass, recycling, CO<sub>2</sub>-conversion & we are strong in hydrogen  
 We import every year > 640 Million tons crude oil  
 Carbon is the only raw material that is available in practically unlimited quantities in contrast to metals & minerals

# Europe has a very high share in the Global Green Chemicals Market

## From challenges to opportunities

Innovations in chemistry have a significant potential in advancing sustainable development (UNEP 2019)

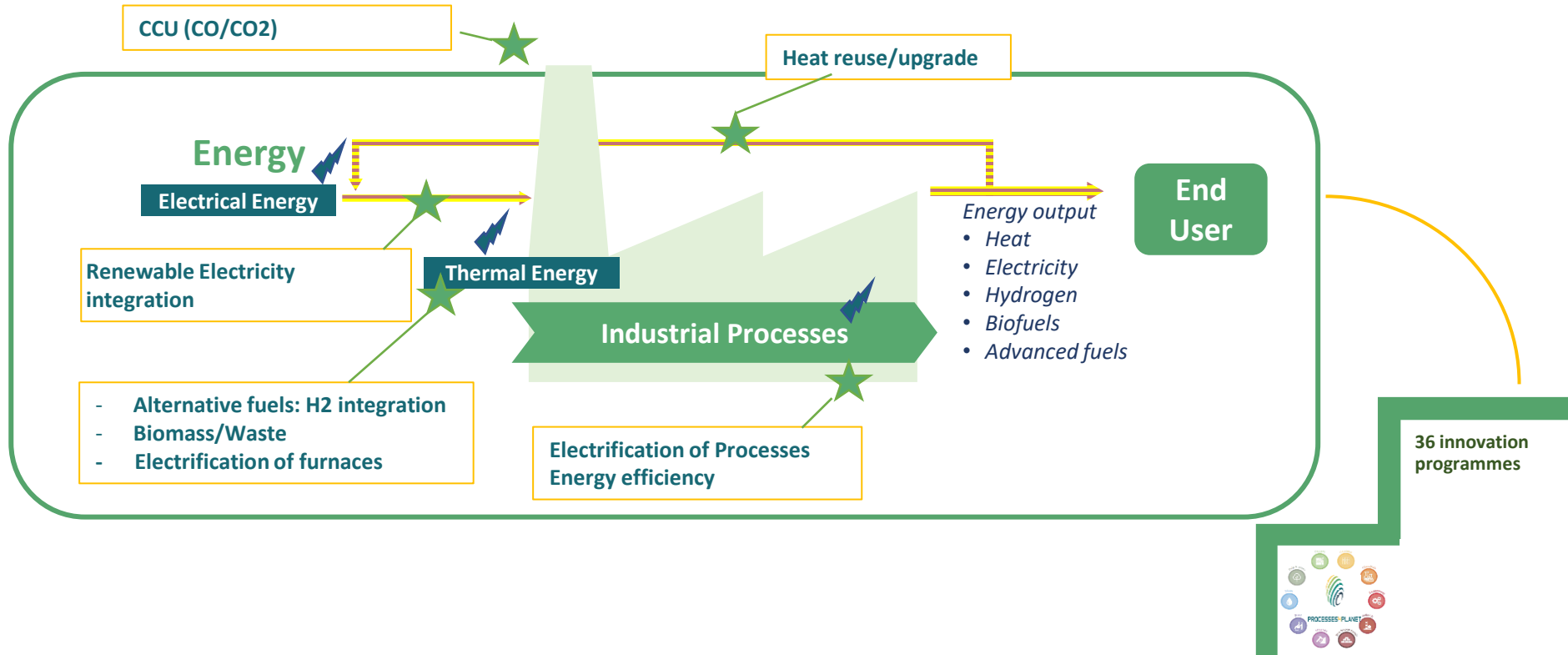


Global Green Chemicals Market by Region 2011-2020 (GC3 2015)

## Disruptive new processes: Towards net-zero CO<sub>2</sub> emissions



PROCESSES4PLANET



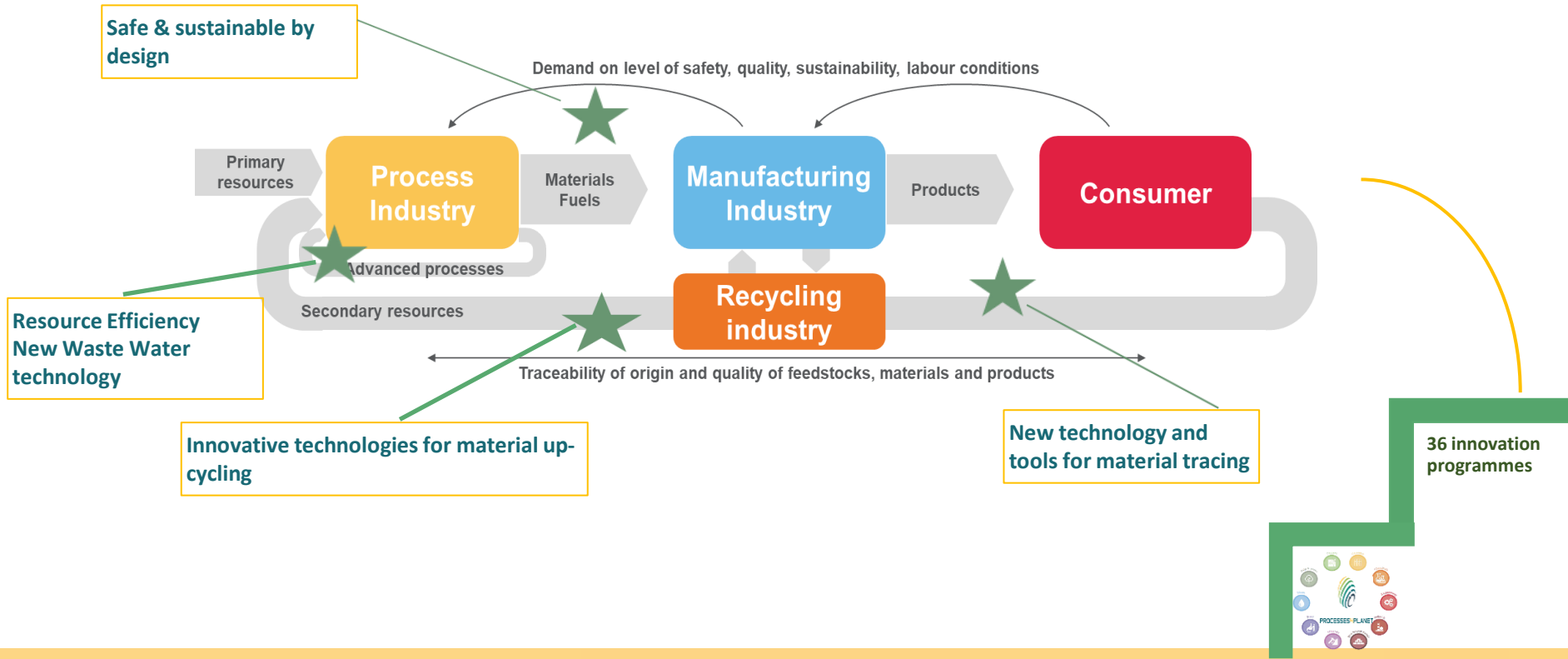


# From feedstock to consumer product and back

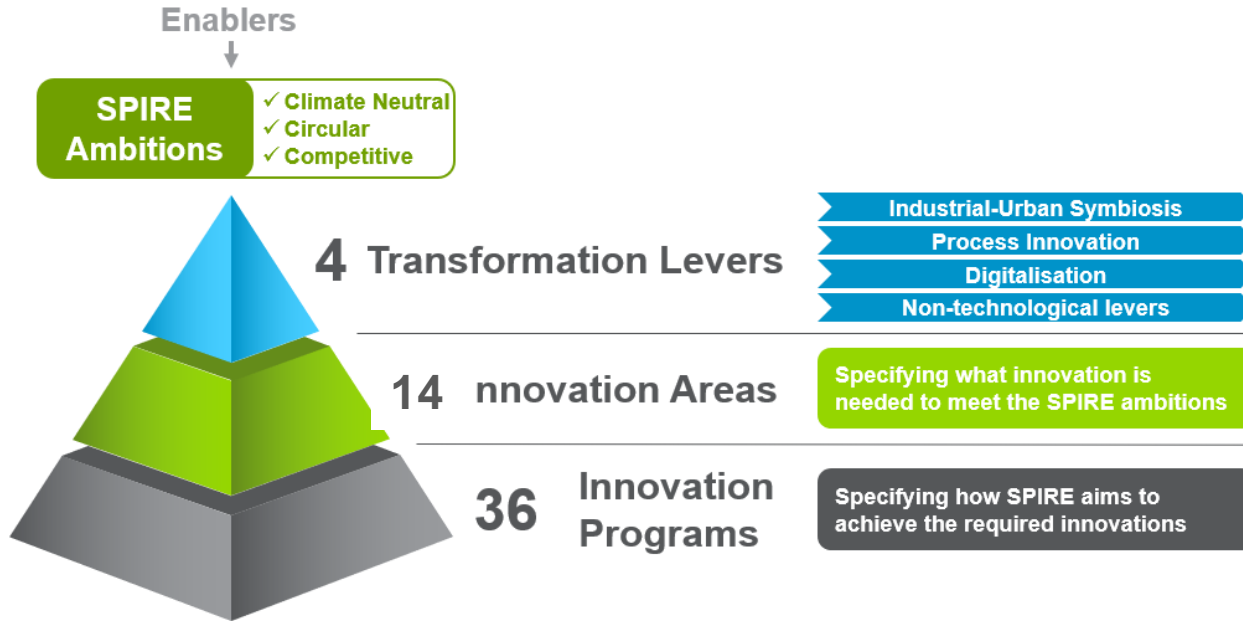
UPCYCLING & ECO-DESIGN: Near zero-landfilling / Near zero-water discharge



PROCESSES+PLANET



Transformation levers and tools to enable P4Planet to achieve its...



AMBITIONS

for Society and the Planet

**2050 Process Industries**

- ✓ Climate neutrality
- ✓ Near-zero landfilling & water discharge
- ✓ Competitive process industries

# Three cross sectoral challenges, three ambitions

## Cross sectoral challenge

750 M tons CO2 emissions



2500 M tons Waste



Competitiveness



## Innovative solutions



Industrial-Urban Symbiosis

Process Innovation

Electrification

Energy mix

CCU

Resources Efficiency & Flexibility

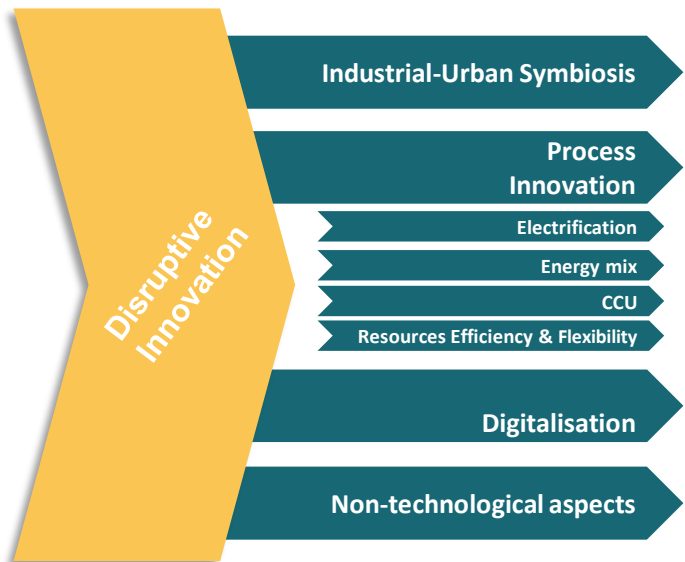
Digitalisation

Non-technological aspects

## Cross sectoral Goals

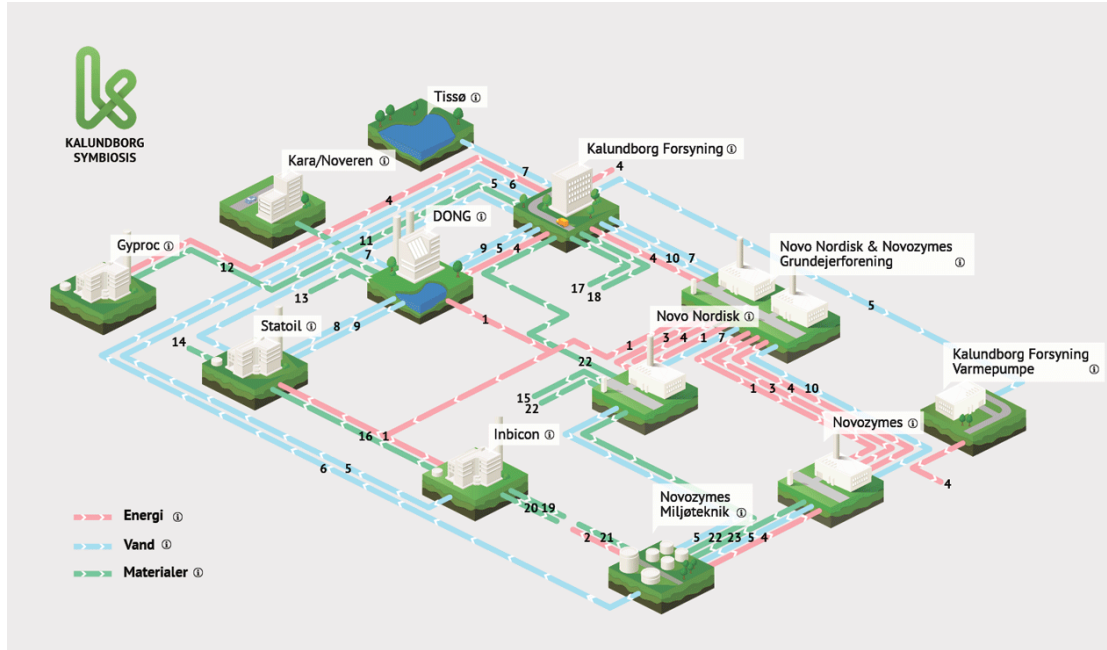
### Pathways for 2050 Process Industries

1. Climate Action  
✓ Climate neutrality
2. Circularity  
Near-zero landfilling & water discharge
3. Competitiveness  
✓ Competitive process industries



Innovation area	Progress up until milestone year <sup>1</sup>			
	2024	2030	2040	2050
Renewable energy integration				
Heat reuse				
Electrification of thermal processes				
Electrically-driven processes				
Hydrogen integration				
CO <sub>2</sub> capture for utilisation				
CO <sub>2</sub> utilisation in minerals				
CO <sub>2</sub> & CO utilisation in chemicals and fuels				
Energy and resource efficiency				
Circularity of materials				
Industrial-Urban symbiosis				
Circular regions				
Digitalisation				
Non-technological aspects				

<sup>1</sup> Progress is depicted here as % of total TRL9 projects programmed in each area, and for circular regions, digitalisation, and non-technological aspects % of total investment needs until 2050



Kalundborg, Source of image: <http://www.energycrossroads.org/industrial-symbiosis-circular-economy>

Connection of **geographically close units** to keep resources in the loop as long as possible

*Self-sustaining economic industrial ecosystems for **full-scale Industrial-Urban Symbiosis and Circular Economy**, closing **energy, resource and data loops** and bringing together all relevant stakeholders, technologies, infrastructures, tools and instruments necessary for their incubation, implementation, evolution and management.*



## Hubs for Circularity

essential tool to deliver the transformation

### Regional demands

- Societal needs
- Customer needs
- Stakeholder demands



### Knowledge sharing through Community of Practice



### Regional community



- RTOs
- SMEs
- Civil society
- Across sectors
- Process industry
- Financial institutions
- Public sector



### Sustainable business model



- Business-to-territory plan
- Co-investments model

### Disruptive innovation



- Social innovation
- Business models
- Technology
- Processes

### Regional benefits

- Industrial-Urban Symbiosis
- Economic growth
- Understanding regional demands



### Exporting innovations



## Value Chain based on:

- Local collection
- Sorting in the Hub
- First processing in the Hub
- Logistics improvement in the Hub
- Interregional collaboration
- Smart specialization of the region  
[European process industry(ies)]



## SYMBIOSIS

Exploring on site cross sectorial symbiosis: EPOS  
⇒ Simplify limitations of discussion  
⇒ Steel, cement, water, residues, recycled materials

## Platforms

Platform for flexible management of shared process resources: SHAREBOX  
⇒ Flexible management of shared process resources

Management & optimization of a symbiotic cluster of Smart production Units: SYMBIOPTIMA  
➔ Resource & Management System energy flows, resources & monitoring

## Sharing Resources Tools

Scaling European Resources with industrial symbiosis: SCALER  
⇒ Sharing Resources  
⇒ Best practices, guidelines, business systems

Total Resource & Energy efficiency management system for process industry: MAESTRI  
⇒ Sharing resources

On-line matching platform: CIRCLEAN  
⇒ Network  
⇒ Reporting tool

Matching tool for industrial excess heat/cold reduction, recovery & redistribution: EMB3Rs  
Sharing Resources

## Demos

Living Lab: Construction industry y (zero waste model): FISSAC  
⇒ Sharing wastes from construction industry  
⇒ Blended cement, ecotiles

Industrial Symbiosis Incubator for maximizing waste heat/cold efficiency in industrial parks/districts: INCUBIS  
⇒ First H4C pilots & example of ECoP

Now on the move to European Community of Practice

Development of demos via the different calls

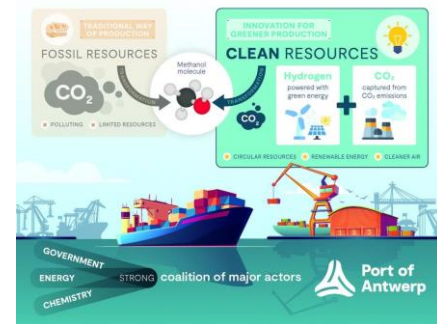
Including industrial – urban symbiosis

Matching tools:

- Need for demand vs supply approach
- Need for intermediate matching of quality
- ➔ Upcycling of wastes via innovation companies (SME's)

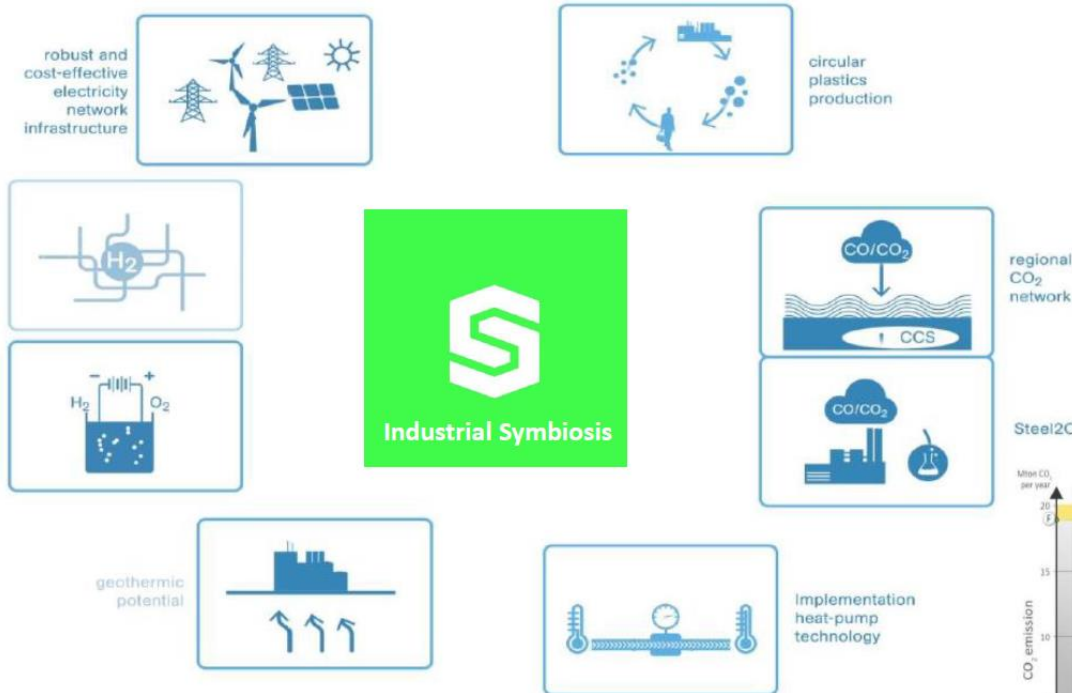


- Symbiosis with Urban systems
  - EOL to secondary feedstock
  - Waste to energy
  - Excess heat to district heating
  - Waste water recycling
- Symbiosis with energy production systems
  - On shore or off shore windmill parks
  - Hydrogen Valleys
  - Off shore windmill parks, hydrogen production and CCU or CCS
  - PV-parks
  - Solar energy parks
- Symbiosis with industry
  - Excess heat to power or steam
  - CO2 to CCU
  - CO2 to common purification for CCS
  - Side products as feedstock





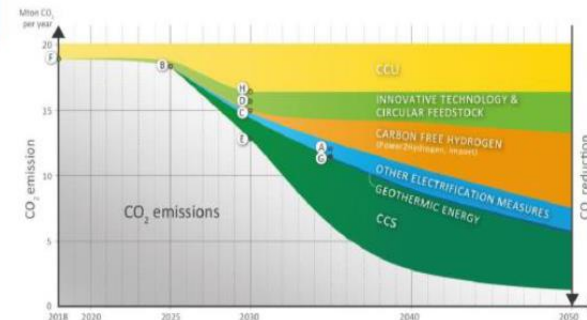


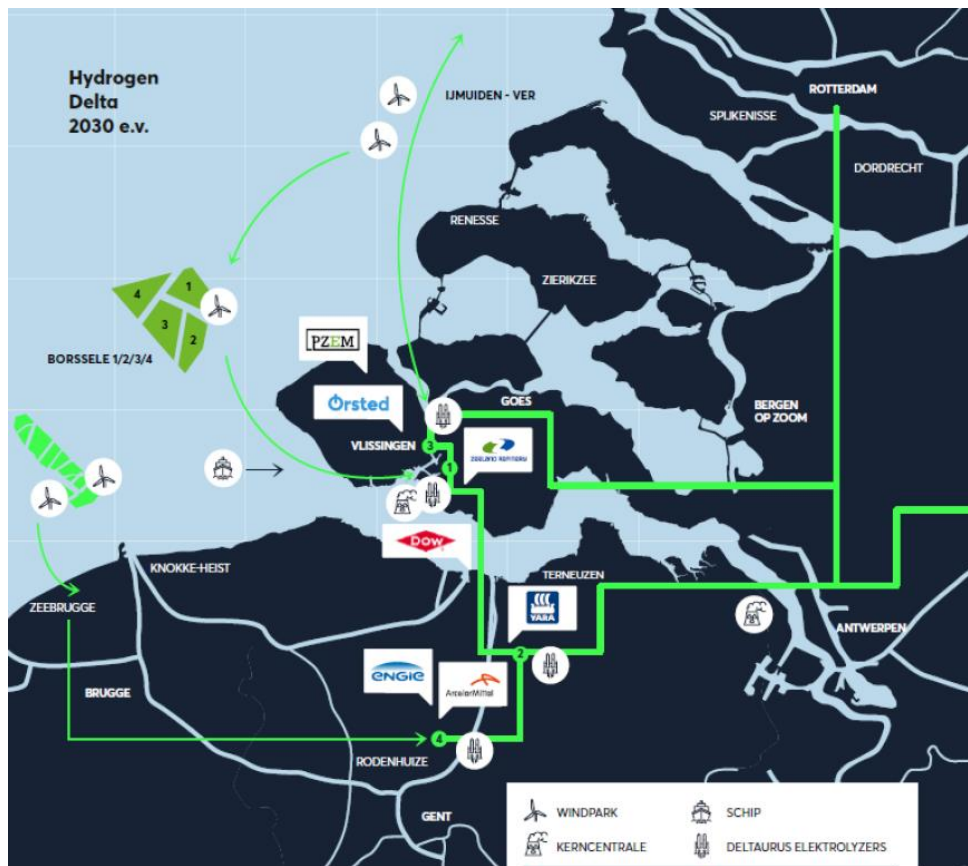


## SDR CO<sub>2</sub> reduction path

- The SDR CO<sub>2</sub> reduction path describes the chosen strategy (transition paths) to make the SDR region more sustainable.
- The SDR Roadmap 2018 lies along this path underpinned. In this were both the transition paths CCU (S), electrification, hydrogen and heat and process optimization already defined.
- In 2020, the SDR ETS companies provided SDR insight in their strategy and plans to achieve their own climate goals.
- Together this gives one clear picture of the size of the target CO<sub>2</sub> reduction by 2030 and 2050 and how and when these must be realized.

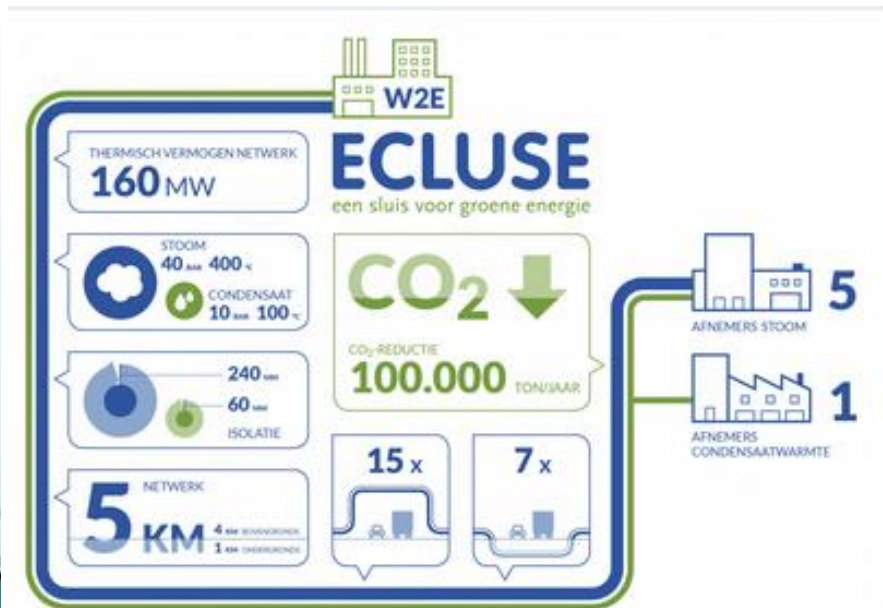
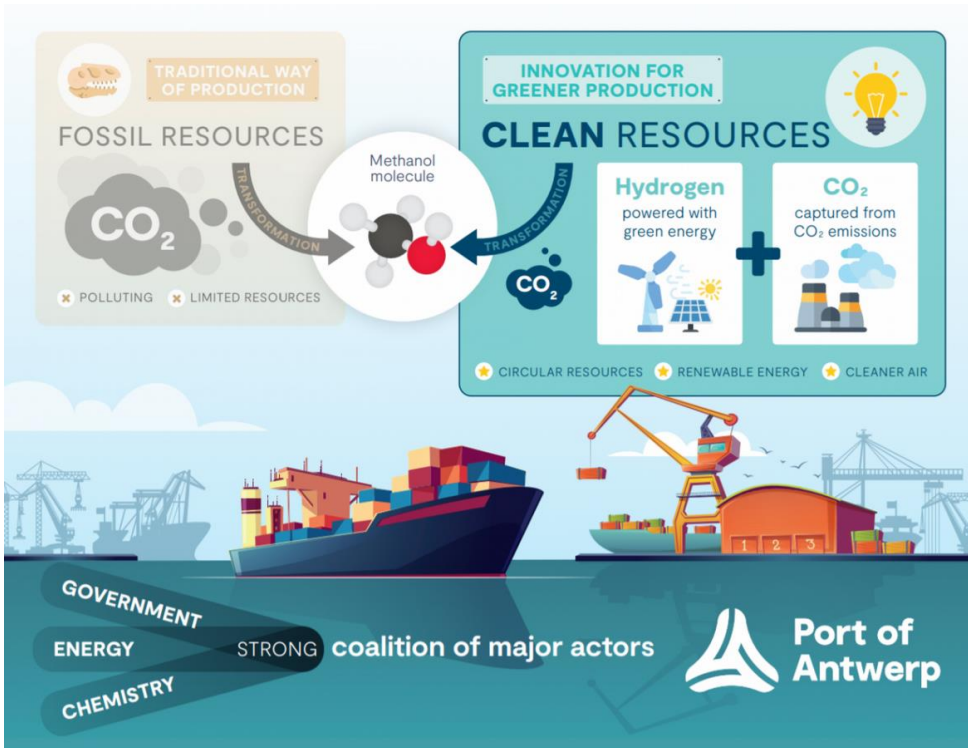
Steel2Chemicals





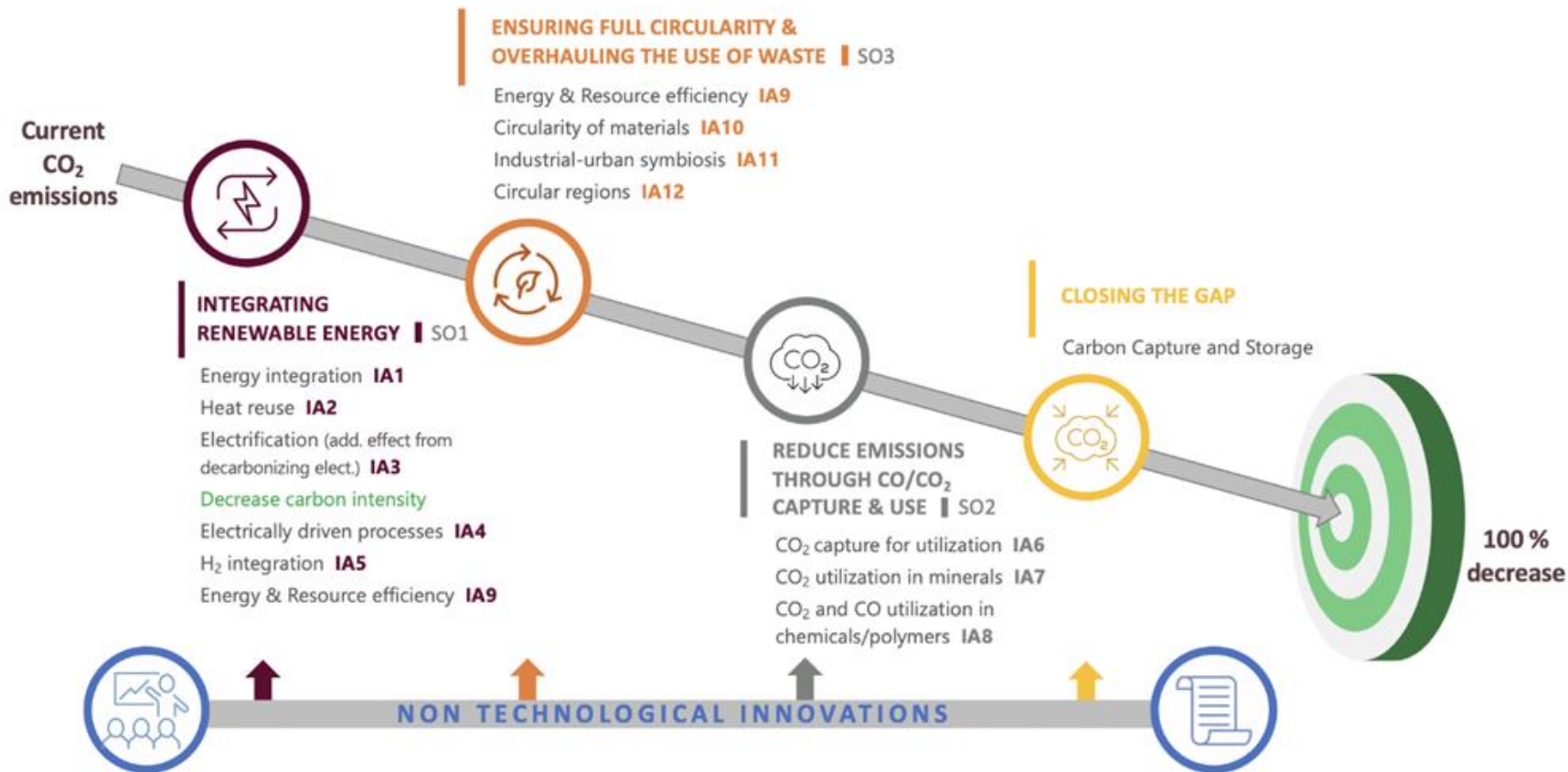
Afbeelding 6: Weergave Hydrogen Delta Programma 2030

- 1 ZR - DELTAURUS
- 2 YARA - DELTAURUS
- 3 SLOE - DELTAURUS
- 4 RODENHUIZE - DELTAURUS
- WATERSTOF
- GROENE ENERGIE

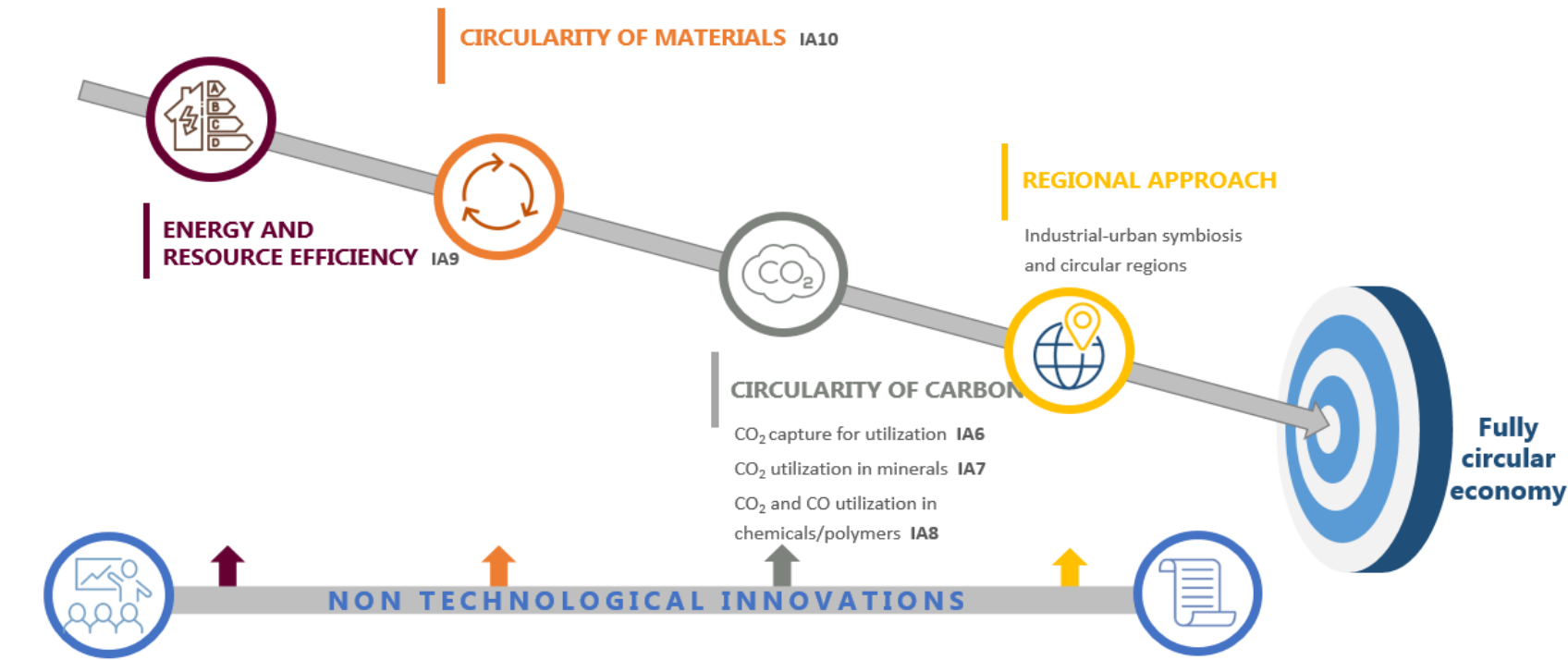




## A patchwork of innovations to achieve climate neutrality







## THE WAY IS LONG, THE MOMENT IS NOW



**Unique cross-sectoral community**

Innovation area	Progress up until milestone year <sup>1</sup>			
	2024	2030	2040	2050
Renewable energy integration	○	●	●	●
Heat reuse	○	●	●	●
Electrification of thermal processes	○	●	●	●
Electrically-driven processes	○	●	●	●
Hydrogen integration	○	●	●	●
CO <sub>2</sub> capture for utilisation	○	●	●	●
CO <sub>2</sub> utilisation in minerals	○	●	●	●
CO <sub>2</sub> & CO utilisation in chemicals and fuels	○	●	●	●
Energy and resource efficiency	○	●	●	●
Circularity of materials	○	●	●	●
Industrial-Urban symbiosis	○	●	●	●
Circular regions	○	●	●	●
Digitalisation	○	●	●	●
Non-technological aspects	○	●	●	●

<sup>1</sup> Progress is depicted here as % of total TRL3 projects programmed in each area, and for circular regions, digitalisation, and non-technological aspects % of total investment needs until 2050

**36 innovation programmes to FILL the GAP**

+ Skills, Jobs, Competitive gap analysis, Framework/Standards



**First-of-a-kind plants (FOAKs)**

**Hubs for Circularity**



**Ambitions to enable Prosperity for all**



Climate neutrality



Near zero landfilling and near zero water discharge



Competitive EU process industries

- **First-of-a-kind Large scale plants in operation**

- Combine one or several P4Planet Innovations towards the 2030/2050 ambitions to reach Climate neutrality and circularity
- Acting as Hubs of bulk amounts of resources from industry and the municipalities.
- Several marbles will likely connect to reach together the targets of the partnership's KPIs
- **50+ “Marbles”** identified. Aiming to **launch 15 in the period 2021 – 2030**, responding to the Green Deal plan, and enabled by the P4Planet innovation portfolio

## PRIVATE INVESTMENTS

- Industry leader commitment
- when technical and economic feasibility is proved through Horizon Europe programs.
- Public support needed to de-risk and accelerate



PROCESSES4PLANET



**First-of-a-kind plants**

**Ambitions to enable Prosperity for all**



Climate neutrality  
Net-zero emissions



Circularity:  
Near zero landfilling  
and near zero water  
discharge



Competitive EU  
process industries

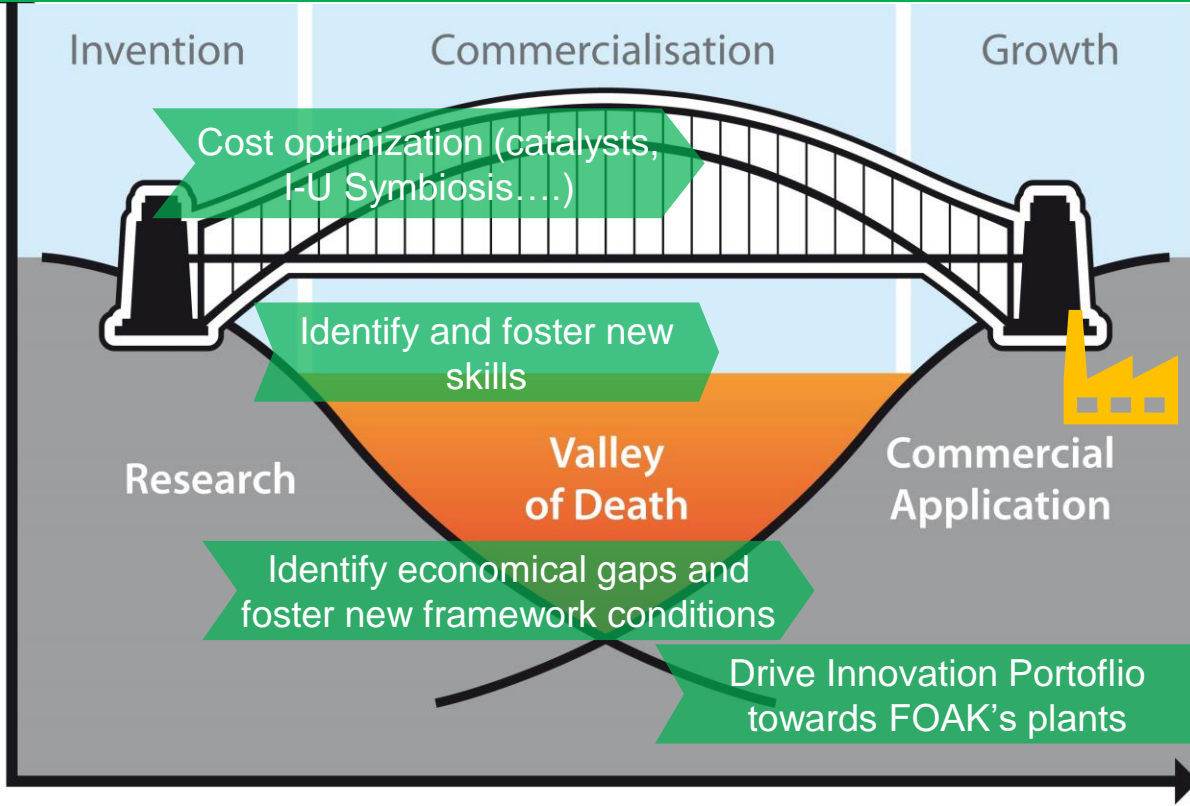
## UNLOCKING PRIVATE INVESTMENTS & THE BARRIERS TO MARKET FOR CLIMATE NEUTRAL & CIRCULAR SOLUTIONS



PROCESSES+PLANET

- De-risk Investments
- FINANCIAL FLOW
- Generate a market for climate neutral & circular products
- Available & Affordable Green Energy
- Digitalisation & H4Cs to accelerate innovation

Funding



Cost optimization (catalysts, I-U Symbiosis...)

Identify and foster new skills

Identify economical gaps and foster new framework conditions

Drive Innovation Portfolio towards FOAK's plants

JOBS

CIRCULAR ECONOMY

SUSTAINABLE PROCESSES & MATERIALS

CIRCULAR REGIONS

CLIMATE NEUTRAL CONTINENT

Level of Development

Funding & Financial tools

HORIZON EUROPE

Energy Co-fund Partnership ?  
MS National Programs

NEW  
INNOVATION  
FUND

INVEST EU & CEF

The RDI process

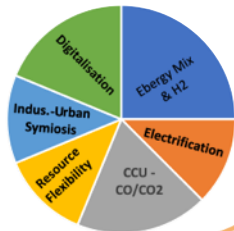
Basic Research  
TRL 1-3

Technology Development  
TRL 4-5

System prototype  
TRL 6-7

Demonstrator, TRL 8  
FOAK, Marbles, TRL 9

Roll-out



The € resources GAP

Cash Flow

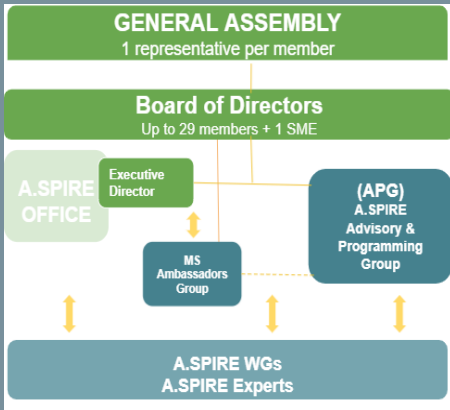
€ Needed R&I

Cash Flow Valley of Death

# Governance and External consultation

## PRIVATE PARTNER

### ASPIRE



## PARTNERSHIP BOARD



### PROCESSES4PLANET

- Signatories
- Commitment
- Decision making

## PUBLIC PARTNER



**+180**  
Members teaming up



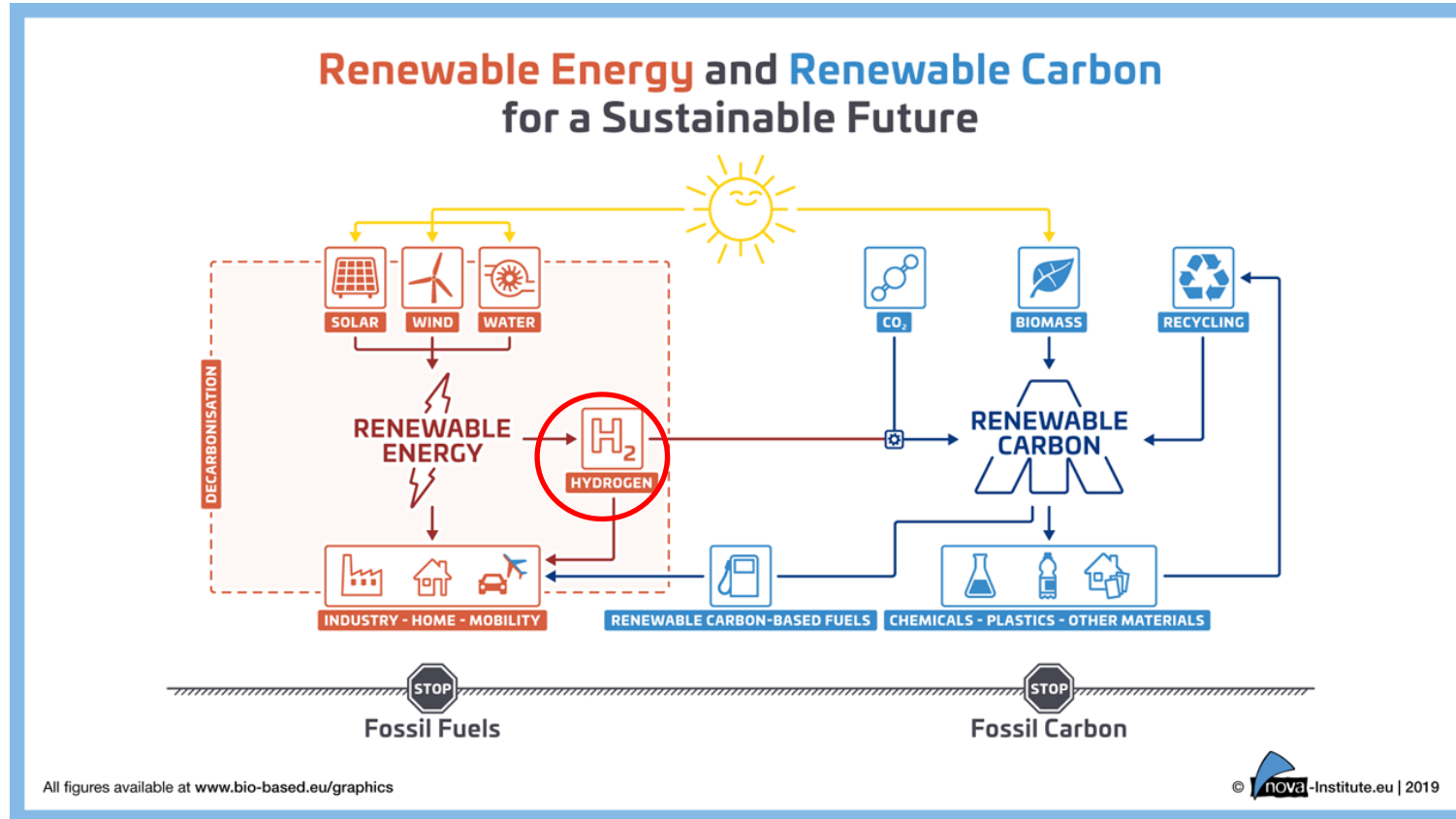
## FEEDBACK PANEL

*Dialogue with civil society*

## IMPACT PANEL

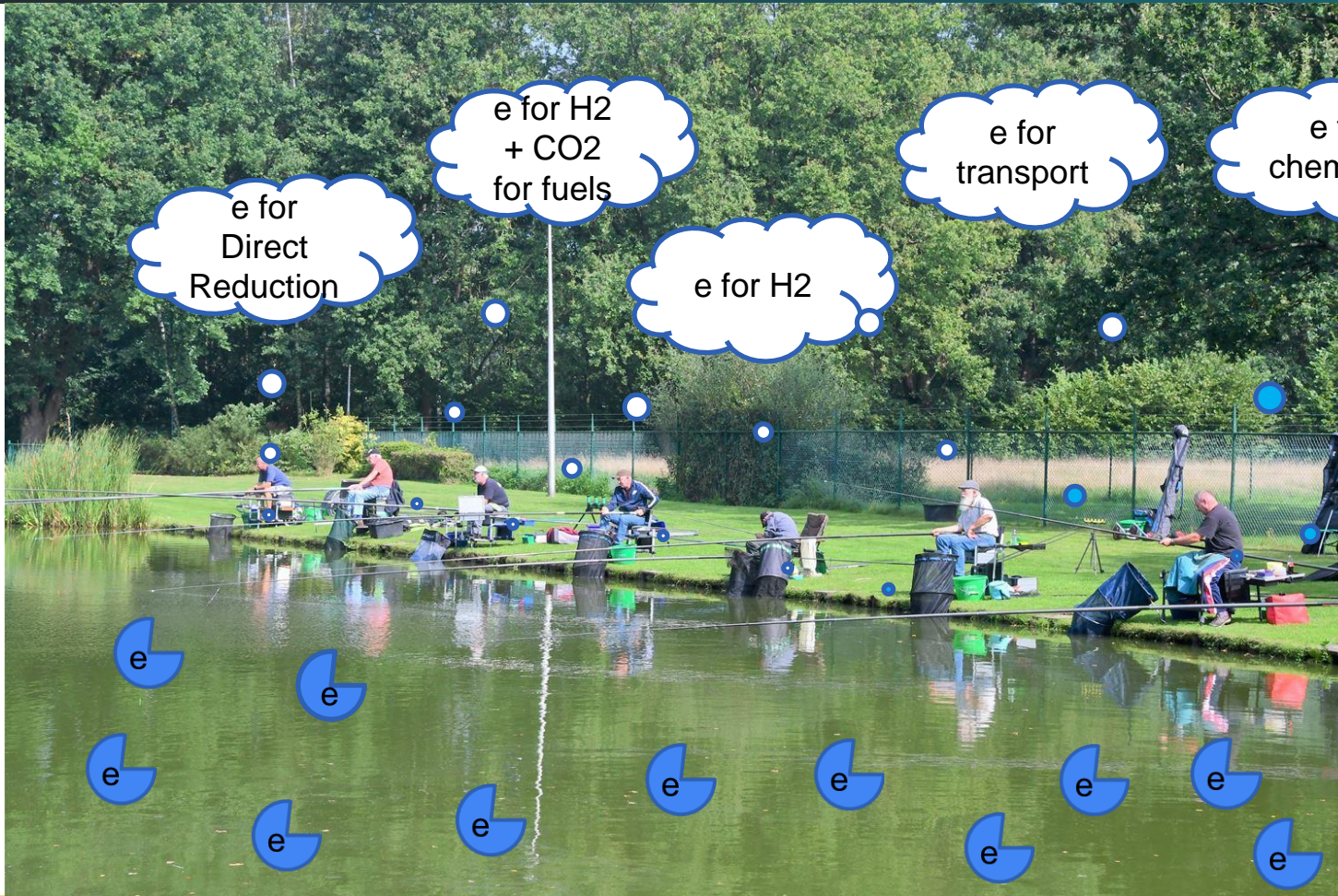
*Dialogue with public investors beyond HEU*

Carbon from atmosphere, biosphere or technosphere





# All fishing in the same electron pool



e for Direct Reduction

e for H<sub>2</sub> + CO<sub>2</sub> for fuels

e for H<sub>2</sub>

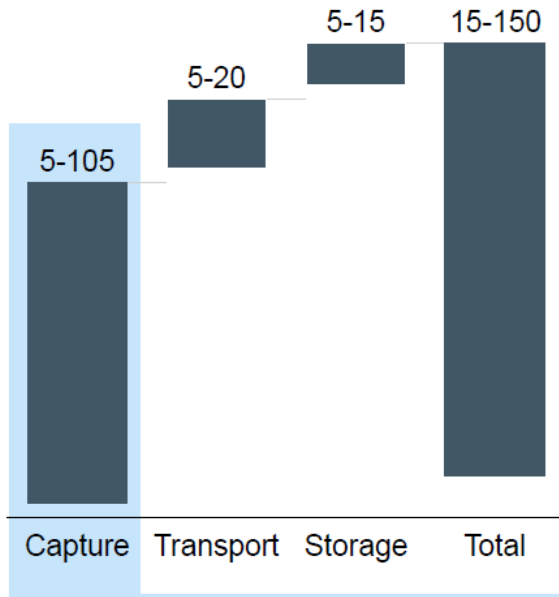
e for transport

e for chemicals

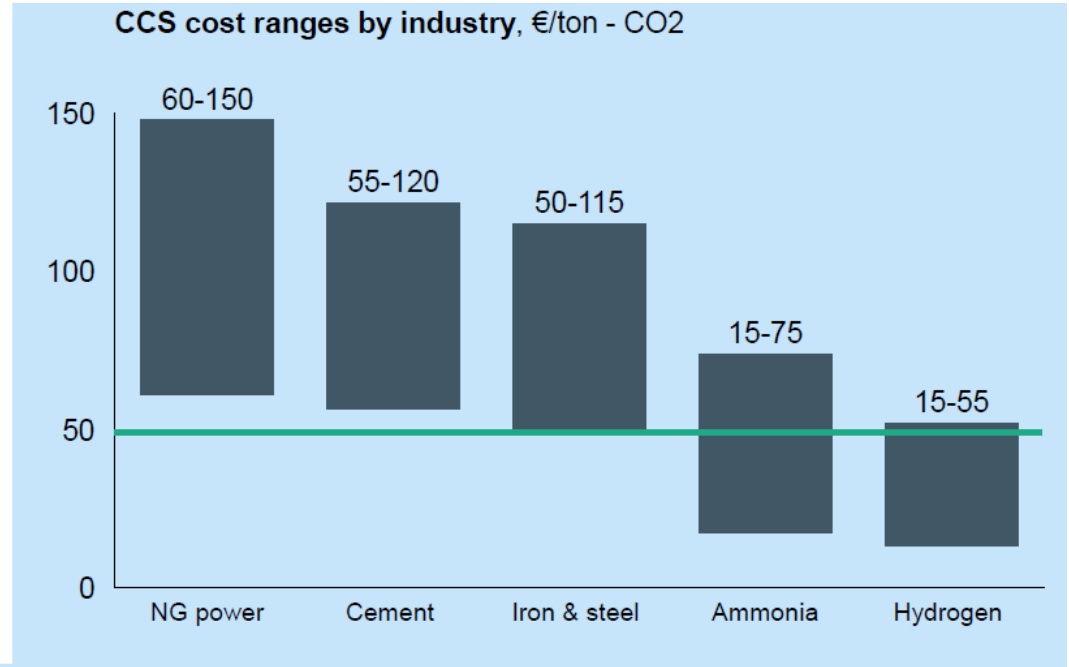
e for electric furnaces/crackers

e for H<sub>2</sub> for transport

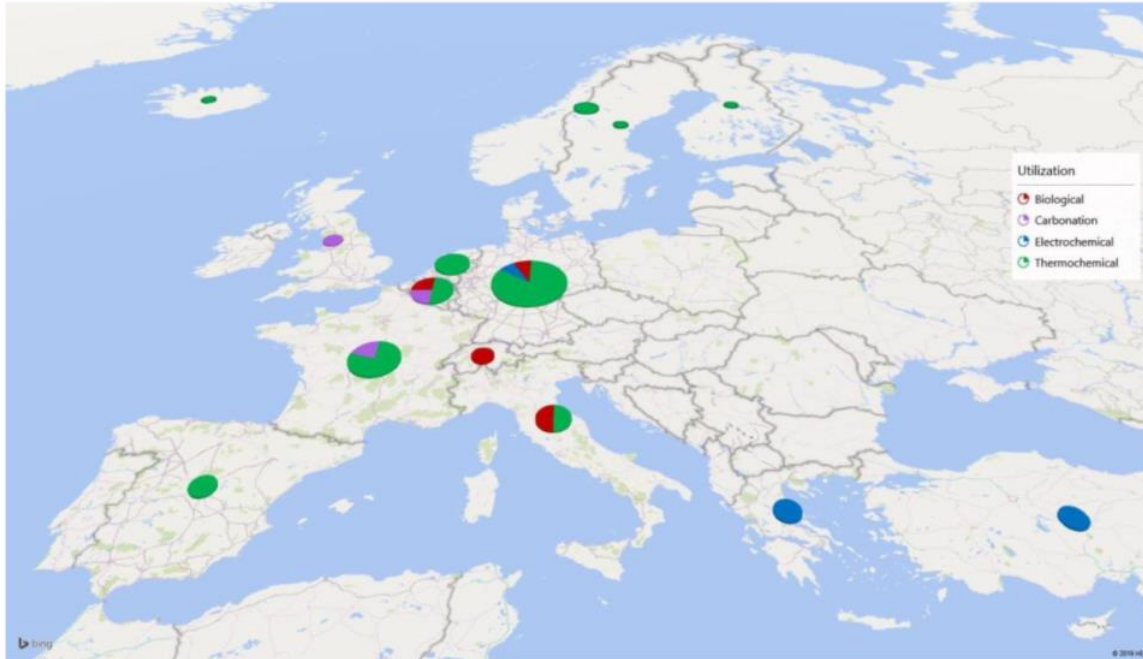
### CCS cost breakdown, €/ton - CO2



### CCS cost ranges by industry, €/ton - CO2

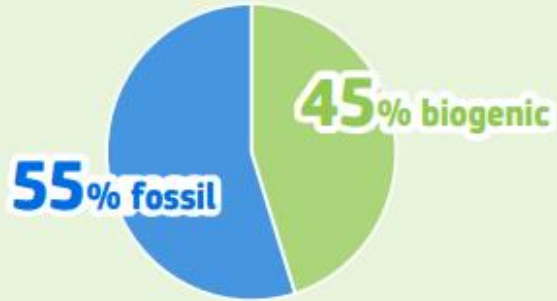


## Collective intelligence: >125 CCU projects in Europe

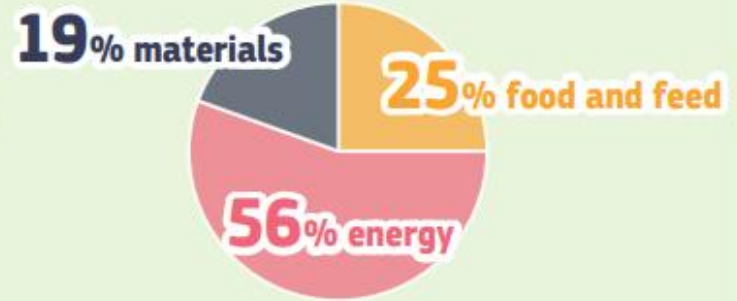


- approx. 50% high TRL projects (from demo. to commerc.)
- approx. 63% CO<sub>2</sub> to chemicals and fuels projects
- approx. 27% CO<sub>2</sub> Capture projects
- approx. 10% CO<sub>2</sub> to mineralization projects

The EU consumed around one billion tonnes of carbon in the economy 2018



Use of carbon in the economy



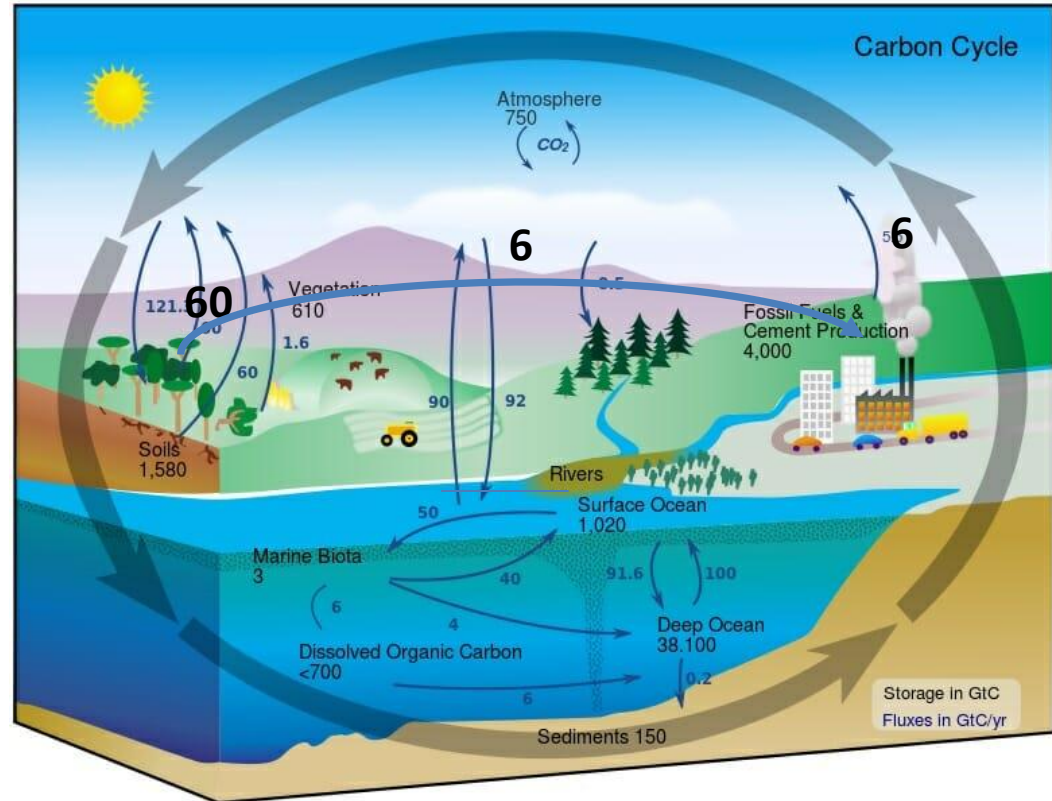


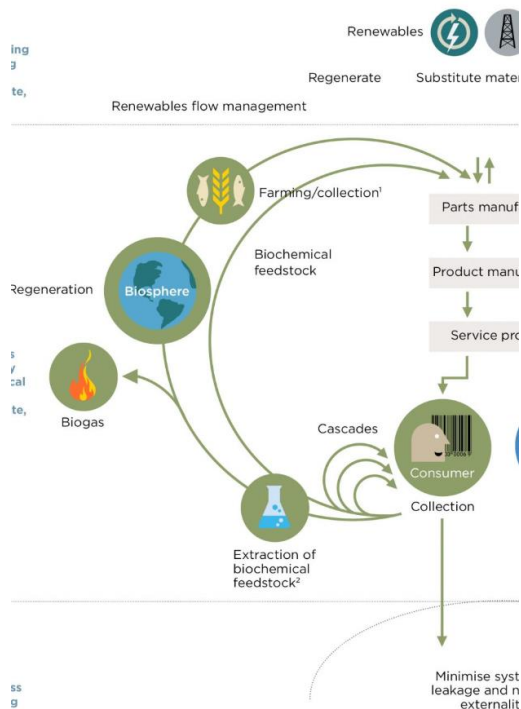
It is possible to close the carbon cycle by using plants as a carbon source.

It would be enough to prevent

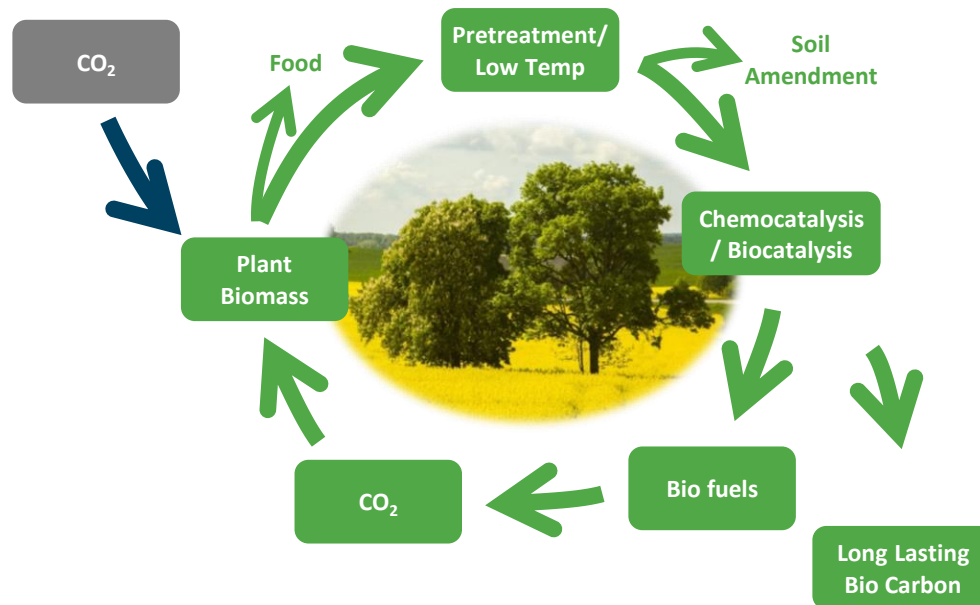
10%

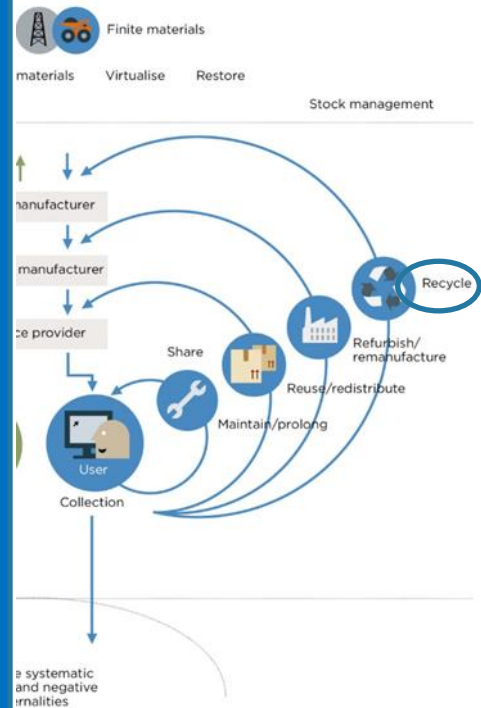
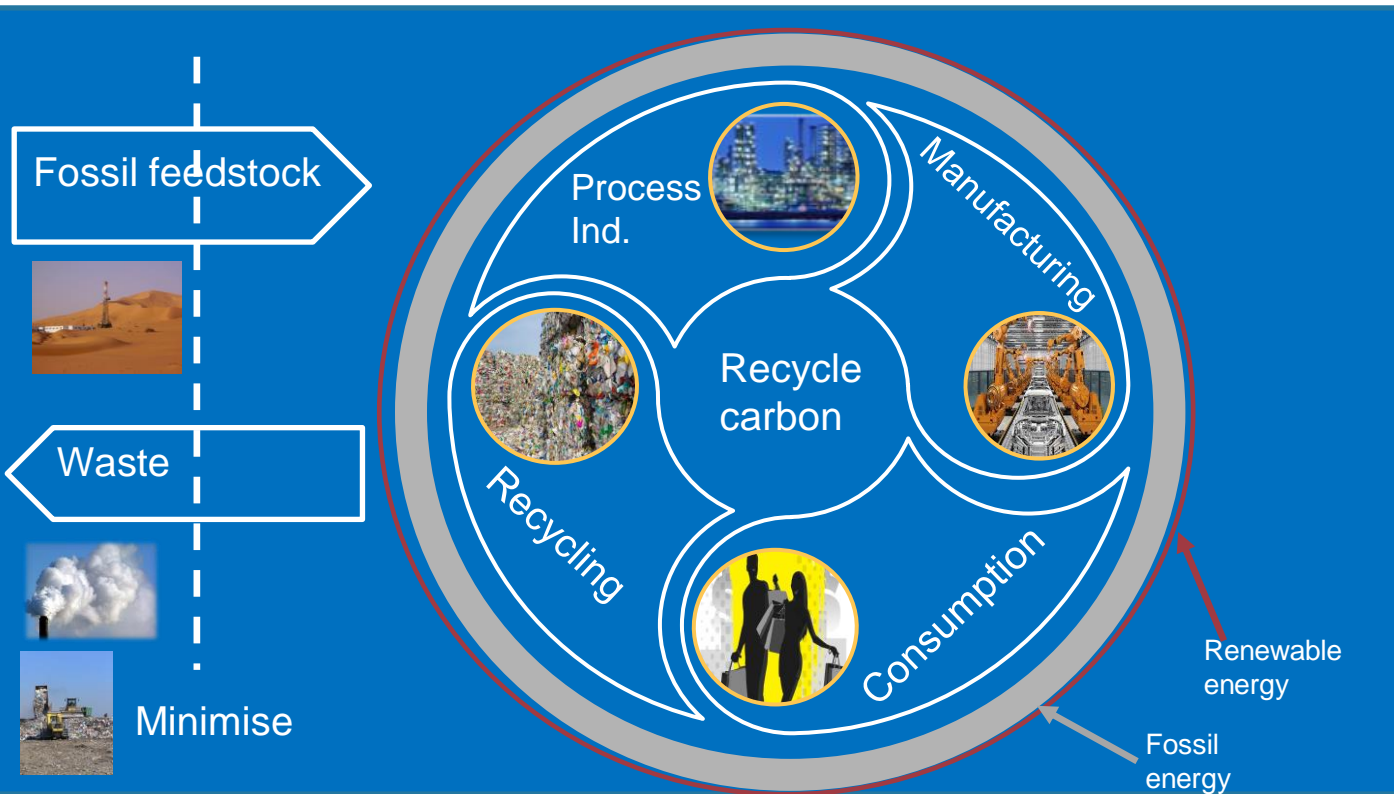
of the biomass from decaying.





## ...to tomorrows Circular Economy





1. Hunting and fishing  
 2. Can take both post-harvest and post-consumer waste as an input  
 Source: Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment; Drawing from Braungart & McDonough, Cradle to Cradle (C2C).



## OUTLINE OF A CIRCULAR ECONOMY

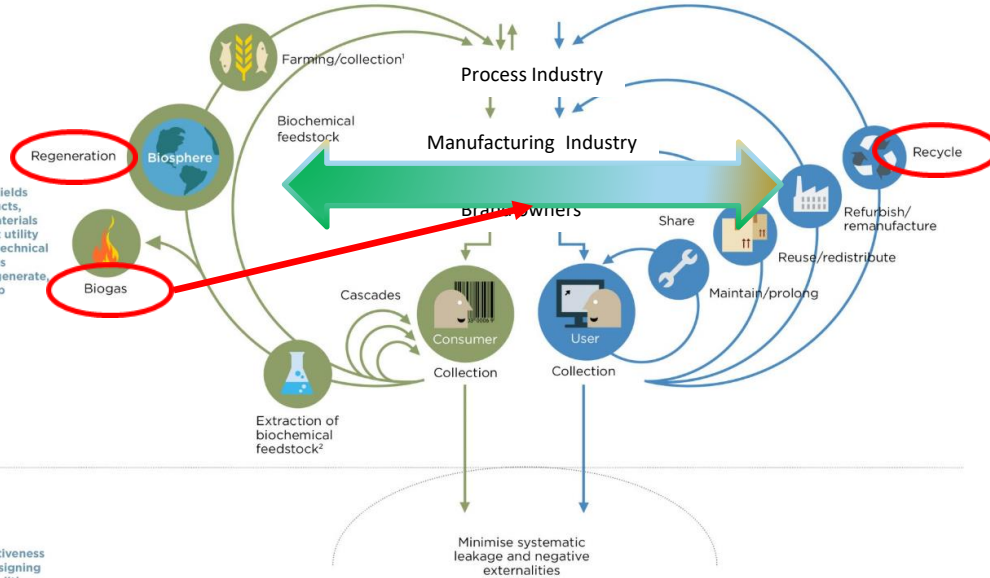
### PRINCIPLE 1

Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows  
 ReSOLVE levers: regenerate, virtualise, exchange



### PRINCIPLE 2

Optimise resource yields by circulating products, components and materials in use at the highest utility at all times in both technical and biological cycles  
 ReSOLVE levers: regenerate, share, optimise, loop

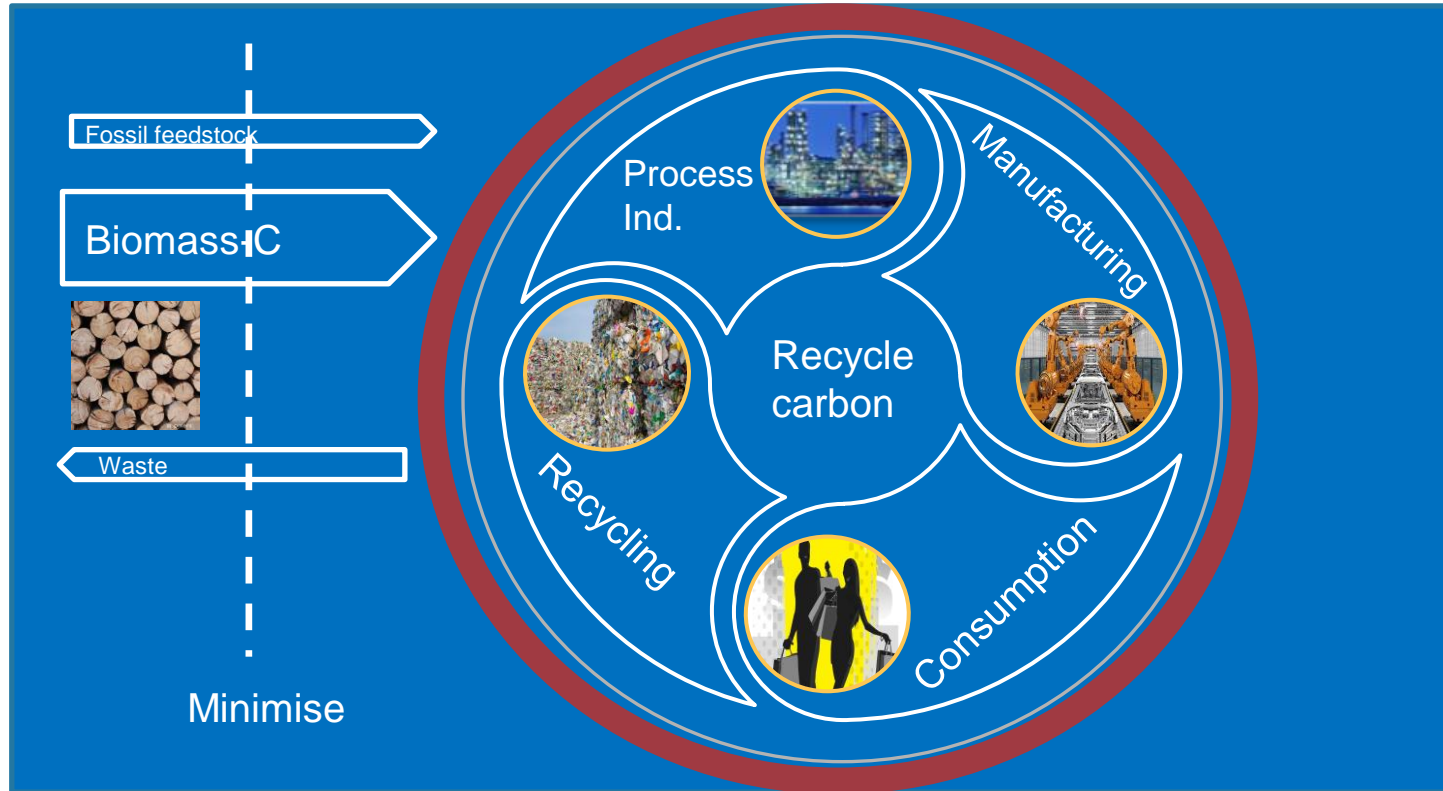


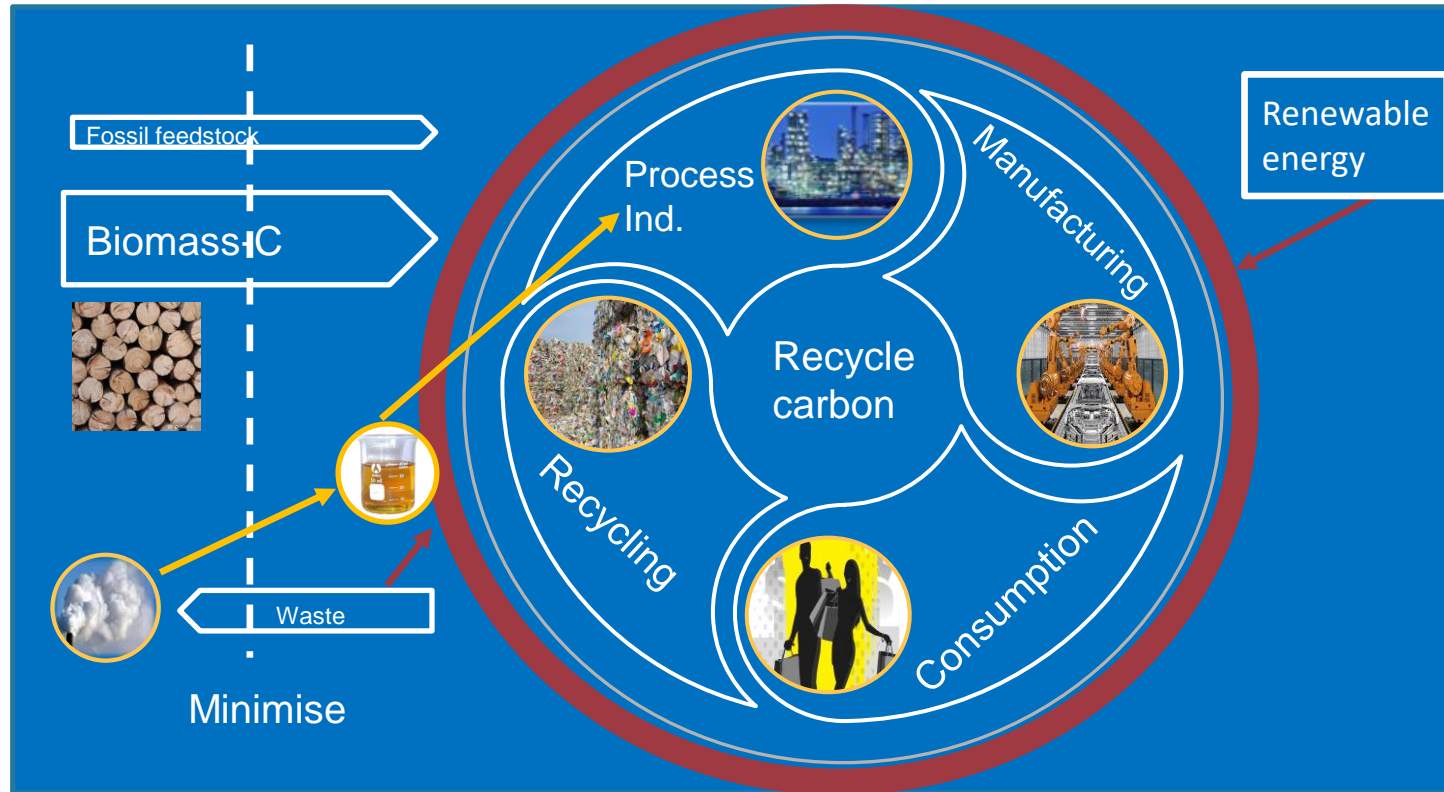
### PRINCIPLE 3

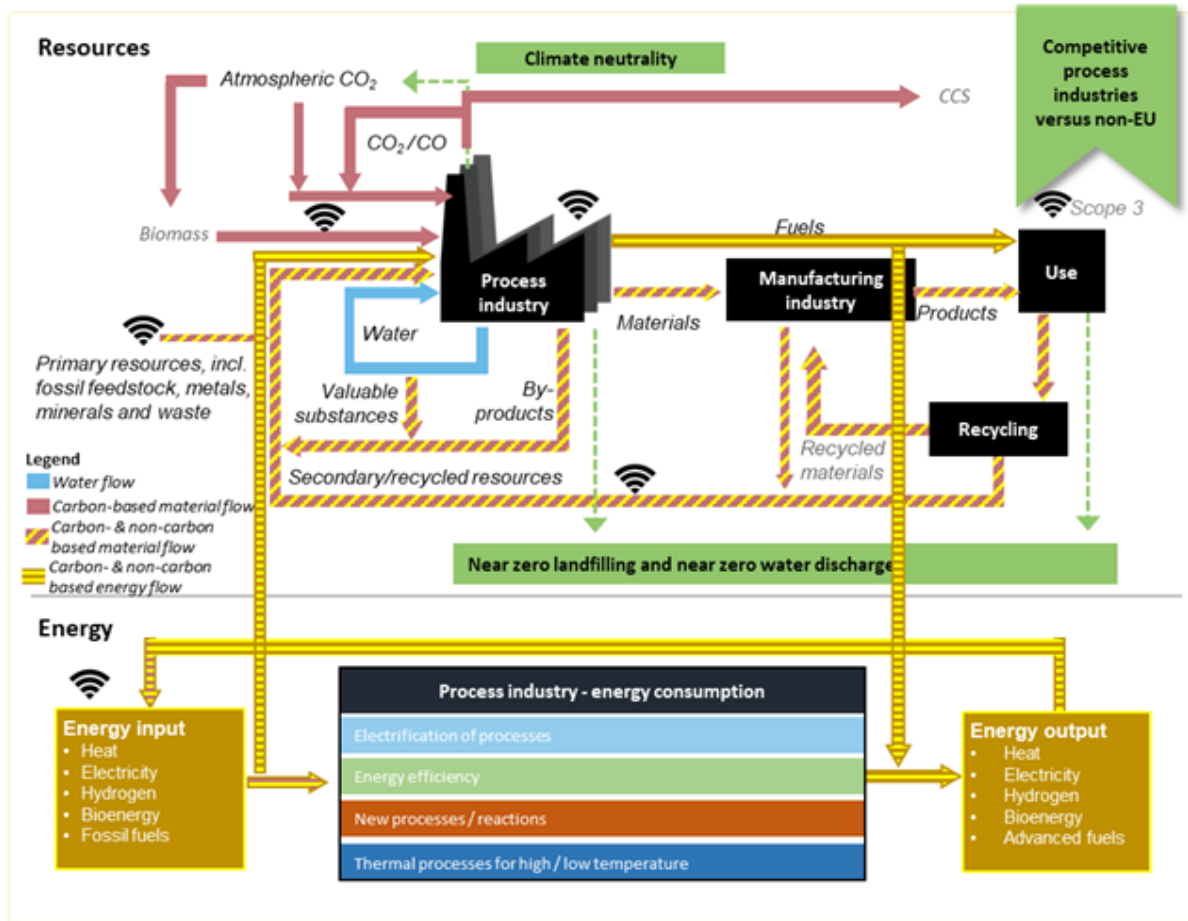
Foster system effectiveness by revealing and designing out negative externalities  
 All ReSOLVE levers

Minimise systematic leakage and negative externalities

1. Hunting and fishing  
 2. Can take both post-harvest and post-consumer waste as an input  
 Source: Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment; Drawing from Braungart & McDonough, Cradle to Cradle (C2C).







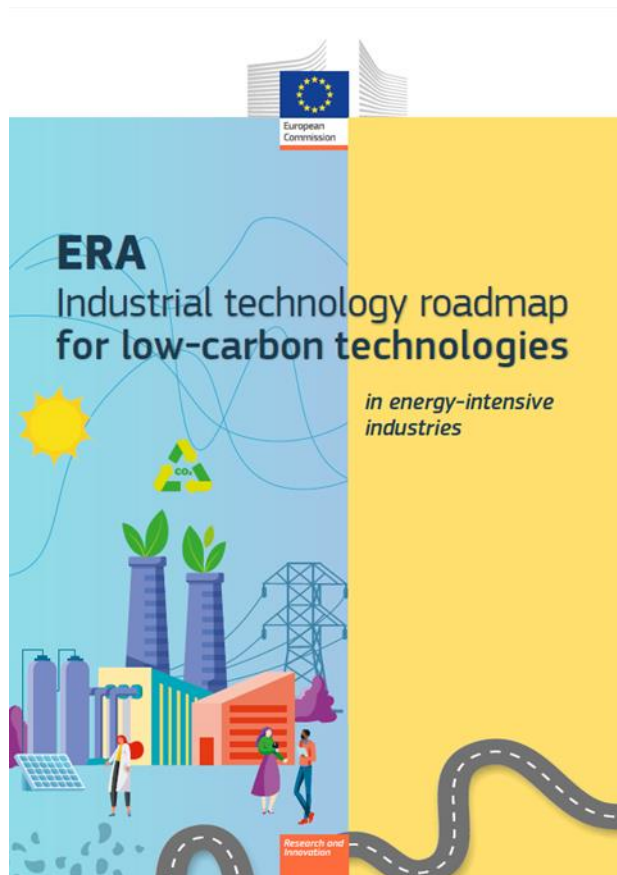
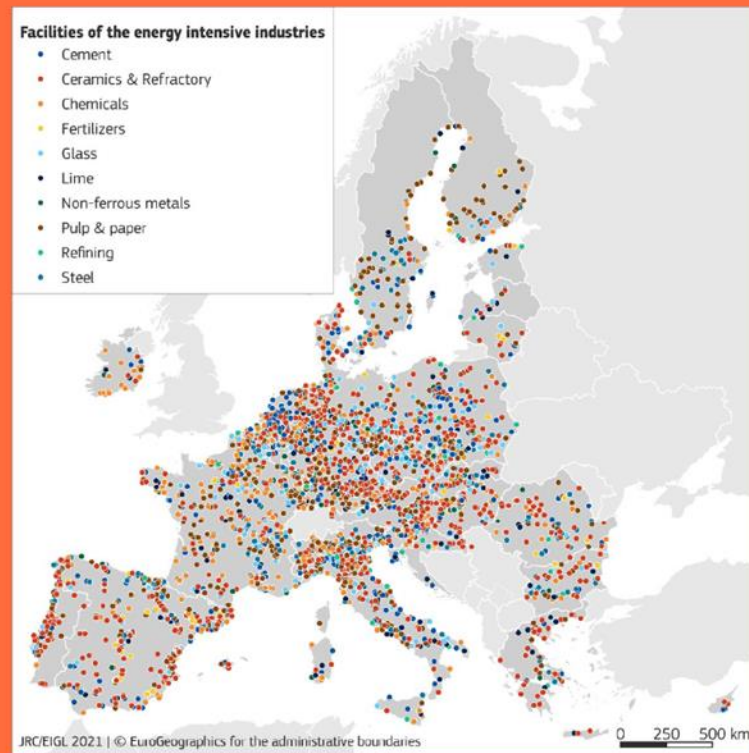


Figure 2 Production facilities of the EII ecosystem in the EU



Source: Energy and Industry Geography Lab (Joint Research Centre).

## P4Planet topics. Destinations in Cluster 4:

- Destination 1: Climate neutral, circular and digitized production TWIN-TRANSITION
- Destination 2: A digitized, resource-efficient and resilient industry RESILIENCE



PROCESSES4PLANET

### Deadline 23/09/2021

- HORIZON-CL4-2021-TWIN-TRANSITION-01-14: Deploying industrial-urban symbiosis solutions for the utilization of energy, water, industrial waste and by-products at regional scale (RIA)
- HORIZON-CL4-2021-TWIN-TRANSITION-01-16: Hubs for Circularity European Community of Practice (ECoP) platform (CSA)
- HORIZON-CL4-2021-TWIN-TRANSITION-01-21: Design and optimisation of energy flexible industrial processes (IA)
- HORIZON-CL4-2021-RESILIENCE-01-01: Ensuring circularity of composite materials (RIA)

### Deadline 30/03/2022

- HORIZON-CL4-2022-TWIN-TRANSITION-01-10: Circular flows for solid waste in urban environment (IA)
- HORIZON-CL4-2022-TWIN-TRANSITION-01-11: Valorisation of CO/CO2 streams into added-value products of market interest (IA)
- HORIZON-CL4-2022-TWIN-TRANSITION-01-15: New electrochemical conversion routes for the production of chemicals and materials in process industries (RIA)
- HORIZON-CL4-2022-TWIN-TRANSITION-01-17: Integration of hydrogen for replacing fossil fuels in industrial applications (IA)

- Energy efficiency
- Electrification
- Energy mix
- Hydrogen
- Excess heat
- Symbiosis
- Resource efficiency
- Circularity of materials
  - Biomass
  - CCU
  - Recycle
- CCS

New calls in Work Program 2023-2024



# THANK YOU



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