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La Utilización del CO2 del concepto a la innovación

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Departamento de Ingenierías Química y Biomolecular

Desarrollo de Procesos Químicos y Control de Contaminantes

1. CONTEXTO DE LA UTILIZACION DE CO2

Argumentos Ambientales

-Argumentos Sociales

-Argumentos Económicos

Pregunta 1. ¿Por qué hay que intentar utilizar CO_2?

-Los fenómenos extremos del Clima.

El Coste de no hacer suficiente

1. Hurricanes Florence and Michael Estimated Cost: $17 billion (Florence)

2. California wildfires $7.5 billion - $10 billion (Camp Fire)

3. Droughts in Europe $7.5 billion

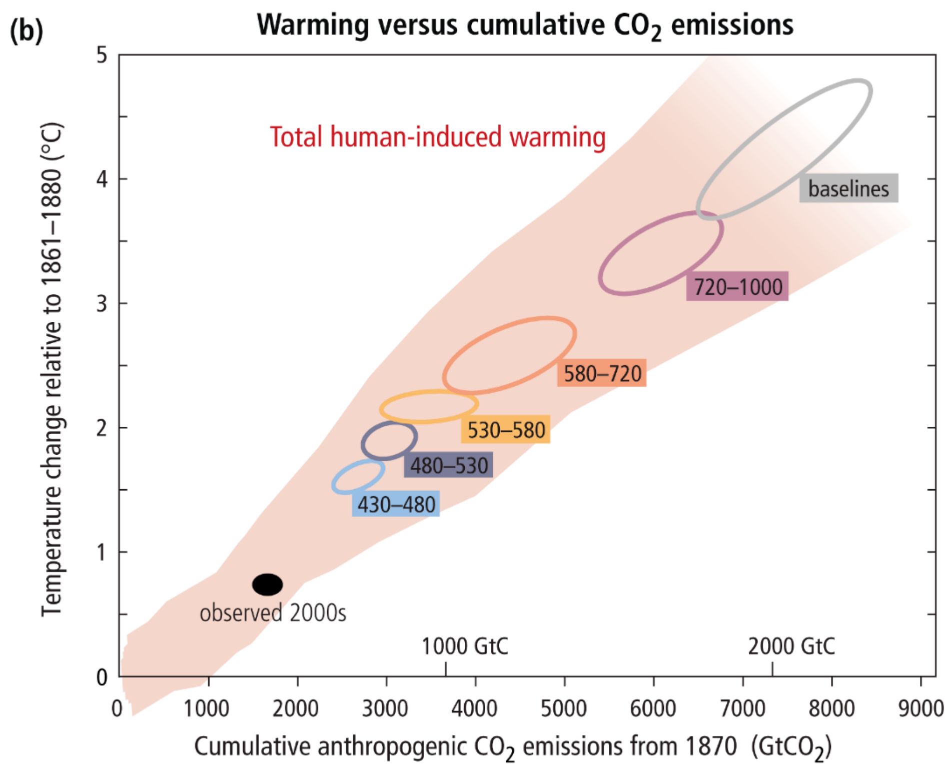
4. Floods in Japan $7 billion (June-July Floods) $2.3 billion - $5.5 billion (Typhoon Jebi)

5. Droughts in Argentina $6 billion

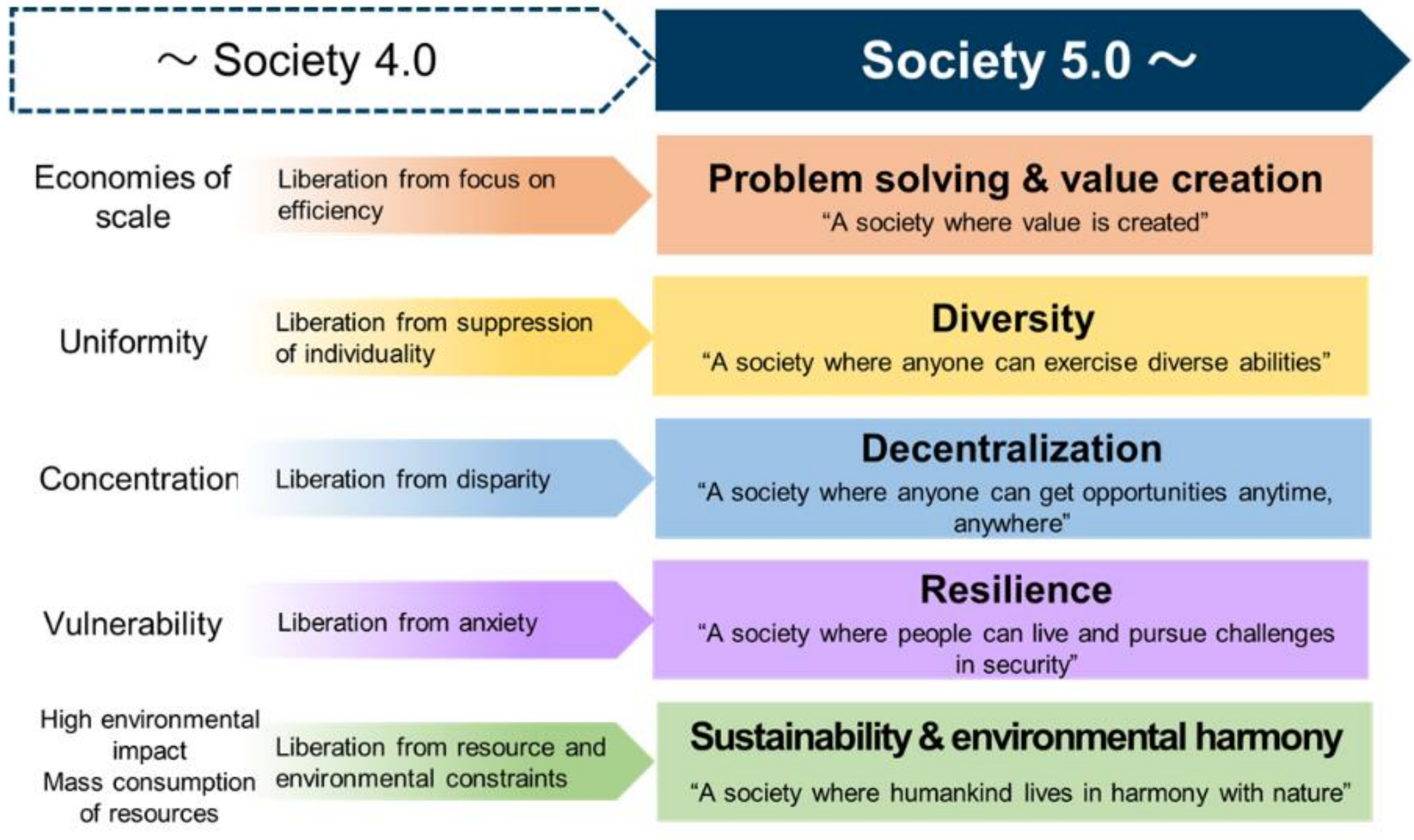
ESCENARIO DE TEMPERATURAS

La acumulación continuada de gases de efecto invernadero causara calentamiento y cambios permanents en todos los componentes del sistema climatico incrementando la probabilidad de impactos severos persistentes e irreversibles para las personas y para los ecosistemas

Limitar el cambio climático require reducciones sustanciales y sostenidas de las emisiones de GEI, lo que junto a las medidas de adaptación puede limitar los riesgos derivados del cambio climático.

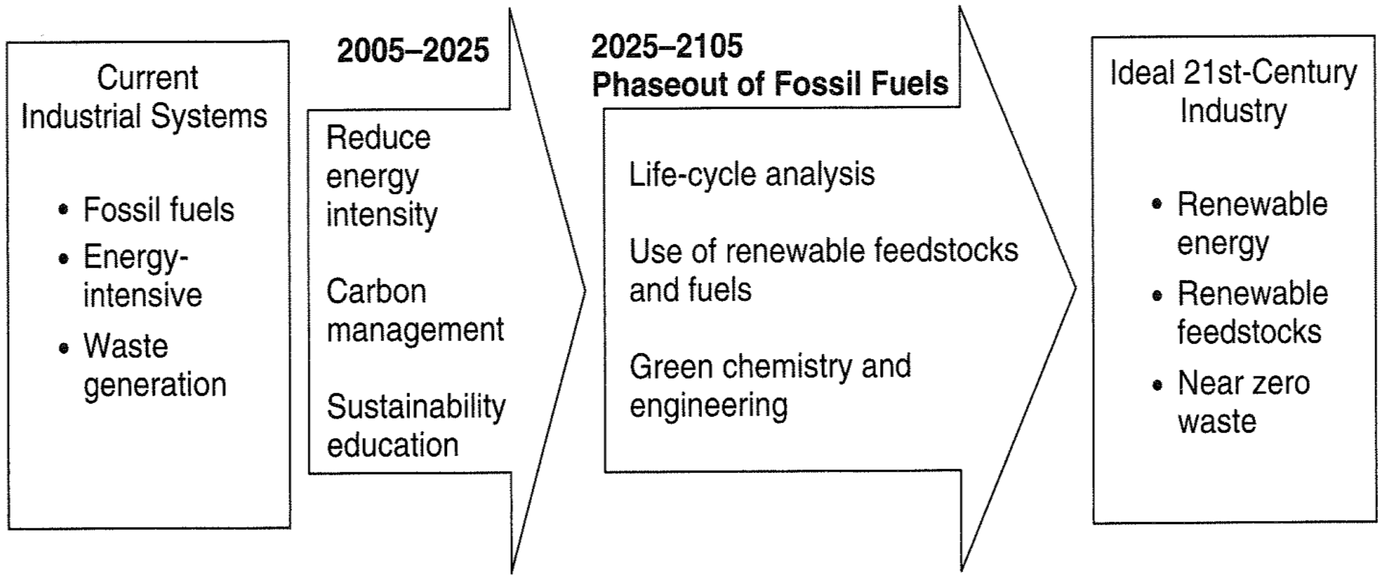


JUSTIFICACION SOCIAL



https://www.weforum.org/agenda/2019/01/modern-society-has-reached-its-limits-society-5-0-will-liberate-us/

SUSTAINABLE PRODUCTION Ideal Scenario 21st Century



Sustainable Engineering. Concepts, Design and Case Studies. D T Allen, D R Shonnard. Prentice Hall 2012

2. DEL CONCEPTO A LA INNOVACION:EJES

-Economía Circular

-Descarbonización (Desfosilización)

-Digitalización

PREGUNTA 2. ¿Qué podemos hacer para utilizar mas CO_2?

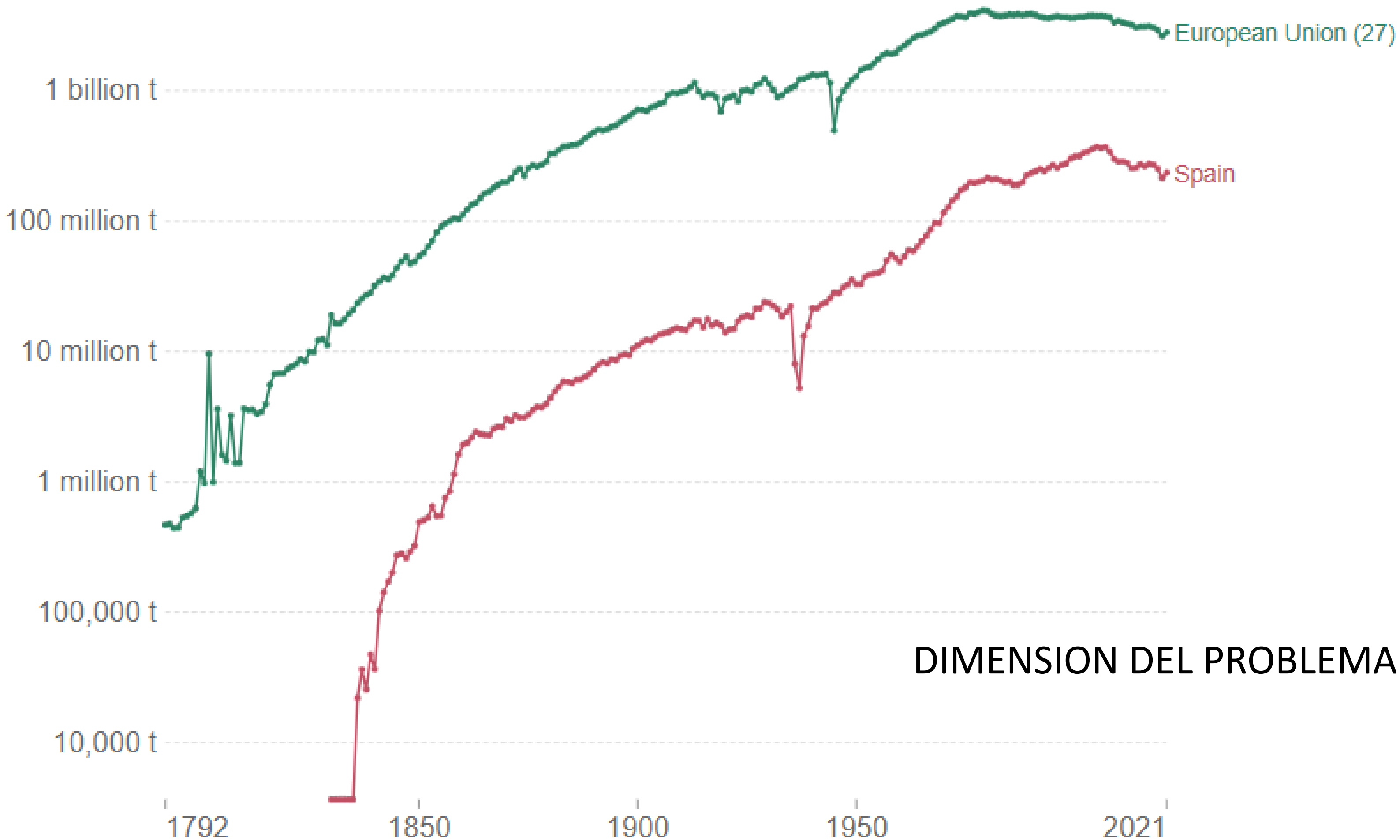
-Economía Circular

-Descarbonización

-Digitalización

Annual CO_2 emissions

Carbon dioxide (CO_2) emissions from fossil fuels and industry[1] . Land use change is not included.



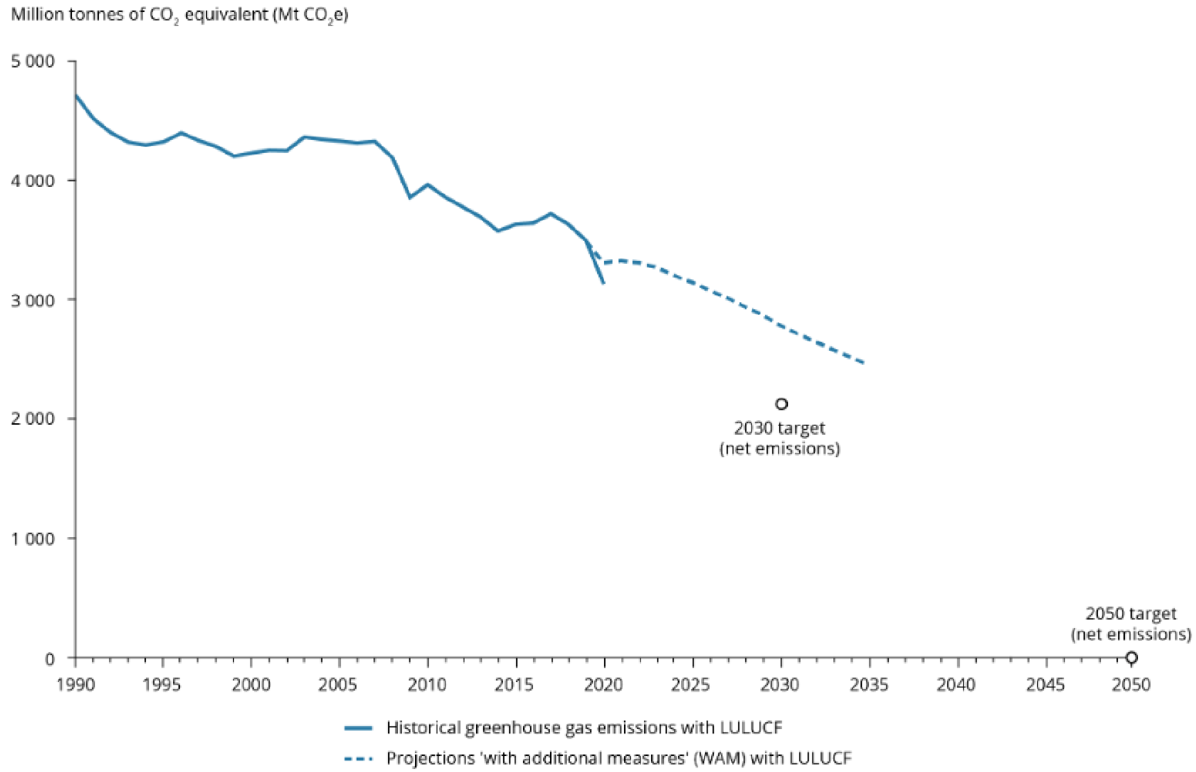
DIMENSION DEL PROBLEMA

Source: Global Carbon Budget (2022)

1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO_2) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO_2 includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

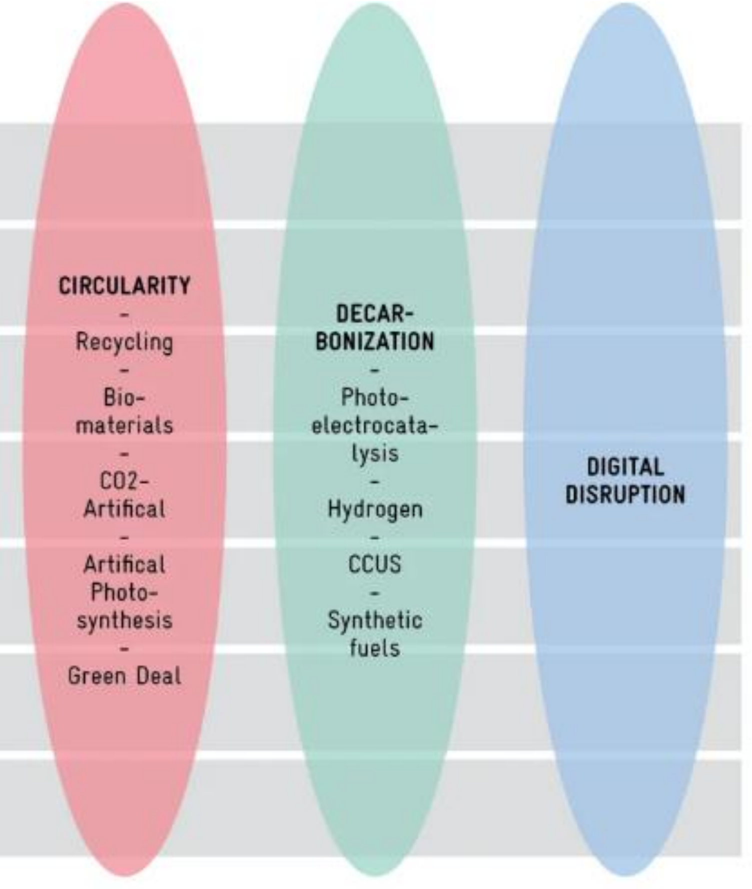
CLIMATE CHANGE MITIGATION: CARBON FOOTPRINT EU-TARGETS

Greenhouse gas emissions targets, trends and projections in the EU, 1990-2050



Source: EEA, *Trends and Projections in Europe 2021*, European Environment Agency.

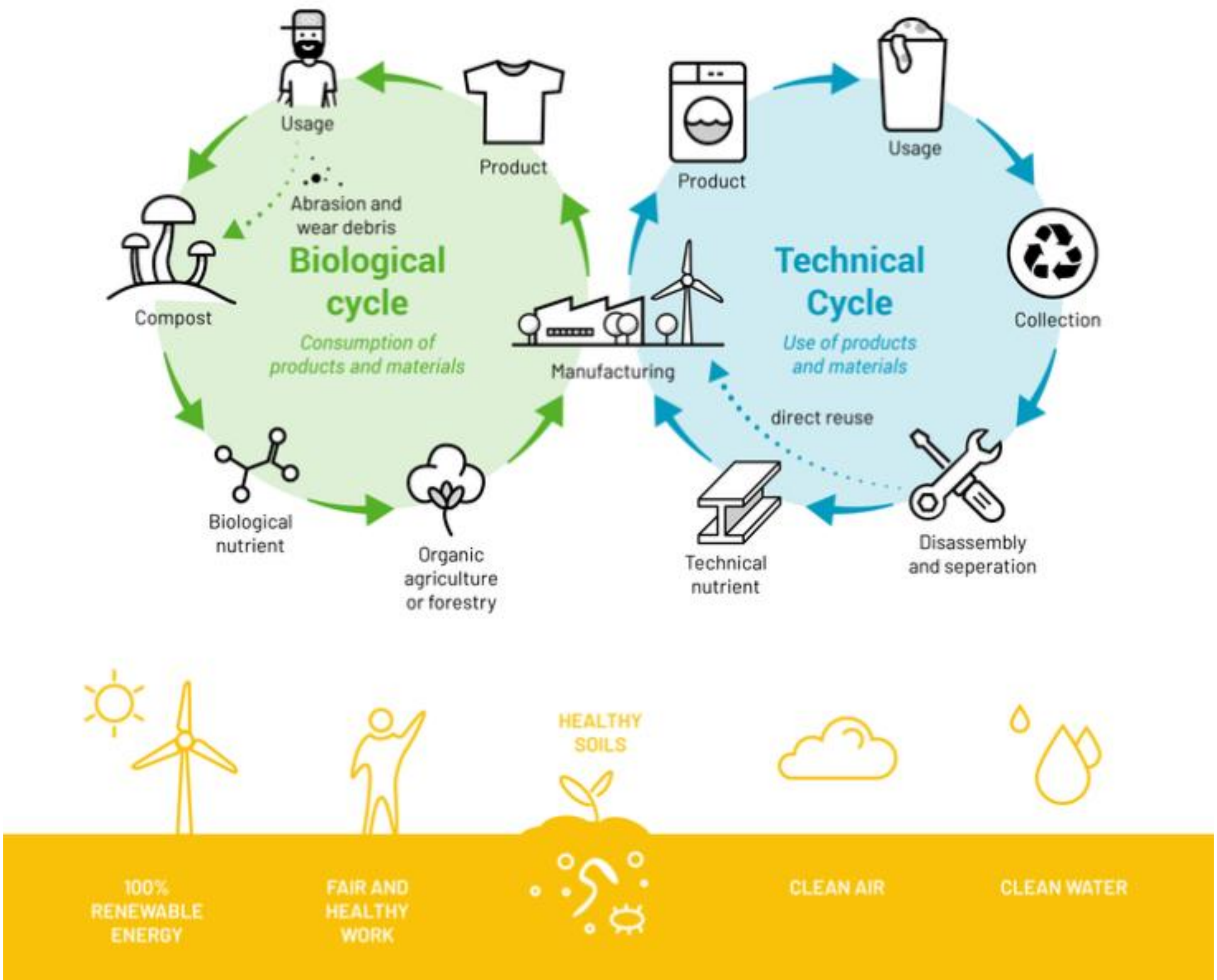
DRIVERS TO A MORE SUSTAINABLE CARBON MANAGEMENT

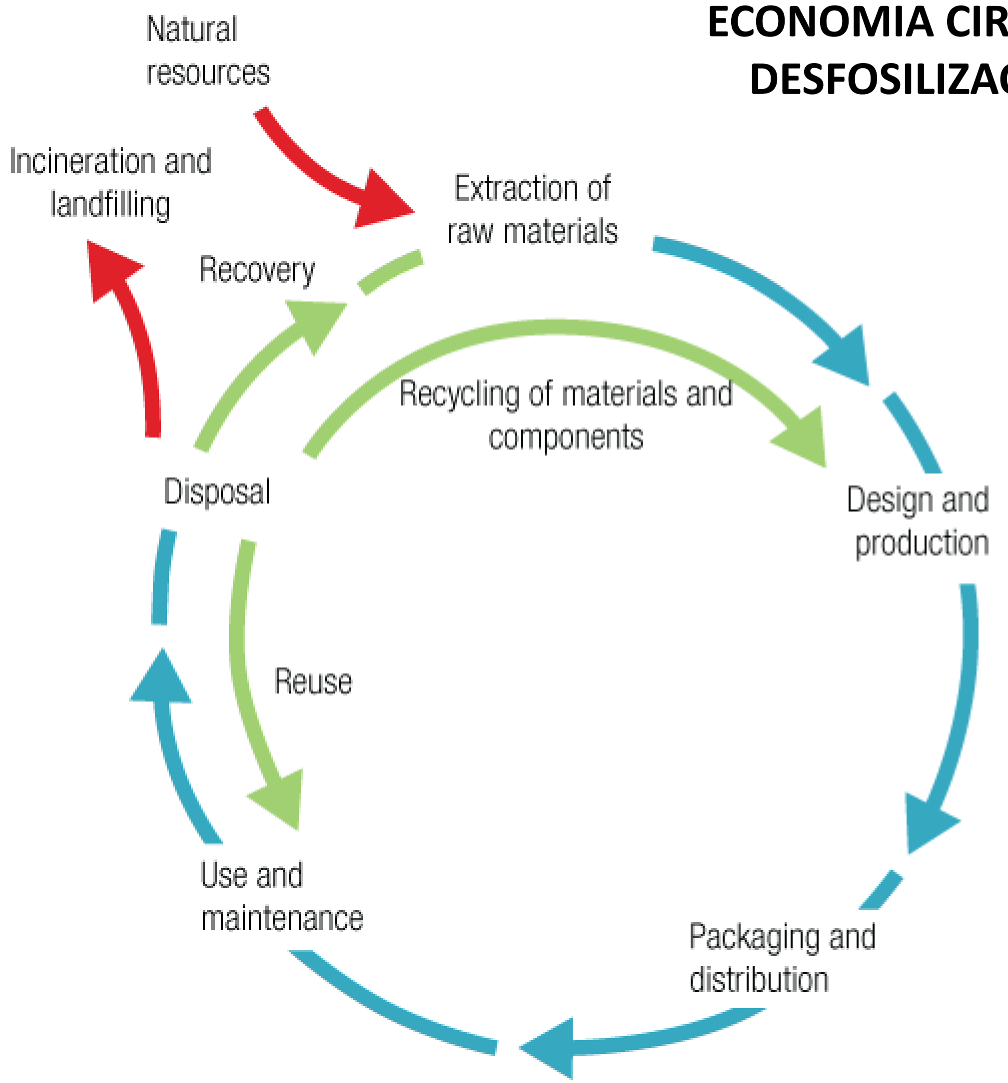


https://www.mecce.org/

CRADLE TO CRADLE

A concept by Michael Braungart and William McDonough



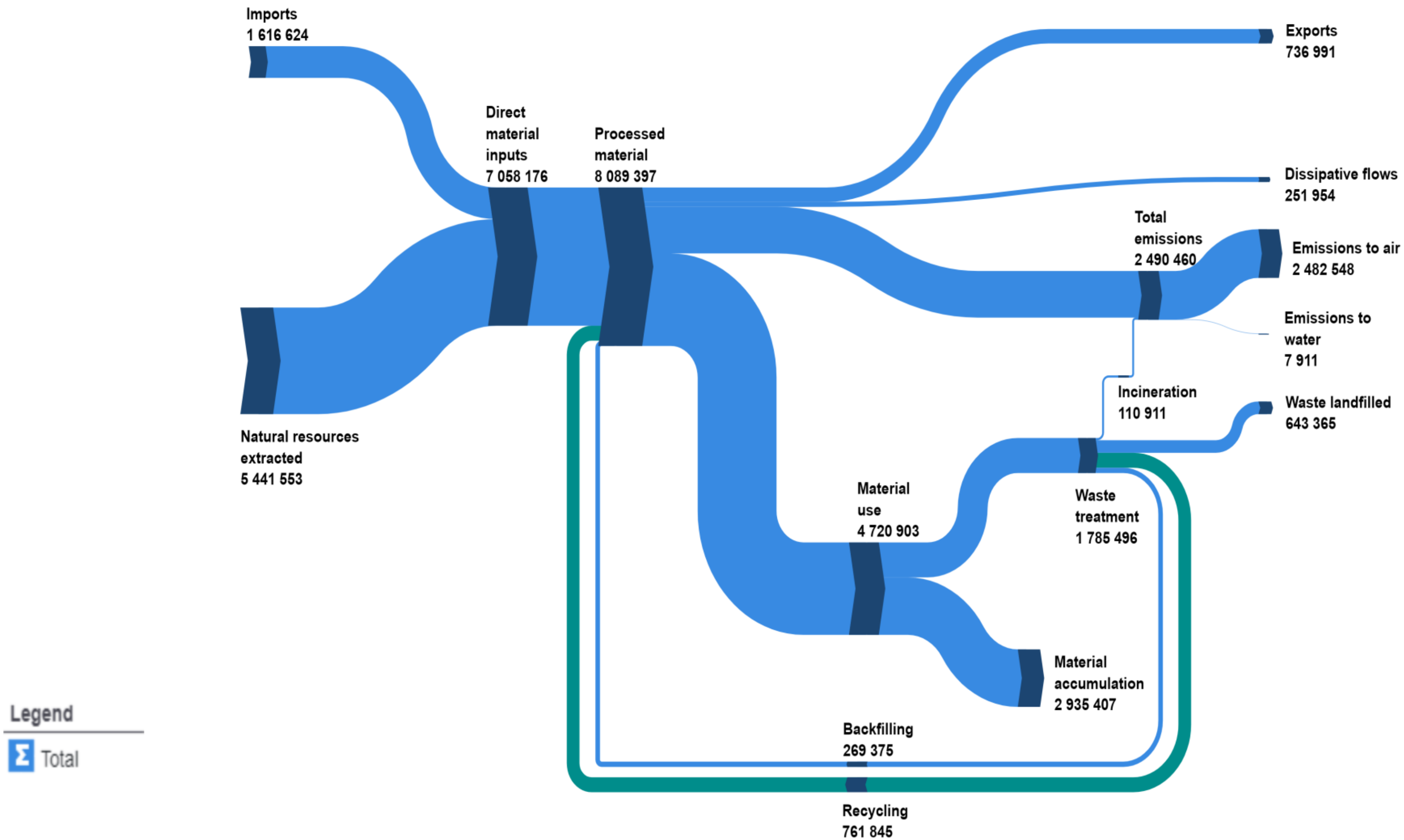


ECONOMIA CIRCULAR
DESFOSILIZACION

https://www.lifecycleinitiative.org/activities/what-is-life-cycle-thinking/

Material flow diagrams
European Union - year 2021
Thousand tonnes

MATERIALS FLOW



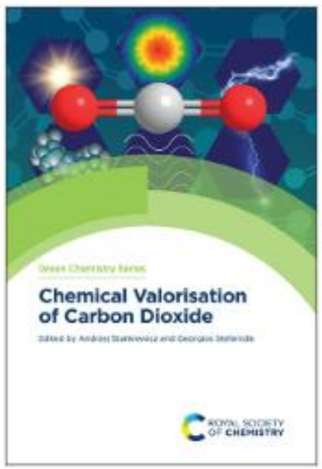
Source: Eurostat (env_ac_mfa; env_ac_sd; env_wassd)

eurostat

3. Examples of RD&I in Carbon Utilisation

The CO2 Recycling Plant (CO2-RP) based on CO2 electroreduction

CO_2 RECYCLING CHALLENGES



GREEN CHEMISTRY SERIES

Chemical Valorisation of Carbon Dioxide

Edited by Georgios Stefanidis; Andrzej Stankiewicz

DOI: https://doi.org/10.1039/9781839167645

BOOK CHAPTER

Chapter 18: Techno-economic Analysis of CO_2 Electroreduction

By A. Irabien ; M. Rumayor ; J. Fernández-González ; A. Domínguez-Ramos

DOI: https://doi.org/10.1039/9781839167645-00413

Published: 19 Dec 2022

Special Collection: 2022 ebook collection

Series: Green Chemistry

FIRST CHALLENGE. Sustainability Assessment

-Environmental

-Economic

-Social

SECOND CHALLENGE. Availability of the technology (TRL 9)

METRICS

CARBON FOOTPRINT

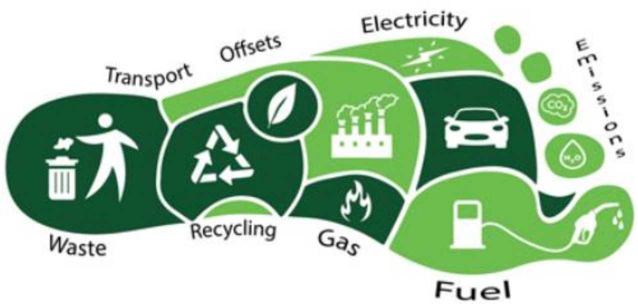
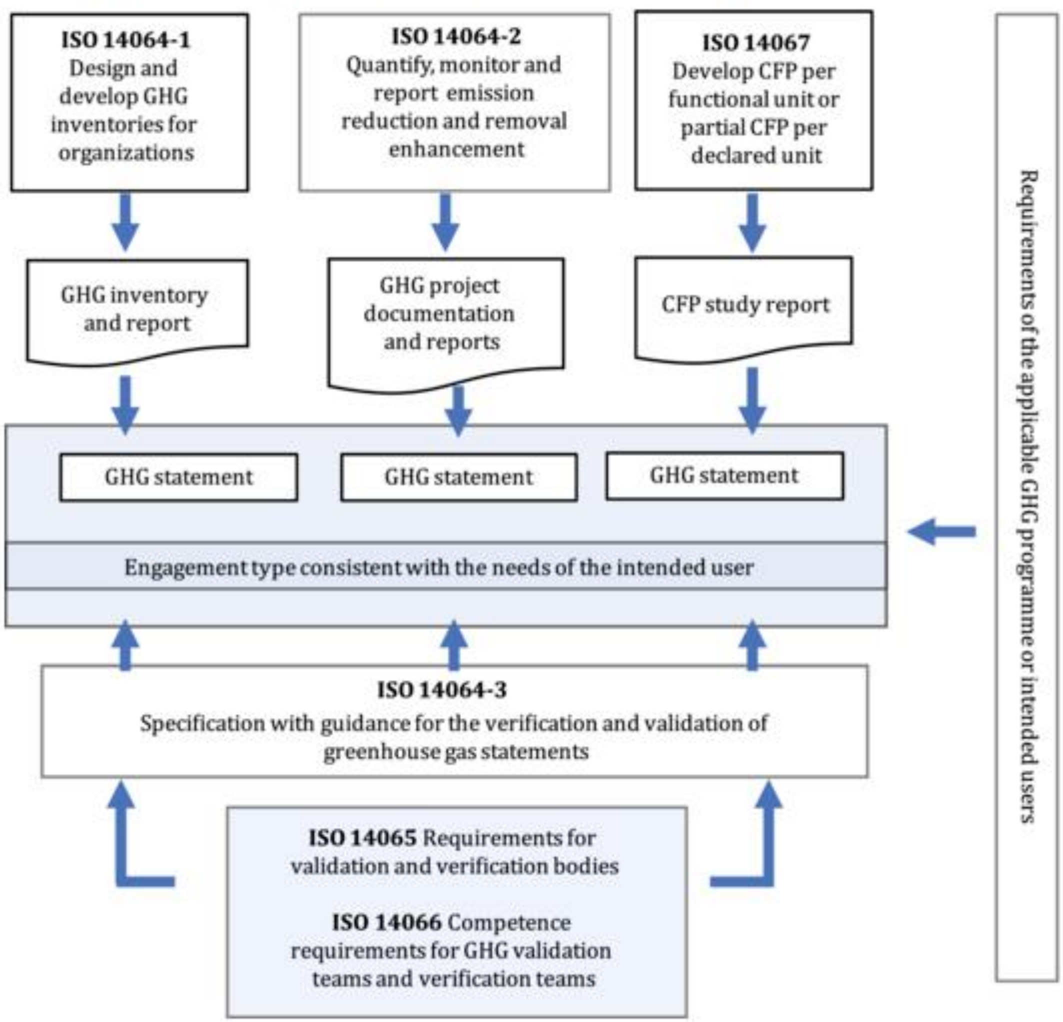


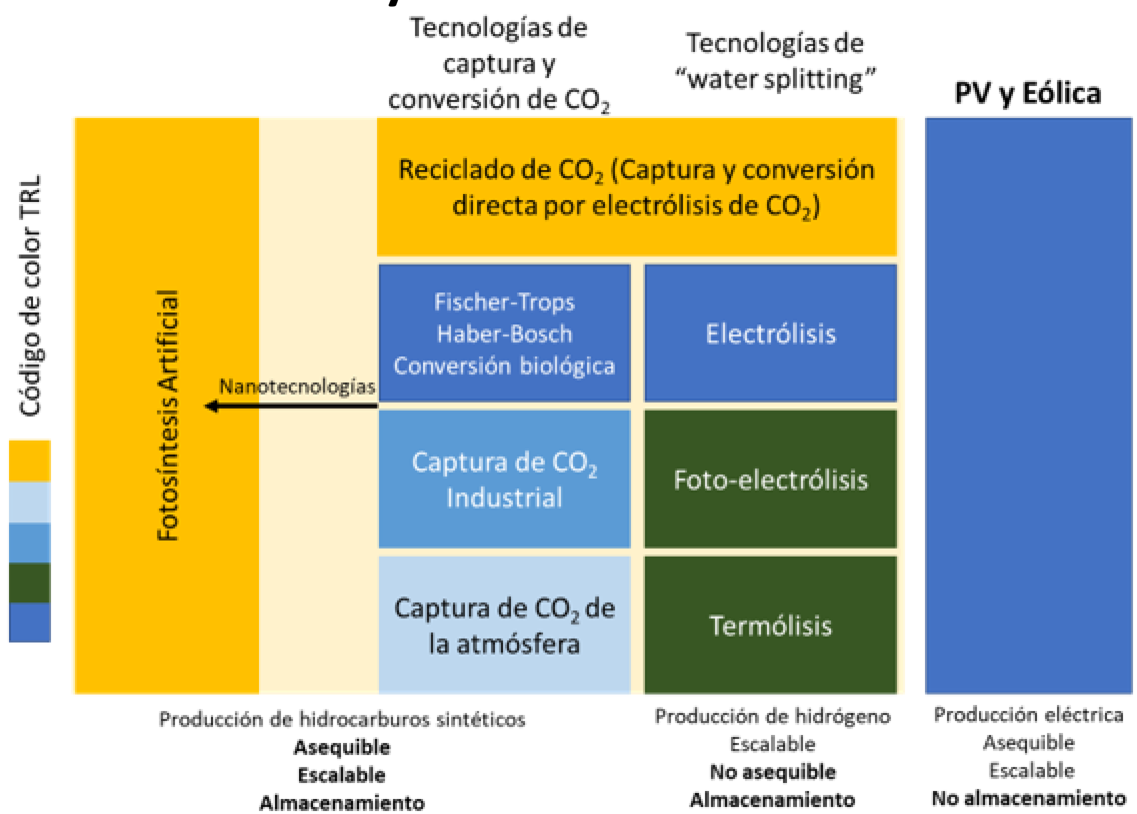
Figure 1 — Relationship among the ISO 14060 family of GHG standards



ISO 14067:2018 Greenhouse gases — Carbon fo
products — Requirements and guidelines for qu

Available Technologies: Synthetic hydrocarbons

https://sunergy-initiative.eu/



Large product variety	**Synthetic Hydrocarbons**	Hydrogen	Electricity
Atmospheric CO2	**Affordable**	Scalable	Affordable
Affordable	**Scalable**	**Unaffordable**	Scalable
Not scalable	**Storage**	**Storage**	**No storage**

TRL color code

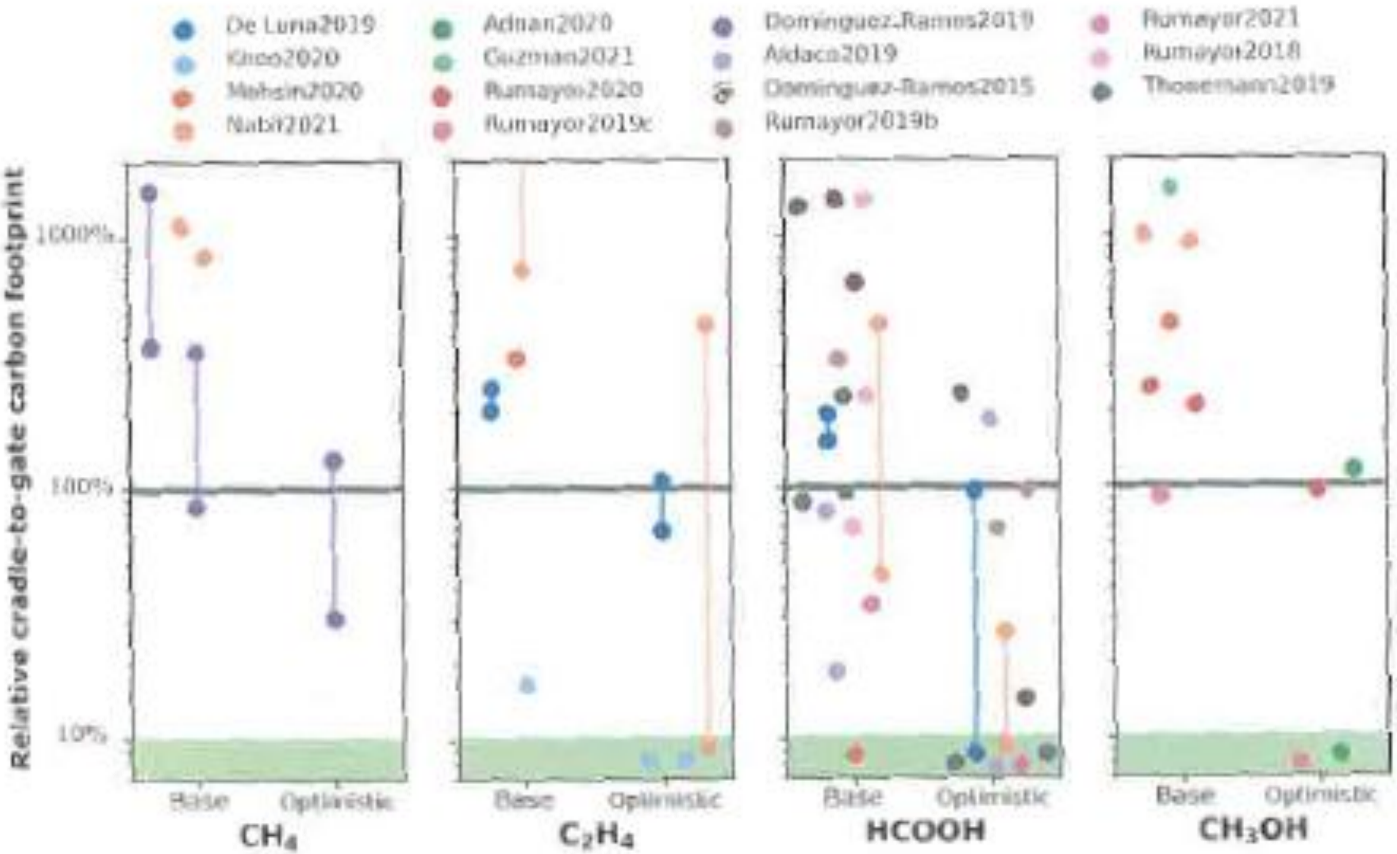
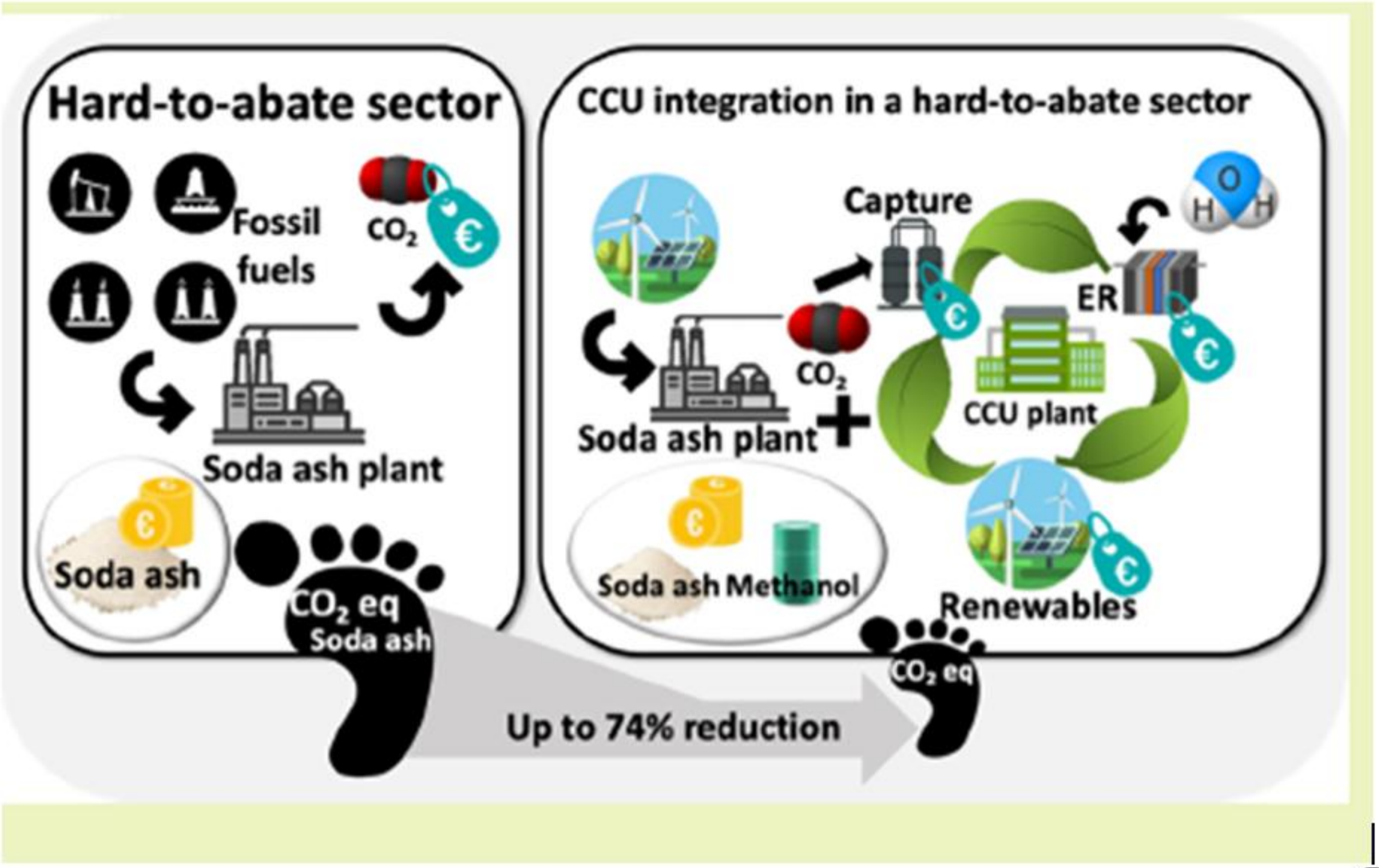


Figure 18.6 Relative cradle-to-gate carbon footprint (kg CO_{2eq} per kg) of CO_2 electroreduction products assessed by several authors. The gray line represents the conventional carbon footprint (kg CO_{2eq} per kg) of CH_4 (0.3), C_2H_4 (1.5), HCOOH (2.3) and CH_3OH (0.57). Dots in green area mean negative cradle-to-gate carbon footprint. Raw data is divided by ideality of assumptions according to each author (base/optimistic).

SIMBIOSIS INDUSTRIAL



(1) Rumayor, M. Dominguez-Ramos, A. Irabien, A. ACS Sustainable Chem and Engng (2020)

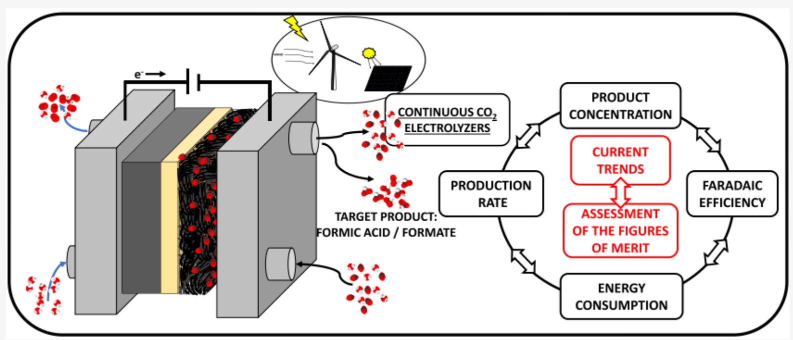
ACS Energy LETTERS

http://pubs.acs.org/journal/aelccp

Electroreduction of CO_2: Advances in the Continuous Production of Formic Acid and Formate

Kevin Fernández-Caso, Guillermo Díaz-Sainz,* Manuel Alvarez-Guerra, and Angel Irabien

Cite This: *ACS Energy Lett.* 2023, 8, 1992–2024



ABSTRACT: The study of the electrochemical CO_2 reduction to obtain formate ($HCOO^-$) or formic acid (HCOOH) is receiving much attention as a promising technology. Since continuous–mode operation has become necessary for practical implementation of electrochemical CO_2 reduction, recent years have seen a rapid increase in the number of research approaches focusing on this aspect. This Focus Review provides a unified discussion of the available studies on the continuous electroreduction of CO_2 to $HCOO^-$/HCOOH, considering the different important features of process design. Moreover, this paper quantitatively assesses the performance of different studies that involve continuous electrochemical reactors for converting CO_2 to HCOOH/$HCOO^-$, comparing relevant typically used figures of merit, including energy consumption. Although some relevant trade-offs have already been achieved, the simultaneous optimization of all the figures of merit remains a challenge. Finally, concluding remarks highlight the detected trends and discuss relevant aspects that will have to be tackled by future studies in this field.

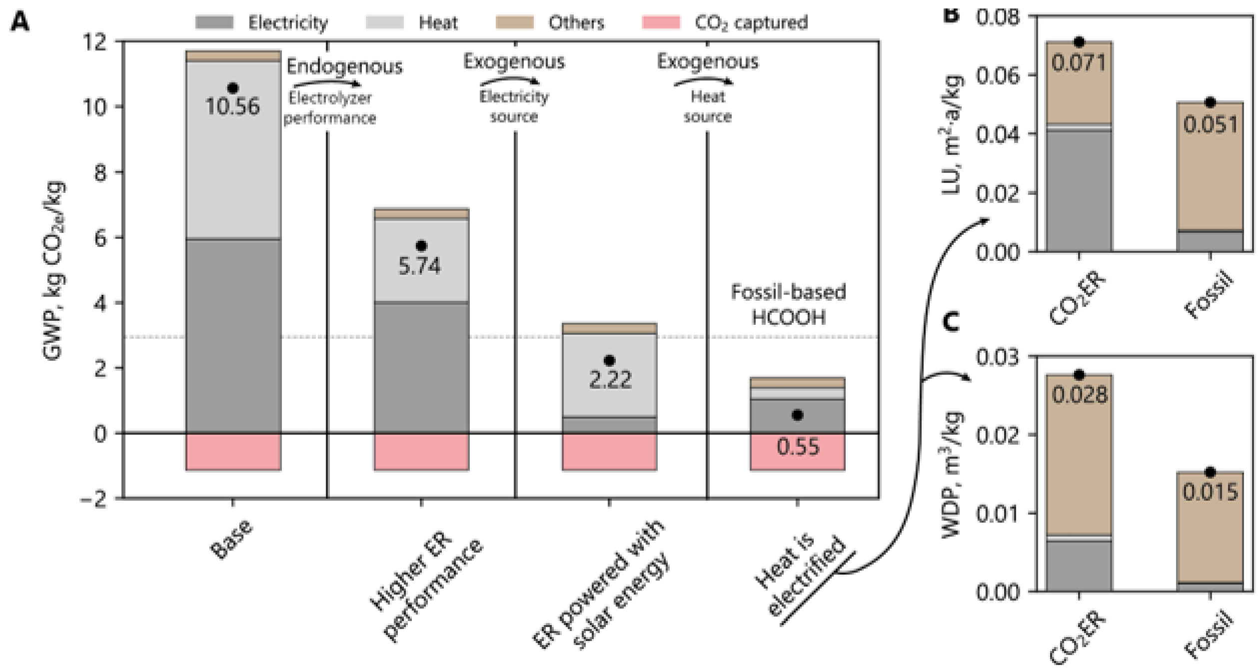
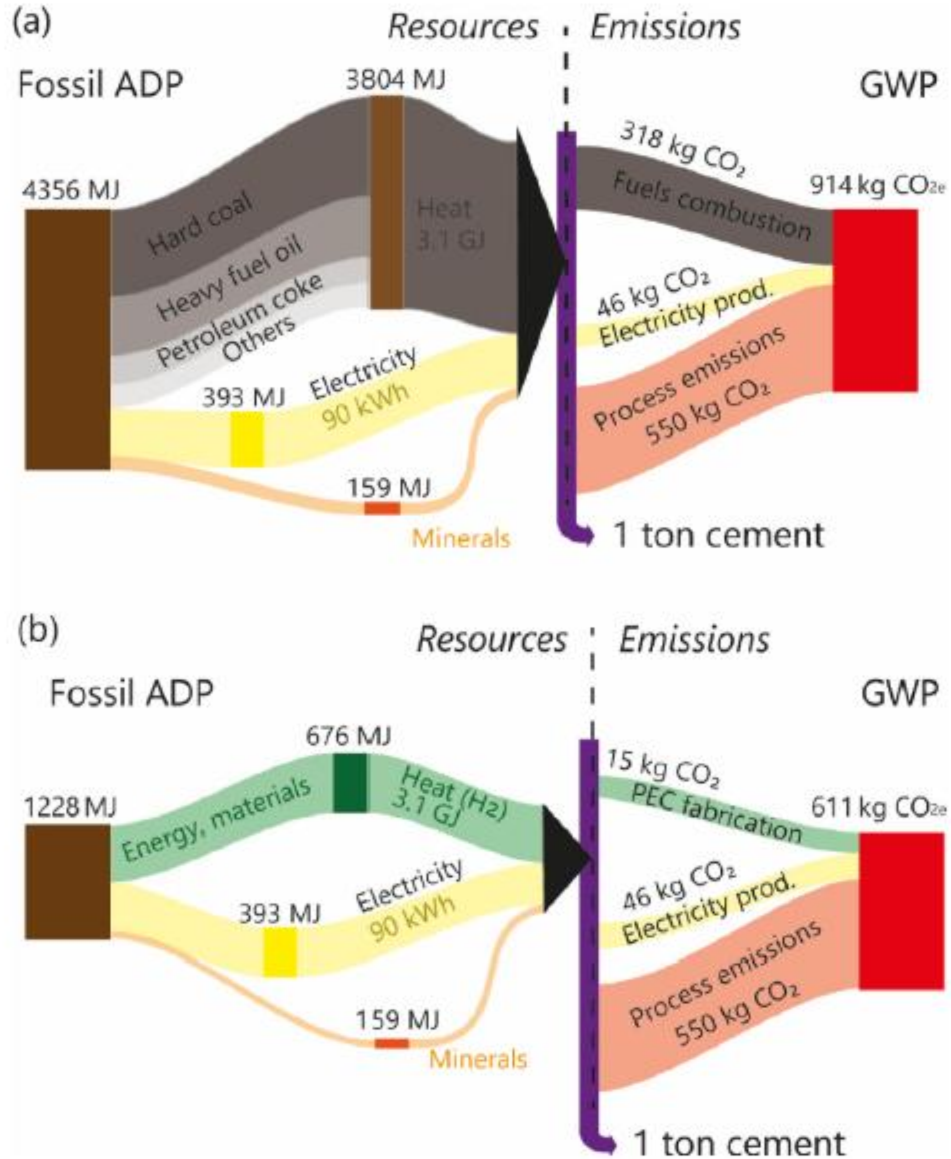


Figure 4. (A) Global warming potential of CO_2ER route under Baseline and improvement scenarios. ER performance assumes increasing the energy efficiency up to 40% and HCOOH pre-concentration up to 20%wt. PV energy comes from the Ecoinvent database[51] , while heat electrification assumes an electric boiler.[60] All steps are additive. The fossil route[51] is shown in the dotted line (2.95 kg CO_{2e}/kg,). Land use in $m^2 \cdot a$ (B) and Water depletion potential in m^3/kg (C) of CO_2ER and Fossil routes. CO_2ER uses the best-case scenario.



https://doi.org/10.1016/j.clpl.2023.100041

Fig. 5. Example of decarbonization/defossilization synergy of a) conventional cement production; and b) cement production using fuel switching to super-H_2 at the NREL-conditions (10% STH, 7 years lifetime) when cell operation and fabrication is powered with PV energy. Electricity for cement production is assumed to come from today's European grid mix.

Validación de un prototipo de planta de reciclado de CO_2 en la industria textil (VALCO2-T)

- **Convocatoria:** Proyectos de I+D+i en líneas estratégicas, en colaboración público-privada 2022
- **Presupuesto:** 539.733,05 €
- **Periodo:** 1 de diciembre de 2022 – 30 de noviembre de 2024

Proyecto PLEC2022-009398 financiado por MCIN/AEI /10.13039/501100011033 y la Unión Europea NextGenerationEU/ PRTR

MINISTERIO DE CIENCIA E INNOVACIÓN
Financiado por la Unión Europea NextGenerationEU
Plan de Recuperación, Transformación y Resiliencia
AGENCIA ESTATAL DE INVESTIGACIÓN

KPI (Key Performance Indicators)

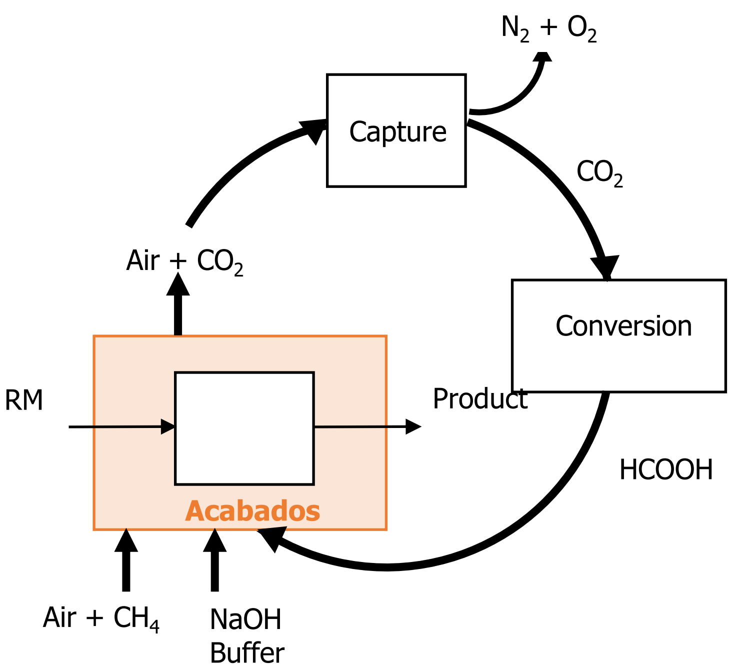


Figura 1. Chemical Recycling Plant in the textile industry

KPI in the conversión of CO2 into formic acid

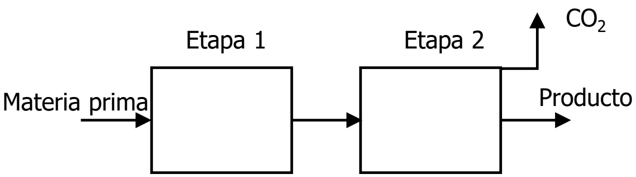
- **CO2 Concentration**
- **Energy Demand**
- **Use of Formic Acid**
- **Sustainability and Risk Assessment**

UC-Textil Santanderina-Apria Systems VALIDACIÓN DE UN PROTOTIPO DE PLANTA DE RECICLADO DE CO2 EN LA INDUSTRIA TEXTIL (VALCO2-T) (PLEC2022-009398 - MCIN/AEI/10.13039/501100011033 y Unión Europea Next GenerationEU/PRTR)

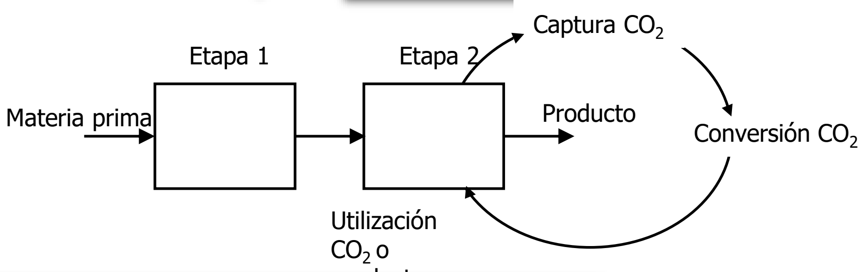
Identificación del proceso CCU

Reciclado de Carbono

Proceso lineal



Proceso circular



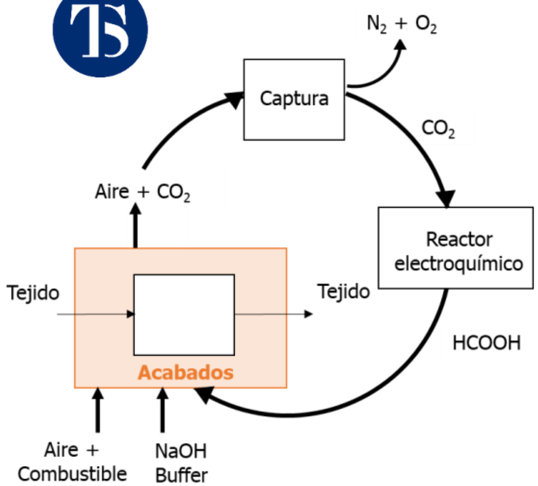


Figura 2. Diagrama esquematizado del proceso CCU

KPIs (indicadores clave del rendimiento)

- **Reducción Huella de carbono**
- **Concentración de CO_2** (viabilidad de conseguir una concentración del 50 % vol.)
- **Requerimiento energético** del electrolizador (viabilidad de aportar electricidad 100 % renovable)
- **Requisitos del producto ácido fórmico** (viabilidad para establecer las condiciones de acidez de baños de acabados, neutralizar pH de aguas residuales)
- **Evaluación de posibles riesgos** de la instalación del sistema en la planta de TS

Carbon Capture and Utilization (CCU)

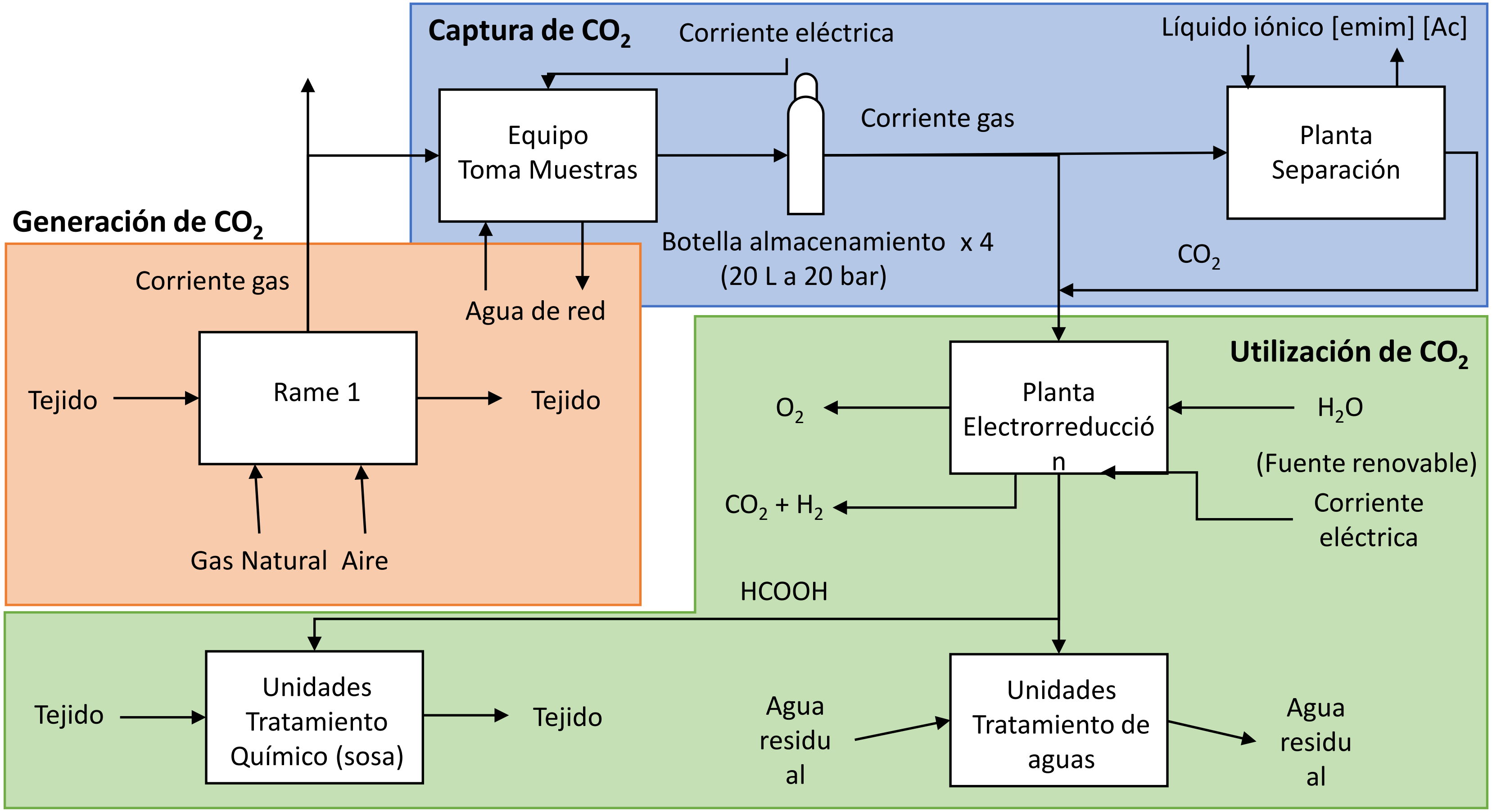


Diagrama de bloques del proceso CCU.

Planteamiento

KPI (Indicadores clave de rendimiento)

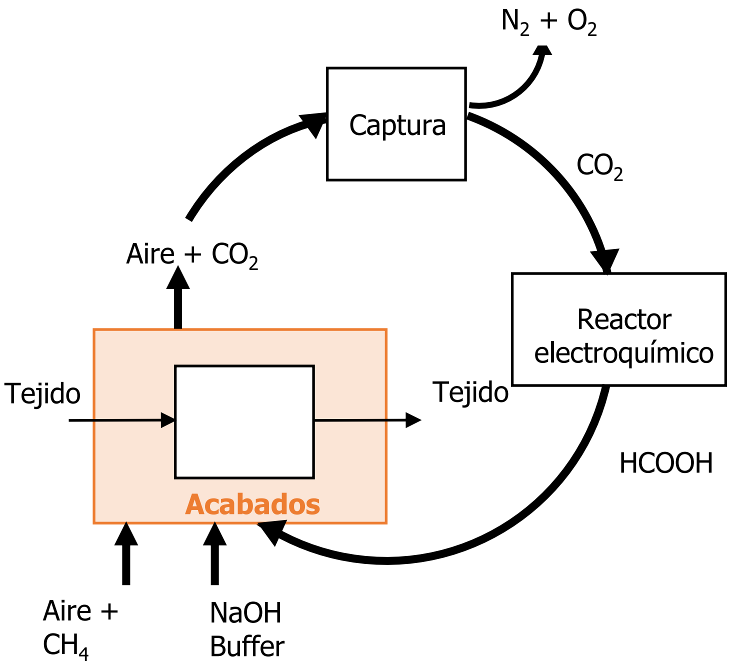
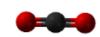


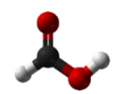
Figura 1. Diagrama del proceso al implementar un sistema CCU.

Parámetros relevantes para la valorización de la corriente de salida mediante la transformación del CO_2 en ácido fórmico:



- **Concentración de CO_2** (viabilidad de conseguir una concentración del 70 % vol.)
  - Proceso de separación mediante contactores de membrana para la absorción con líquidos iónicos

- **Requerimiento energético** del electrolizador (viabilidad de aportar electricidad 100 % renovable)
  - Proceso de electrorreducción de CO_2 con electrodos de Bi



- **Requisitos del producto ácido fórmico** (viabilidad para establecer las condiciones de acidez de baños de acabados, neutralizar pH de aguas residuales, etc.)
  - Comparación con las soluciones tampón empleadas actualmente

- **Evaluación de posibles riesgos** de la instalación del sistema en la planta de TS

UC-Textil Santanderina-Apria Systems VALIDACIÓN DE UN PROTOTIPO DE PLANTA DE RECICLADO DE CO2 EN LA INDUSTRIA TEXTIL (VALCO2-T) (PLEC2022-009398 - MCIN/AEI/10.13039/501100011033 y Unión Europea Next GenerationEU/PRTR)

DESCARBONIZACION INDUSTRIA CEMENTERA

CAPTUS

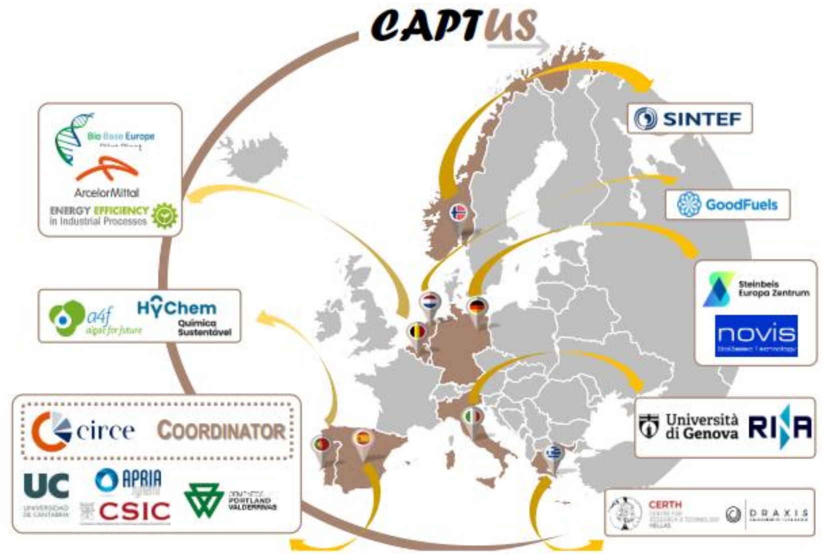
“Demonstrating energy intensive industry-integrated solutions to produce liquid renewable energy carriers from CAPTUred carbon emissionS”

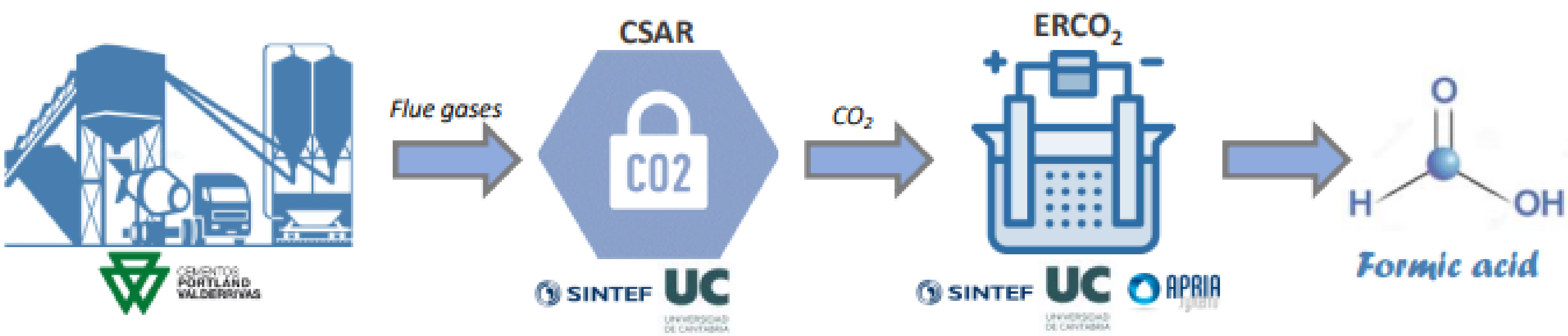
Call: HORIZON-CL5-2022-D3-02 (Sustainable, secure and competitive energy supply)

18 socios

11,5 M€

Comienzo 1 Jun 2023





UNIDAD SOSPROCAN-DEPRO

GRACIAS POR SU ATENCION!!!!!!!

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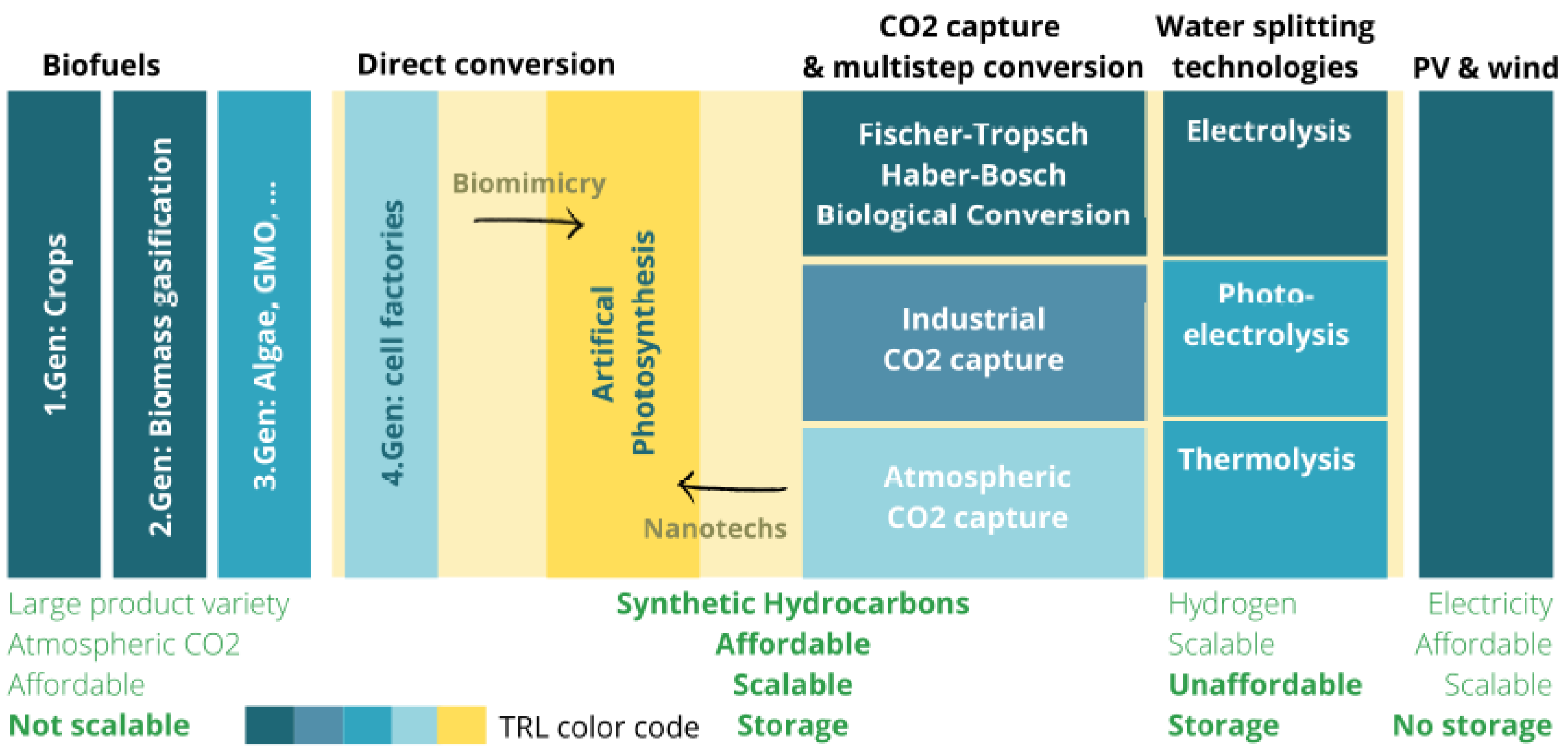
Departamento de Ingenierías Química y Biomolecular

Sosprocan DePRO Desarrollo de Procesos Químicos y Control de Contaminantes

TECHNOLOGIES FOR CO2 RECYCLING



https://sunergy-initiative.eu/

Asequible, Escalable, Almacenable