Demonstrating sustainable value creation from industrial CO2 by its thermophilic microbial conversion into acetone

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Duration: 60 months

D6.12 - REPLICATION STRATEGY – FIRST VERSION OF REUSABLE PROCESS AND TOOLS FOR FACILITATING THE EMERGENCE OF LOCAL CCU HUBS

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Contributor(s)	AXELERA		
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05	14/03/2023	Francesca Di Bartolomeo	revisions

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TABLE OF CONTENTS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

List of figures

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List of Abbreviations

Abbreviation	Description
CCU HUB	A CCU hub takes carbon dioxide from several different emitters, transports and utilize it to produce new products, using common infrastructure
CCU	Carbon Capture and Utilization
CCUS	Carbon Capture, Utilization, and Storage
GHG	Greenhouse Gases
AURA	Auvergne Rhône-Alpes
EU ETS	European Union Emission Trading System
LRF	Linear Reduction Factor
CBAM	Carbon Border Adjustment Mechanism
EHB	Europe Hydrogen Backbone
PtG	Power-To-Gas
PtL	Power-to-Liquid
PtX	Power-to-X
SME	Small and Medium-Sized Enterprises
TRL	Technology Readiness Levels
CSF-NSE	Strategic Committee – New Energetic Systems
IREP	French Register of Pollutants Release

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FOREWORD

AXELERA is a French Cluster supporting Chemical & Environmental companies in their innovation process and business development. It counts more than 400 members by end of 2022.

It is engaged in the Task 6.3 “Derisking and Market Readiness in 4 emerging CCUS hubs for Replication.”

The present deliverable is a first version of the reusable process and tools for facilitating the emergence of local CCU hubs. The application of this methodology will serve as a basis to replicate in other industrial clusters in Europe.

This methodology takes into consideration:

- ✓ The market information, the available CCU technologies,
- ✓ The CCU legal framework in Europe,
- ✓ The available funding mechanisms,
- ✓ Information that will be crucial to make CCU projects development possible in the region.

In the context of PYROCO2 project, one of the objectives of Axelera is to facilitate the emerging of local CCU hubs, first in the AURA valley region, and then elsewhere in the most promising locations across Europe. That it is the reason why the methodology presented here is illustrated with some examples from the AURA Region.

In your case, you will have to adapted it to your own region, as market structuration are different from each other. This example is only used for a better understanding. However, the clusters are free to use the same proposed structure of this report considering the new region information.

To set up the most appropriate replication methodology AXELERA has worked on several axes thanks to different tools such as:

- Market research via various public studies
- Interviews with emitting CO_2 plants to collect information on the AURA Region
- Interviews with CCU technology suppliers
- Online Surveys
- Working groups
- Large-scale Seminars
- Consortium development

The objective of this deliverable is to build a didactic and easy to understand methodology that will help European clusters to be able to develop their CCU Hubs in a systematic and efficient way, enabling the increase of CCU projects and therefore reducing CO_2 emissions.

AXELERA is working in other two documents which will be complementary to this one: CCU Hub Roadmap and preliminary Investment Plan (Deliverable 6.13) and the toolbox (D6.14 “Toolbox for the facilitation of emergence of systemic CCU hubs.

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and related investments") These three documents together will support clusters in Europe to leverage CCU hub development. They are expected to be published in M24 and M25.

The document replication methodology is based on 10 steps which are demonstrated in the figure below. These 10 steps will be developed below. After the explanation of each topic, the document will provide the readers with examples of what has been completed in the AURA region to help a CCU hub emerge.

Enjoy reading!

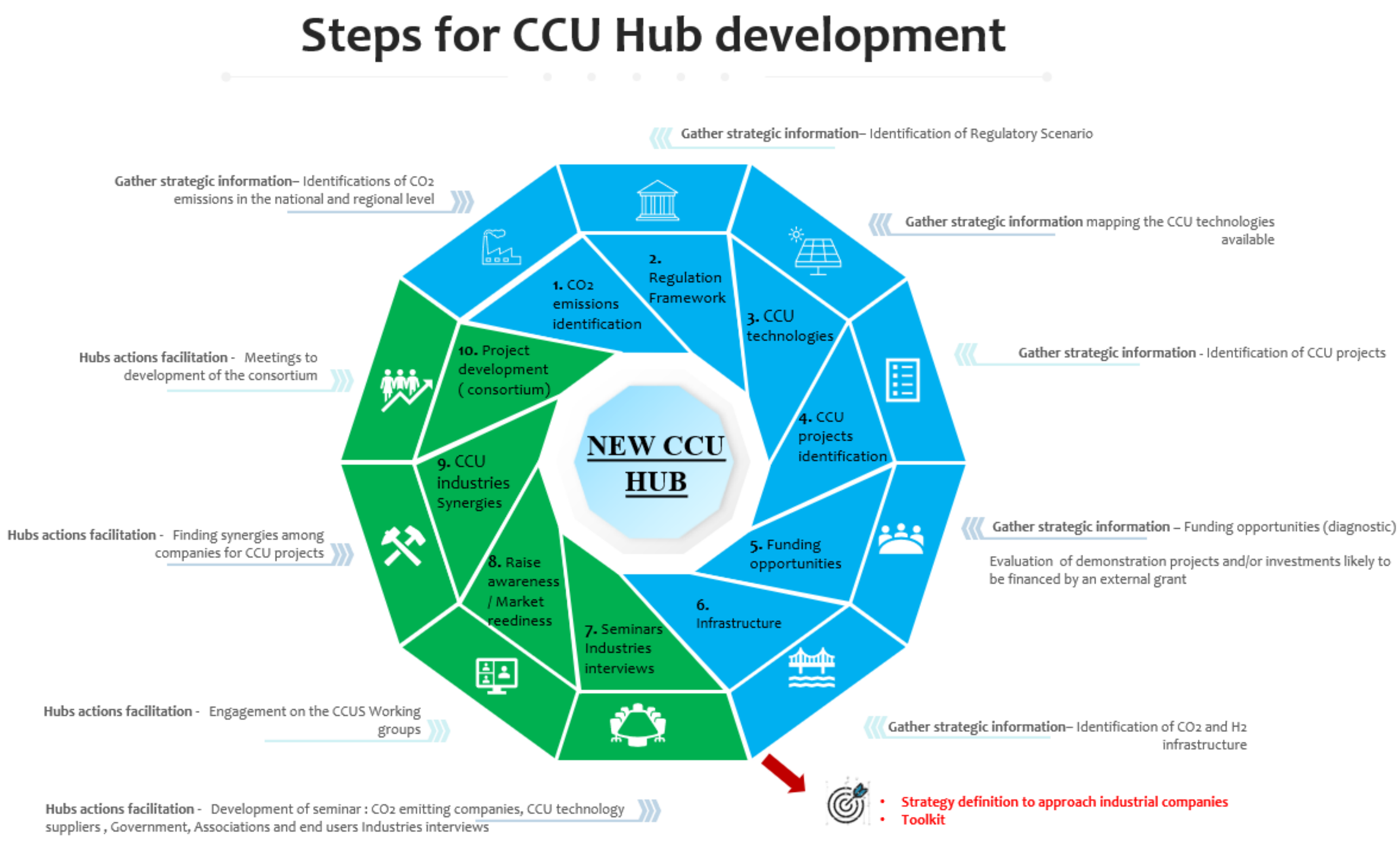

Figure 01: Complete list of steps to be performed for the development of CCU hub. Source: AXELERA

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1 MARKET READINESS - BACKGROUND INFORMATION TO DEVELOP CCU HUBS

CCU projects are highly dependent on the market demands, the region, the legal framework, the availability of raw materials, the energy prices, the societal acceptance, the maturity of CCU technologies, the CO_2 and H2 infrastructure and the possibility to create a synergy among several industrial partners. Knowing all these factors in detail will be crucial to engage other players of the value chain in this type of project.

Markets where the price of energy (or green Hydrogen) is too expensive may render difficult CCU projects. The same applies if the regulatory framework is not clear in a specific market, new projects will face barriers that can be difficult to overcome.

An appropriate infrastructure for CO_2/Hydrogen transport is also an important asset that needs to be developed. Affordable access to green Hydrogen for chemical transformation reactions to produce the high value-added products will be the key for the development of the CCU sector.

As CCU projects are expensive, synergy among companies is a major factor of success that will facilitate projects to be more cost effective. In this way, looking for regions with a business ecosystem composed of a range of CO_2 emitting companies, end user companies, industries capable of sharing waste heat, and companies providing renewable energy will facilitate the projects to succeed.

For the reasons presented above, the development of company hubs is a key success factor for large CCU projects. in the following pages of this document, we will present the first steps for developing CCU hubs.

Find below the first steps of the methodology:

- Identification the main CO_2 emitting companies in the area of the hub,
- Identification of the main regulations in place for CCU projects,
- Identify the technologies that can meet the needs of the local market,
- Identify the funding opportunities, both public and private,
- Identify all the relevant potential CCU projects in the area,
- Identify the pipelines and other infrastructure in the area.

The funnel below summarizes our recommendation on the steps to gather strategic information on the market. Through these steps you will be able to define the best strategy to engage companies in emerging CCU projects.

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6 Steps to gather strategic information from the market to define the best strategy to approach industrial companies

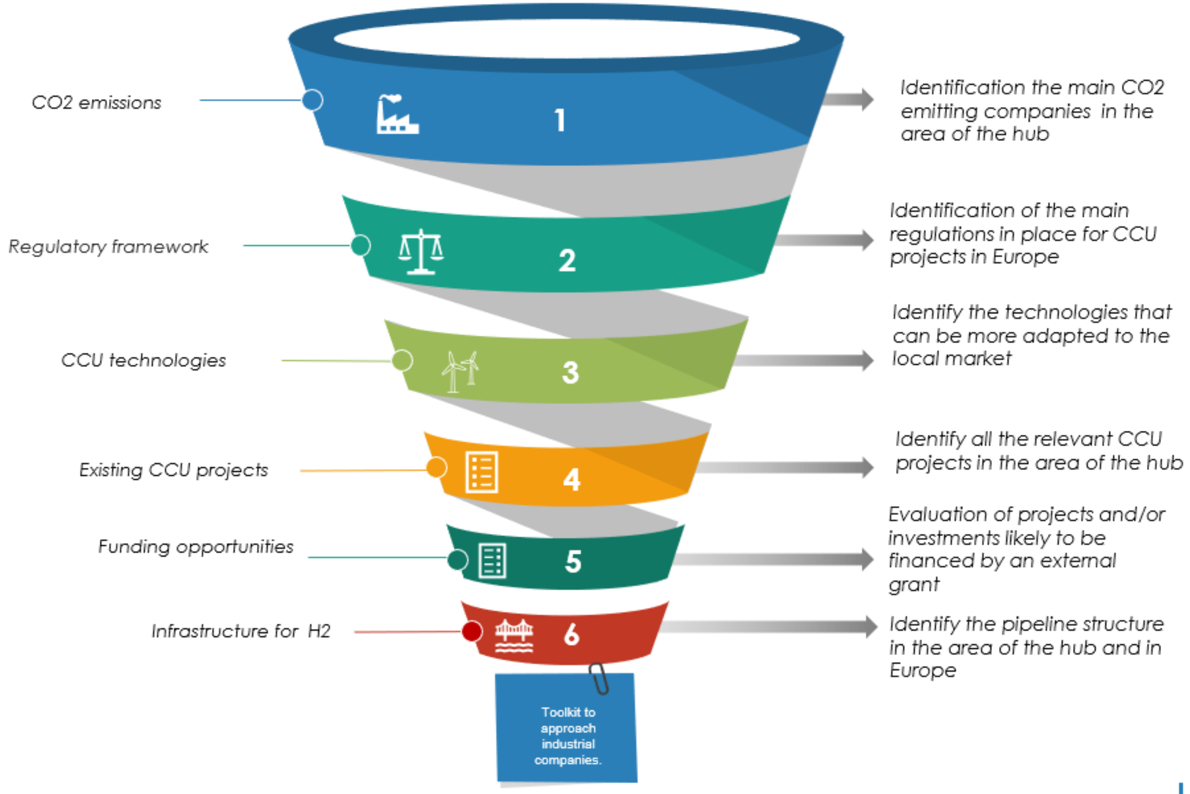

Figure 02: Six steps to define the best strategy to approach industrial companies

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The result of these six steps will be a toolkit which will provide information to embark companies in CCU projects and a structured strategy on how to approach companies and motivate them to develop and/or invest in new projects, maximizing the potential CCU projects in the hub. You will find below more details about each step. We invite you to replicate the same steps for your market.

1.1 CO_2 EMISSIONS – INDUSTRY PROFILE

1.1.1 Overview of CO_2 emissions

The first step is to gather information about CO_2 emissions in the region. Before obtaining these pieces of information, it is necessary to keep in mind that CCU projects will take place mainly in companies that:

- ✓ Are submitted to the EU ETS market,
- ✓ Have a considerable CO_2 emission,
- ✓ Are located in areas where projects mutualization may be possible such as ports, industry parks, chemical clusters, etc.
- ✓ Are close to infrastructure that enables access to renewable energy and green hydrogen at a competitive price,
- ✓ Are part of a group of energy intensive industries such as: cement, steel, chemical, petrochemical or energy companies.

The first step will be the development of a map of the companies that emit CO_2 and are subject to the EU ETS market. This information will be important to target companies which will be contacted later. A good strategy will drive us towards companies where decarbonization projects will be more likely to happen and will also prevent us from spending our time discussing with companies where these projects will have no future. This mapping will also support us to identify the existing CO_2 clusters.

1.1.2 CO_2 emissions database

Several databases are available with information about CO_2 emitting companies. Among the main ones, we can mention:

The European Pollutant Release and Transfer Register (E-PRTR) which provides key environmental data from industrial facilities in European Union Member States: https://ec.europa.eu/environment/industry/stationary/e-prtr/legislation.htm

EU Emissions Trading System (EU ETS): https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en

French Register of the pollutants releases France: https://www.georisques.gouv.fr/risques/registre-des-emissions-polluantes/synthese/donnees#/recherche=polluant&milieu=1&polluant=131

Through these databases, we were able to develop a map to identify the main CO_2 emitters companies.

We would like to point out that some of these databases have European information that can be used by all European countries.

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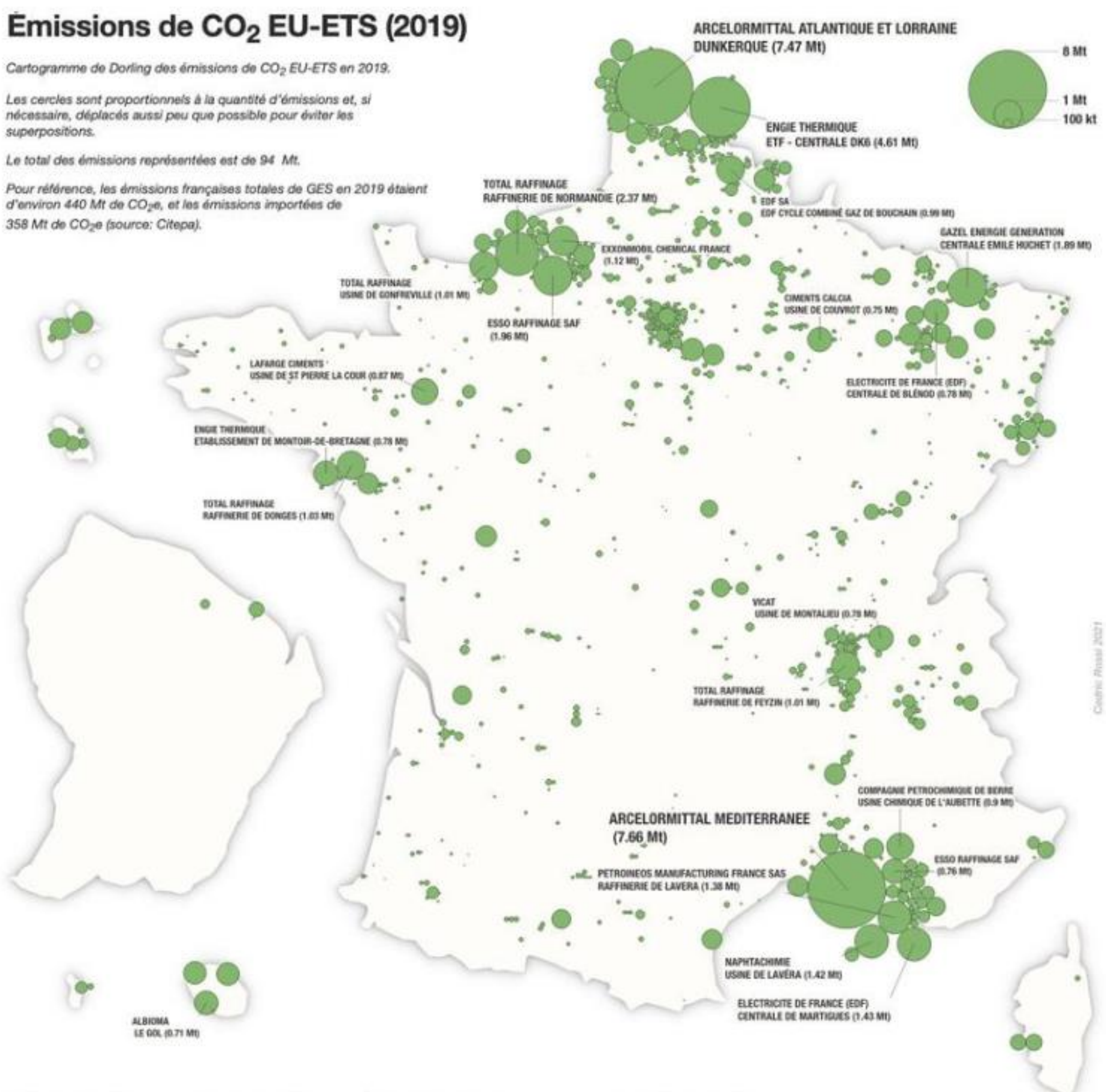
The map with data from EU-ETS for companies in the scope of our region is found below. This map identifies the main potential companies/ regions for CCU projects.



Source: Graph developed by Cedric Rossi. Data from European Union transaction log 2021, base Sirene 2021: Insee: La poste: Natural Earth

Figure 03: Emissions of CO2 in France and AURA region (EU ETS)

Analyzing the data from the map above, we can see five main zones of high industrial CO_2 emissions with strong potential for the development of CO_2 reduction projects: Dunkerque, Normandy, Paris Region, Mediterranean Region, Auvergne Rhône-Alpes and the Grand-Est region.

The Auvergne Rhône-Alpes region was chosen in the scope of the PYROCO2 project to be the first region for AXELERA to foster CCU development. The region is ranked first chemical production region in France (7th in

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Europe). Its variety of chemical industries are assets for the reuse of CO_2, although this region is not the first CO_2 emitter in France.

The next graphs present more information about the Auvergne Rhône-Alpes region and its CO_2 emissions by industrial sectors.

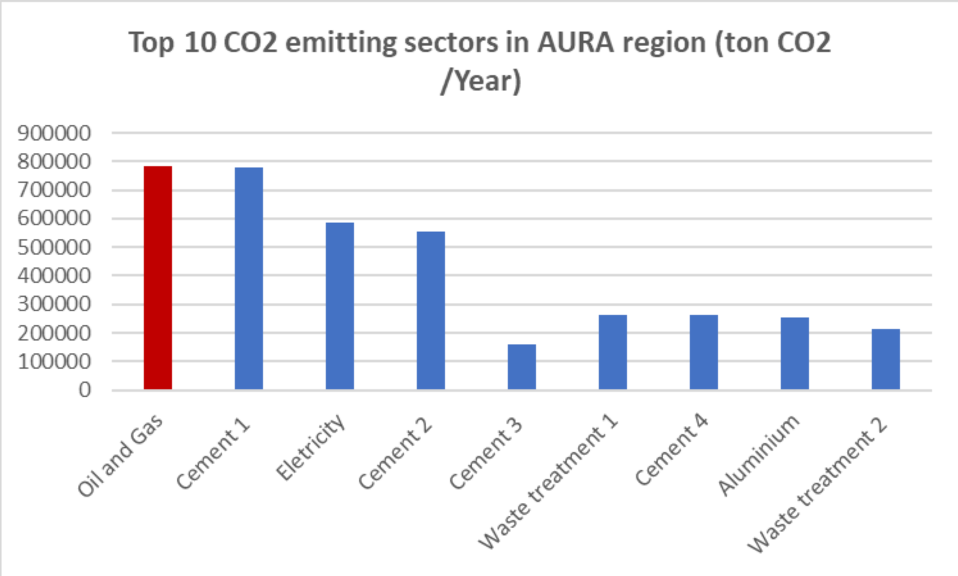
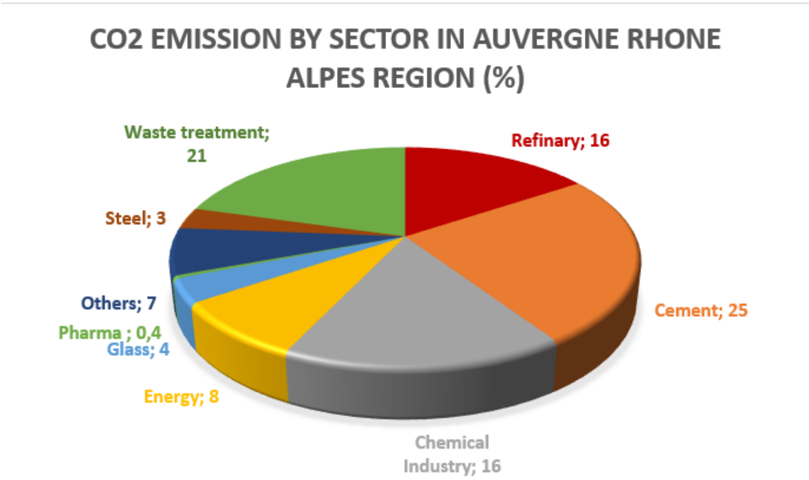


Figure 04: Top 10 CO2 emitting sectors in Auvergne Rhône Alpes region. Data source: IREP 2020.

The graph above shows an analysis of the 'Top 10' CO_2 emission sectors within Auvergne Rhône-Alpes region. The biggest CO_2 emitting sector identified is a petrochemical refinery. Among the 10 largest CO_2 emission sites, 4 are cement plants.



Source: AXELERA, (data from IREP 2020)
Figure 05: CO2 Emission profile per industrial sector in the AURA region

Looking at the graph above, five sectors are responsible for 86% of the CO_2 emissions in the AURA region. The sector that accounts for the largest volume of CO_2 is cement manufacturing with 25% of the region's CO_2

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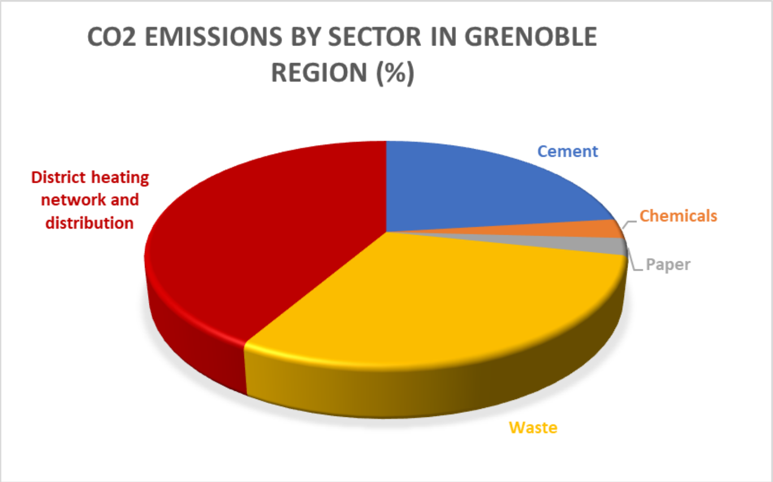
emissions. In second place are the waste treatment plants which represent 21%. The chemical and petroleum refineries represent 16% of CO_2 emissions each, and the energy sector, 8% (electricity and heating). All five types of emitters represent a large potential to engage in CCU projects. The cement plants have a great potential for oxy-combustion projects followed by the carbon capture and CO_2 transformation in order to produce fuels, for example. There is also a strong potential for CCU mineralization projects that according to the new European legislation should be considered in the European carbon market (Fit for 55). The waste treatment plants have a potential to change the fuel used in the incinerators as well as a great potential to produce methane through methanization and methanation process.



Source: AXELERA, (data from IREP 2020)
Figure 06: CO2 Emission profile by industry sector in Grenoble region

Within the Auvergne Rhône Alpes region, we can find several conglomerates of companies that are divided into sub-regions. The graph above shows the emissions of the region near the city of Grenoble. This area has been mapped as a potential cluster for CCU projects due to the proximity among the CO_2 emitting companies and the variety of companies with complementary needs. 3 sectors are the majors CO_2 emitting sectors in the region: Waste treatment, district heating and cement production.

We developed an extensive list with the main sites emitting CO_2 in France. The list is available upon demand.

1.2 Regulatory framework for CCU

The second step is to identify the legislation that governs or facilitates CCU. For this section, we consolidate the main information about the legislation up to this date. You can use these pieces of information for your replication process, but it is important to keep in mind that legislation is changing fast for this subject, and updates may be needed.

CCU is a relatively new subject, and in many countries, the lack of clear legislation makes it difficult for companies to invest in new projects as they are expensive and time consuming to implement without regulatory certainty over the long-term. Knowing well the current legislation as well as its critical points and opportunities will help to find the key factors that will motivate the industries to develop and to invest. In

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the next two chapters, we identified the pertinent legislation as well as the critical points and opportunities considering the European legislation.

Currently CCU projects are affected by several European legislations, such as:

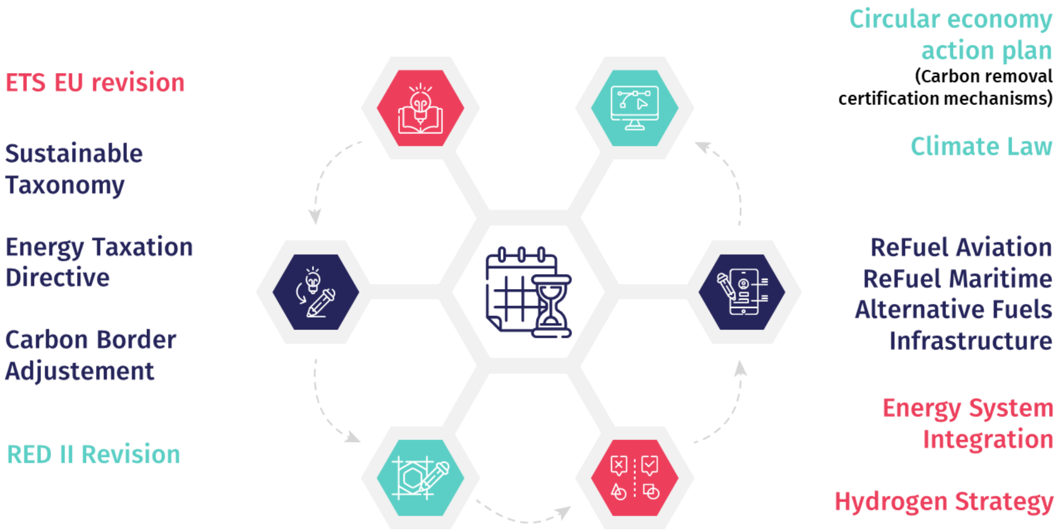

Figure 07: Main European legislations linked to CCU

Several other initiatives can be linked to CCU, such as:

- ✓ SET-Plan CCUS Action 9
- ✓ Sustainable Products Initiative
- ✓ The new industrial national and European strategies
- ✓ EU Green Deal
- ✓ Next Generation EU → Recovery & Resilience Fund
- ✓ REPOWER EU

You will find below a brief description of the main EU regulations impacting the CCU market.

In this paper, we will focus on the most important legislations from the point of view of project emergence. A new legislative proposal called Fit for 55 is under discussion. This legislation was proposed by the European Commission on July 1, 2021. It aims to reduce greenhouse gas emissions by 55% by 2030. The idea of this new legislation is to align the new law with the European new environmental ambitions. The main points of this new legislation related to CCU are:

- **EU emissions trading system (EU ETS is under discussion)**

The main changes provided by this EU ETS reform are (to this date - January 2023):

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- The sectors covered by the EU ETS scheme will now have to reduce their emissions of CO_2 by 62% by 2030 (from a 2005 baseline).
- Fewer allowances in the market - It is being proposed a reduction of 117 million allowances over two years and an annual reduction rate of the cap by 4.3%. (Linear reduction factor).
- New sectors will join the European carbon market, such as shipping, construction and road transport. Gradual reduction of the free allowances will be implemented in parallel with the carbon border adjustment mechanism (CBAM) in order to avoid carbon leakage and create a market in Europe for low-carbon materials and fuels.
- Increase of funds for decarbonization of industries submitted to the EU ETS market. (Modernization fund and innovation fund)
- The new changes in the legislation indicate that CO_2 that is permanently bound to the product will not need to surrender ETS allowances for that CO_2 (e.g. mineralization). For CO_2 that is not permanently bound to the product, the legislation is ending double counting (CO_2 captured and reused for the manufacture of fuels or chemicals will not be counted again).
- Another important change will be the inclusion of the waste incineration sector in the verification, reporting and monitoring scheme from 2024 with the aim of introducing this sector into the EU ETS from 2028.

Link for more information

- **ReFuel Aviation**

Refuel Aviation seeks to leverage the use of sustainable fuels in European aviation. Currently the use of these fuels represents only 0.05% of the fuels used in aviation. To increase the use of these fuels, the European Commission has proposed a minimum percentage to be used for synthetic fuels and sustainable aviation fuels (SAF).

The term RFNBO (Renewable Fuels of Non-Biological Origin) is being used to designate renewable transport fuels that do not have any biological content. These fuels are considered renewable where the energy content of the fuel comes from non-biomass derived renewable energy sources including wind, solar, aerothermal, geothermal, hydrothermal, ocean energy, or hydropower.

The new proposal sets targets per volume shares for RFNBOs: min 0.7%, 8%, 28% of RFNBOs by 2030, 2040, 2050, respectively. Synthetic fuels from CCU projects will thus be strongly leveraged by demand from the aviation sector in the coming years.

In December 2022, EU officials also agreed on specific rules to include aviation fully in the ETS system. The goal is to finalize the emissions of free quotas for the aviation sector as of 2027 (25% in 2024, 50% in 2025 and 100% from 2026). Thus, the airlines will need to accelerate their efforts towards decarbonation, or they will have to pay full EU ETS price.

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Link for more information

- **FuelEU Maritime**

FuelEU Maritime may apply as of January 2025 if adopted. The European Parliament is discussing the reduction of greenhouse gases emissions from the maritime sector by 2% as of 2025, 20% by 2035 and 80% by 2050 compared with 2020 levels. This reduction should be applied to all vessels above 5000GT, as they are responsible for 90 % of CO_2 emissions in the maritime sector.

Benefits for CCU projects: The European parliament has voted the introduction of quotas for the use of RFNBO in the marine sector. 2 % by 2030. In this way, the use of green hydrogen as well as synthetic fuels produced from CO_2 may be favored. The EU Parliament has been calling for creating specific fuels quotas, in particular for synthetic fuels, to push the sector to move faster towards non-fossil fuels.

- **Carbon Border Adjustment Mechanism:**

Corresponds to a carbon tax at the borders of the EU to be levied on products that do not abide by the same climate standards compared to products made in Europe under the ETS system. CBAM will prevent companies from exporting production in order to avoid the added cost of the low-carbon transition. In December 2022, EU policy-makers agreed on a Carbon Border adjustment mechanism (CBAM). CBAM will be valid initially for sectors such as: steel, iron, cement, aluminum, fertilizers and electricity. The EU authorities have also included Hydrogen and some other indirect emissions. The EU commission also reviewed the rules in order to avoid tax avoidances. The revenues of this mechanism will be used to support defossilization projects in Europe. For more information

- **REDII Delegated Acts (DA)**

The RED II legislation is under discussion on the EU parliament and the main critical discussions are the delegated Act 'on additionality' and delegated Act 'on GHG methodology'. DA 'on additionality' defines the basis for the use of renewable electricity for RFNBO production and the DA 'on GHG methodology' establishes the basis for calculating the reduction of GHG emissions from RFNBOs. Information about the delegated act can be found here link

- **REDIII**

EU policy-makers are negotiating for new rules on renewable energy. The main critical discussion involves increasing renewable energy in the energy mix as well as increasing quotas of CCU fuel in industry and transport. The discussions are considering that 2.6% of the energy used in the transport sector as well as 50% of the industrial hydrogen used should come from RFNBO, by 2030. This action will be a clear incentive for new CCU projects. (for a fuel to be classified as RFNBO it must reduce GHG emissions by 70%, compared with production using fossil fuels. In addition, renewable electricity for CCU must not consume electricity that could otherwise be used for more energy efficient alternative applications).

- **Carbon Removals Certification Framework:**

On 30 November 2022, the European Commission published its latest proposal on carbon removals. The proposal takes into account that only CO_2 from biogenic origin and DAC (Direct air capture) are eligible for removals once it is proven that CO_2 is permanently stored and not re-emitted. Three types of removal are

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considered: geological storage (CCS), products storage (CCU when permanent, wood construction…), and carbon farming. Additional information: Link

- **Energy Taxation Directive revision**

Benefits for the CCU: A differentiation among the taxes paid for the less GHG polluting fuels will be an important factor in the viability of projects involving RFNBOs. This directive proposes a zero-taxation rate for sustainable fuels and electricity for a transitional period of 10 years for shipping and aviation transport, until 1 January 2033.

- **Communication on Restoring Sustainable Carbon Cycles**

In December 2021 was published the Communication on Restoring Sustainable Carbon Cycles with the objective to establish the EU strategy on carbon cycles, considering several levers as CCS, CCU, carbon farming and carbon removals.

The initial goal was that 20% of the CO_2 used in the production of plastics and chemicals should have a non-fossil origin by 2030.The initiative is under discussion.

1.2.1 Identification of main bottlenecks and main opportunities for CCU projects

Main Bottlenecks:

- **Use of industrial CO_2 sources for CCU projects**

According to CO_2 value Europe (the Art. 28.5 – GHG methodology/threshold for RFNBO/RCF Delegated Act), the proposed sunset date (2035) for the use of industrial CO_2 sources would immediately lead to a halt in CCU investments today. CO2 emissions from fossil sources are set to be reduced gradually by multiple regulatory files, including the renewable energy and energy efficiency directives and the EU Emission Trading System, leaving only process-related and thus unavoidable hard-to-abate or not-to abate emissions. CCU is an effective solution to capture those remaining emissions and convert them into valuable transport fuels by using CO_2 emissions that would have been otherwise emitted to the atmosphere. Storage options for captured carbon may not be accessible or even allowed in certain locations. This time limitation would have significant profitability implications as an operating lifetime of max. 13 years is not sufficient to recover the investment costs for CCU and would therefore discourage investments that enable meaningful recycling and reuse of CO_2 emissions.

More information will be provided on the Investment roadmap document. (D6.13)

- **Constant changes in the regulatory framework**

Constant changes in environmental legislation bring legal uncertainties, making it difficult for industrial companies to analyze new CCU projects.

The AURA CCU Roadmap deliverable (D6.13) and the Toolbox (D6.14) will bring clarification on that.

You will find below a figure describing the main opportunities:

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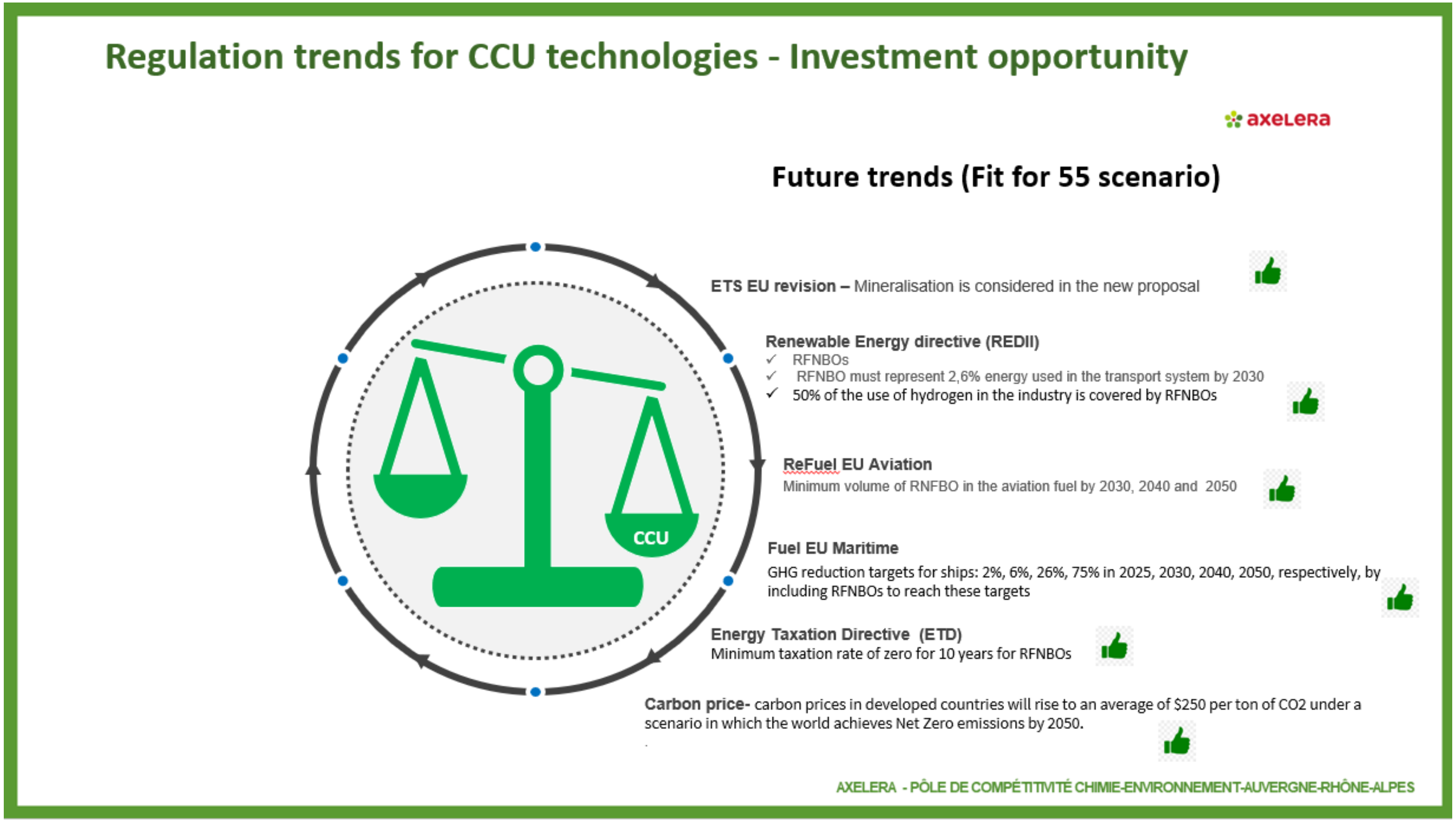
Regulation trends for CCU technologies - Investment opportunity
axelera
Future trends (Fit for 55 scenario)
CCU
ETS EU revision – Mineralisation is considered in the new proposal
Renewable Energy directive (REDII)
RFNBOs
RFNBO must represent 2,6% energy used in the transport system by 2030
50% of the use of hydrogen in the industry is covered by RFNBOs
ReFuel EU Aviation
Minimum volume of RNFBO in the aviation fuel by 2030, 2040 and 2050
Fuel EU Maritime
GHG reduction targets for ships: 2%, 6%, 26%, 75% in 2025, 2030, 2040, 2050, respectively, by including RFNBOs to reach these targets
Energy Taxation Directive (ETD)
Minimum taxation rate of zero for 10 years for RFNBOs
Carbon price- carbon prices in developed countries will rise to an average of $250 per ton of CO2 under a scenario in which the world achieves Net Zero emissions by 2050.
AXELERA - PÔLE DE COMPÉTITIVITÉ CHIMIE-ENVIRONNEMENT-AUVERGNE-RHÔNE-ALPES

1.3 CCU TECHNOLOGIES AVAILABLE

1.3.1 CCU technologies

The third step of the methodology will be the identification of CCU technologies that can potentially be used. The survey of these technologies as well as the mapping of their technical details will be important in the company's decision of which CCU technology should be used for each type of project. A catalogue of available technologies based on industry needs can help them to find the most suitable technologies for each situation. This work will be important for several reasons.

1 – Keeping up to date with all the innovations in the CCU field is a time-consuming activity and industries need to keep focused on their core business

2- Companies need someone to make their lives easier with consolidated, relevant and reliable information that can be used in the search for new technologies

3- Identification of what the best technologies to be used for each situation are

To ensure local sourcing and a short value-chain, AXELERA worked with its members to create a catalogue to identify CCU technologies solutions that could support companies. The catalogue is a tool to discuss with industrial sites the potential technologies that could respond to their needs. It will be available in the toolbox (D6.13 available M25).

1.3.2 Example of promising CCU technologies

The template developed takes into consideration the technological approach describing the technology, the benefits of the technology, the economical approach which gives an overview of the business model, the special conditions, the target industry and the TRL. Find below a template to identify the different technologies. It contains some examples to illustrate what could be the content:

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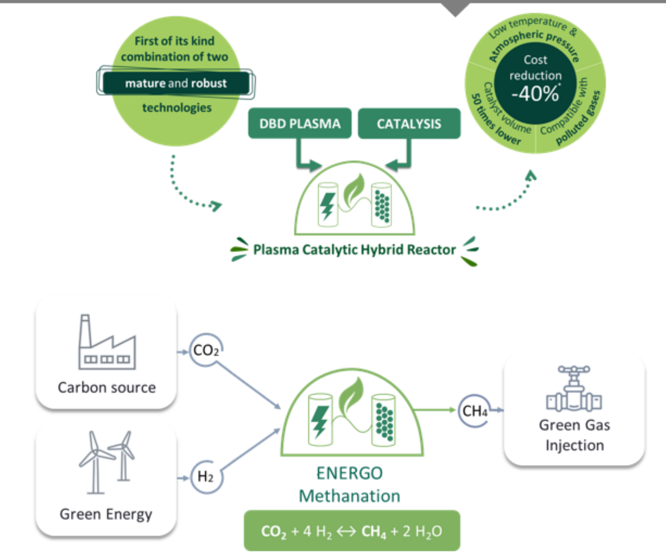
Energo - Plasma-catalytic Technology

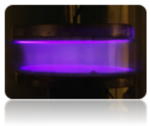
ENERGO

Technical approach



Technical Approach

- ✓ The CO2 is excited in the presence of DBD plasma.
- ✓ This situation promotes the conversion to intermediates with a lower energy barrier than with thermal catalysis alone.



- ✓ In order to reach the low-temperature and efficient conversion of CO2 via hydrogenation

The catalyst can be integrated with the DBD plasma reactor to generate a synergy, where the respective properties of active metals, supports, and promoters (additives) can be effectively combined.

Energo - Plasma-catalytic Technology

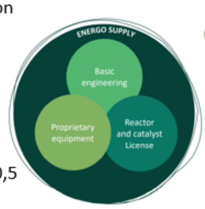
ENERGO

Benefits

- ✓ Cost reduction of 40% * (CAPEX + OPEX) compared to currently available solutions (for Methanation)
- ✓ Resistance to pollution : COV, O2 , N2 , halogenates
- ✓ Very Low Reactor volume needed (compact process + low catalyst cost) and no adjustment of (CO+CO2)/H2 ratio
- ✓ Operation at atmospheric pressure and moderate Temperature
- ✓ Cold start-up in few seconds
- ✓ 50 times less catalyst volume than standard technologies

Economic Approach

- ✓ Semi-industrial demonstrator Conversion of 12,5 m3/h (inlet gas Production of 30 kW of methane)
- ✓ Mobile demonstrator Conversion of 150 L/h (inlet gas Production of 0,5 kW of methane)



Special conditions

- ✓ The technology can not be used under pressure
- ✓ CO2 capture needed

Target industry

- ✓ Waste companies which want to produce CH4
- ✓ CO2 producers (cement plants, steel industry, etc..)

Technological readiness

TRL 7

*Values from an independent consultant (ENEA Consulting)

Figure09: Presentation of the KPIs of ENERGO's Plasma catalytic technology

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Note that a catalogue of technologies will be part of the Toolbox for the facilitation of emergence of systemic CCU hubs and related investments (Deliverable D6.14 – Release M25)

1.4 IDENTIFICATION OF CCU PROJECTS

The fourth step is the identification of potential CCU projects in the future hub. This step analyses and highlights potential opportunities as well as potential risks in the implementation of future projects. The development of a CCU project depends on a complex ecosystem of support, such as a distribution infrastructure for gas (H_2/CO_2), availability of resources like water and low-carbon electricity for H_2-electrolysers, CO_2 emitting companies, appropriate technologies for CO_2 capture and purification, CO_2 transformation technologies, companies interested in buying the products of the process, etc.

These CCU projects identification will support the clusters to answer the following questions:

- Who are the main stakeholders (customers) of the potential products produced by CCU?
- Which technologies are the most used today, and why?
- Which sectors of industry are most interested in the development of CCU projects?
- What are their requirements in terms of CAPEX, footprint, return-on-investment, scale, etc.?
- How can companies gain value via the CCU hub?
- What are the regions where more CCU projects are being developed and what are their success factors?
- What are the main benefits and problems faced in these projects?
- Will these projects be viable in the coming years?

From the study of these projects, we will be able to define the potential projects to be developed, the regions where these projects will have a greater potential to be viable, the most promising technologies as well as understand how the entire value chain can work during the development of the CCU project.

The next chapter we will present the CCU projects identified in the region.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

1.4.1 CCU projects: Main CCU projects identified in the region

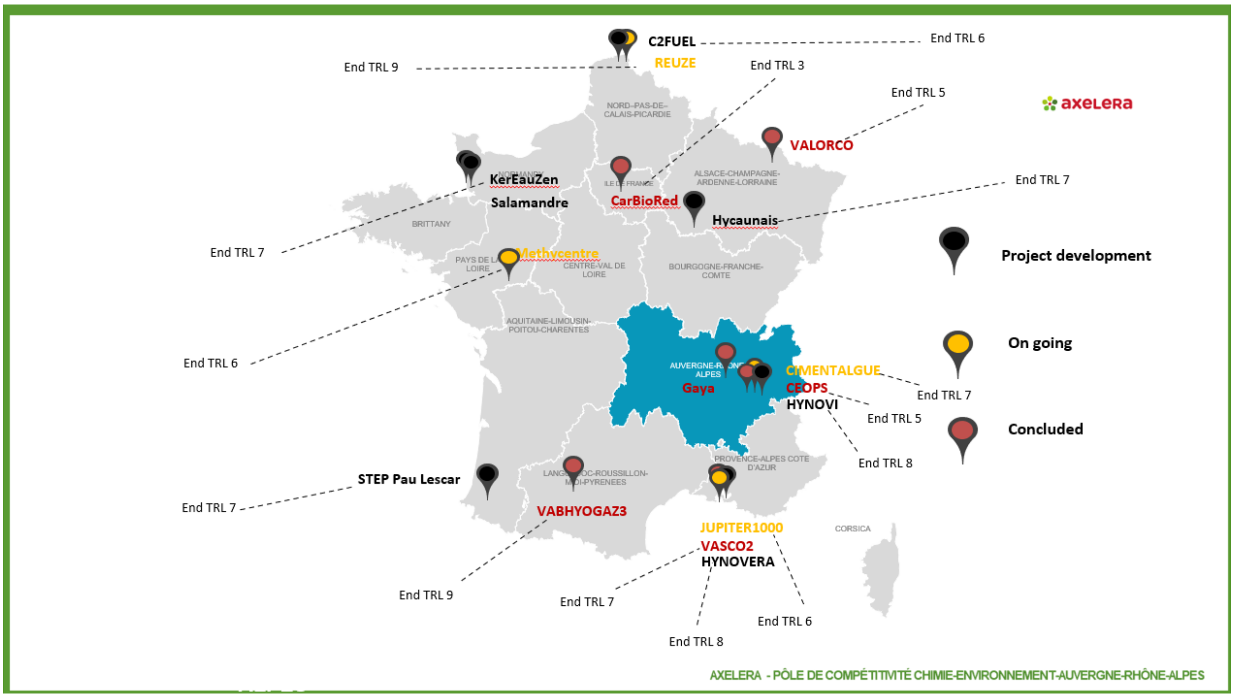


Figure 10: CCU projects identified in the region, AXELERA, 2022

C2FUEL – Production of two promising energy carriers: Formic acid and dimethyl ether using CO_2 from the steel industry and hydrogen produced from water electrolysis using surplus electricity from renewable energies.

Key figures:

- ✓ Location: Dunkirk harbor
- ✓ 2.4 million tons of formic acid
- ✓ 100.000 tons of green hydrogen
- ✓ 1.8TW/h of green electricity
- ✓ 1.2 million tons of DME
- ✓ 320.000 ton of green hydrogen
- ✓ 11TW/h renewable electricity

REUZE – This project aims to produce 100,000 tons of electro-fuels and naphtha using 300,000 tons per year of CO_2 from the local steel production industry. It will also produce steam to satisfy the needs of the local industries. The production of hydrogen will be done by the electrolysis of water using renewable energy.

Key figures:

Location: Dunkirk harbor

- ✓ CO_2 captured and utilized per year: 300.000 tons.

- ✓ Total production of Electrofuel and naphtha per year: 100.000tons

VALORCO – Project aims to reduce CO_2 emissions in the steel making industry through CO_2 capture and valorization. The project objectives are to develop laboratory-scale reduction and valorization of CO_2 from industrial processes to establish the economic viability and implement the most promising technologies in the form of a pilot laboratory-scale.

Key figures:

- ✓ CO2 Source: Steel production
- ✓ Project Budget: 17000000.0 €
- ✓ Start TRL: 4
- ✓ End TRL: 5
- ✓ Project Status: Completed

CarBioRed – This project aims the development, based on non-noble metals, of new efficient and selective catalysts for the electroreduction of CO_2, as well as the study of their mechanisms of action.

Key figures:

- ✓ Timeline Start - End: 2012-2016
- ✓ Project Status: Completed
- ✓ Project Budget: 556916.0 €
- ✓ Funding source: ANR
- ✓ Project Status: Completed

Hycaunais – Project led by Storengy. Synthesis of methane from CO_2 using a water-based electrolysis system to provide the necessary hydrogen. The energy required to power the electrolysis will be from wind energy. The electrolysis will be of 1 to 2MW. The methane produced will be injected into the grid.

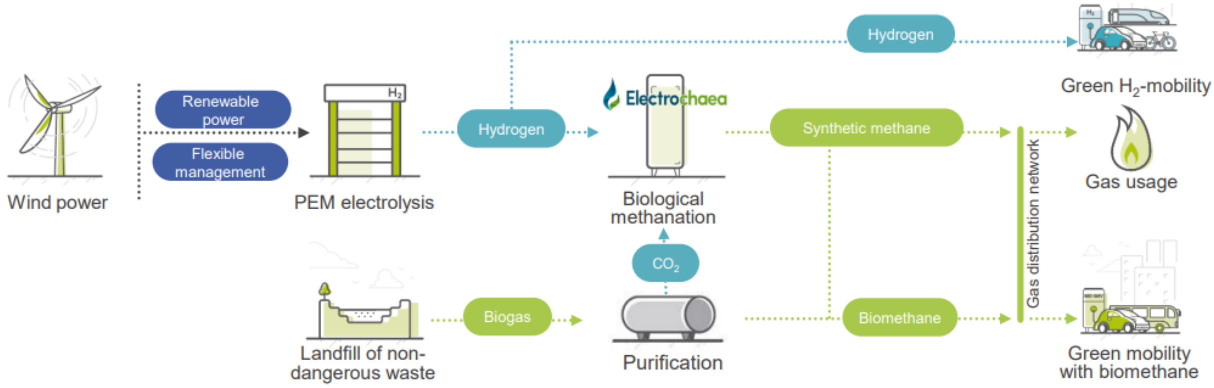
The project has 3 ambitions:

- ❖ Demonstrate the feasibility of operating a flexible P2G system adapted to its territorial context.
- ❖ To improve the technology of biological methanation.
- ❖ Replicate the technological and business model developed in HYCAUNAIS.

Key figures:

- ✓ CO_2 reduction: 1522 teq/year
- ✓ Wind power with electrolysis power of 1 MW/2 MWp

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.



Source: https://www.storengy.de
Figure 11: Power to Gas with methanation, Hycaunais project

KerEauZen – Production of e-kerosene from biogenic CO_2, renewable electricity and water. The project aims to find an alternative support for biokerosene. The e-kerosene should be blended with fossil aviation kerosene to meet the decarbonization targets of the aviation industry. Part of the e-kerosene produced will be used for research and certification purposes by French players in the aviation sector.

Key information:

- ✓ Project Lead: ENGIE
- ✓ Partners: SAFRAN, AIR FRANCE, Airbus, ADP, Sunfire
- ✓ First production unit: Normandy

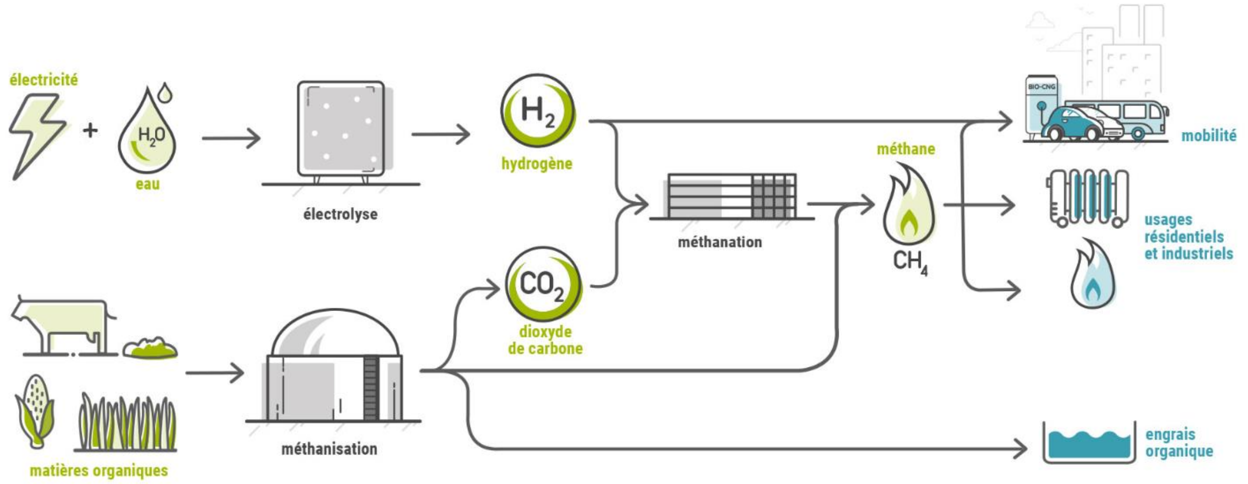
Salamandre – Project based on the pyrogazeification process followed by a methanation process for biomethane production with subsequent injection of the produced methane into the grid. The unit will be fueled by dry biomass from local wood-waste sources.

Key figures:

- ✓ Location: Le Havre
- ✓ Project led by Engie
- ✓ Site production (expected): 11,000 tons of biomethane annually, starting in 2026.
- ✓ Total investment of €150 million euros

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

Methycentre – Power to Gas. The project will have an equipment for performing the water electrolysis for hydrogen production that will be needed for the methanation process. The methanizers will supply the CO_2. The hydrogen + CO_2 will be transformed into methane by the methanation process, and this methane will then be injected into the grid. MéthyCentre will consume 1 GWh per year of electricity from the grid, accompanied by certificates of guaranteed renewable origin.



Source: https://methycentre.eu/projet/
Figure 12: Methycentre methanation project

Key figures:

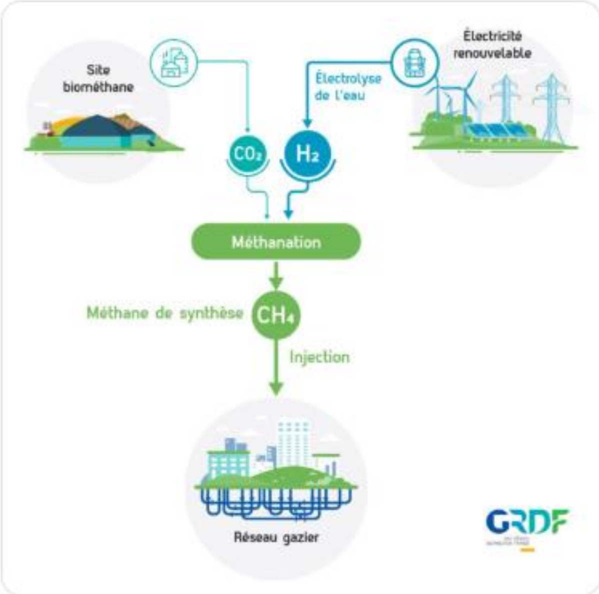
- ✓ Location: site d'Angé, France
- ✓ Project coordinator: Storengie
- ✓ Technology partners: Khimod, CEA, Elogen, Prodenval
- ✓ Starting date (Operating): 2022

Step Pau Lescar – Utilization of the CO_2 from the methanization units (sludge from wastewater treatment plants) for the methanation process. In this process the necessary hydrogen will be obtained through the electrolysis of water. The product of the methanation will be the synthetic methane which will then be sent to the network. As a sub product of the electrolysis, the oxygen will be used for the oxygenation of the wastewater treatment basins.

Key figures:

- ✓ Valorization of 100% of the CO_2 from methanization
- ✓ Complete balance of -550 tons of CO_2 per year for the plant, which is therefore a carbon sink.
- ✓ -2,300 tons of CO_2 per year compared to the past site thanks to methanation.
- ✓ Location: Agglomeration of Pau Béarn Pyrénées

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.



Source: GRDF website
Figure 13: Step Pau Lescar methanation project

VABHYOGAZ3 – Hydrogen production units by steam reforming of raw biogas. A process to produce sodium bicarbonate from the renewable CO_2 from the H_2 production process will also be developed.

Key figures:

- ✓ Project coordinator: Hera
- ✓ Location: Labessière-candeil, Tarn
- ✓ TRL: 9
- ✓ Production Volume: 3 kt/year
- ✓ Timeline Start - End: 2016-2020
- ✓ Project Budget: 11500000.0 €

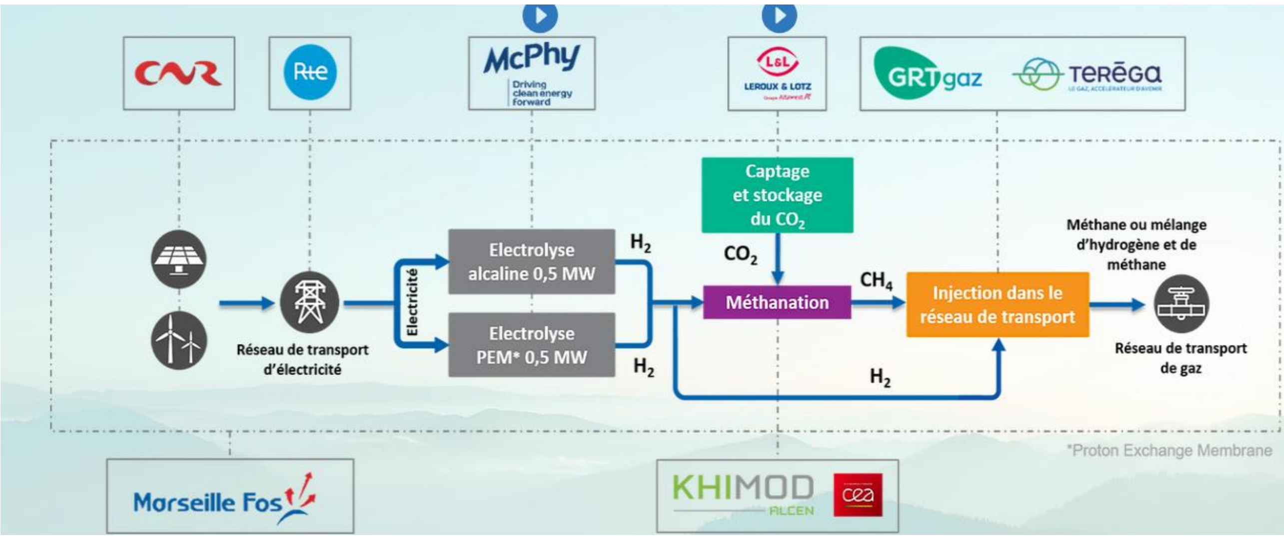
Jupiter1000 – The project consists in transforming renewable electricity into gas to store it. Surplus electricity will be converted into hydrogen by two electrolyzers and also into synthetic methane by means of a methanation reactor. The project also has a CO_2 capture structure from the gases emitted by nearby industries.

Key figures:

- ✓ Location : Fos-sur-Mer (Bouches-du-Rhône)
- ✓ Project coordinator: GRTGAZ
- ✓ 1 MWe hydrogen production, consisting of two electrolyzers
- ✓ Electrolysis technology: PEM (membrane) et Alcaline

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

- ✓ Methane production up to 25 m³/h
- ✓ Hydrogen injection up to 200 m³/h



Source : https://www.jupiter1000.eu/projet
Figure 14: Jupiter 1000 methanation project

Vasco2 – Microalgae is cultivated in basins (Kem One site, then ArcelorMittal and Solamat-Merex). These microalgae will then be collected and processed into biocrude. This biocrude will then be refined to obtain the final biofuel product.

Key figures:

- ✓ Project Budget: 1900000.0 €
- ✓ TRL: 7
- ✓ Timeline Start - End: 2015-2019
- ✓ CO2 Source: Natural gas heater, iron mill, waste processing plant
- ✓ Location: Harbor of Marseille Fos

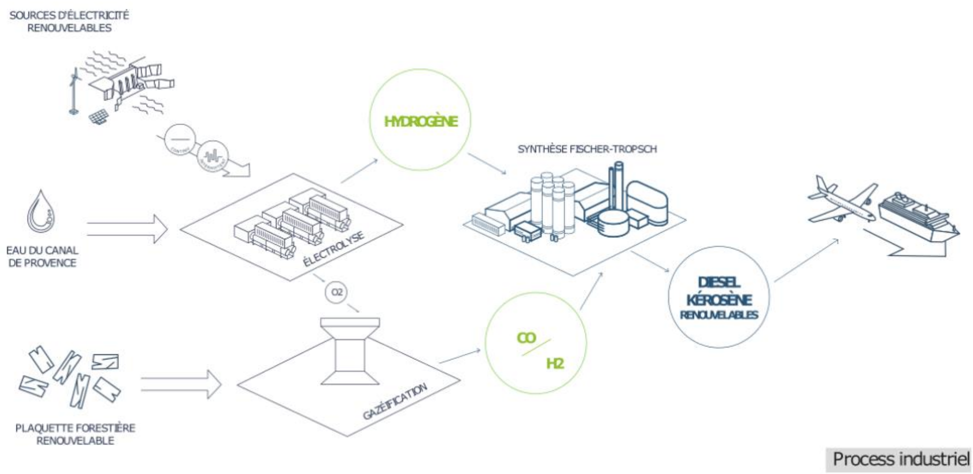
HYNOVERA – Torrefaction and subsequent gasification of biomass from forests to produce initially a synthesis gas that will be the basis for the subsequent production of kerosene or diesel. They are considering the production of methanol from renewable energy by 2030.

Key figures:

- ✓ Budget: Approximately 460 million euros
- ✓ Production of Kerosene/ Diesel (2027): 16.000ton/year
- ✓ Oxygen production (2027): 97.000 ton/year
- ✓ Naphtha paraffinic production (2027): 9.000Ton/Year
- ✓ Methanol production (2030): 70.000ton/Year

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

- ✓ Location : Gardanne, Meyreuil - Bouches-du-Rhône - Provence-Alpes-Côte d'Azur



Source : https://concertation.hynovera.fr/le-projet-hynovera/
Figure 15: Hynovera project

Projects in the Auvergne Rhône Alps region

Gaya – Project for gasification of material from dry biomass (forests and agriculture) to produce biomethane. This biomethane will be produced from 100% renewable resources, which can be transported in the current networks or directly usable as fuel. The process consists of 4 phases:

1 - Dry biomass preparation.

2 - Injection of the biomass into a gasifier working at a temperature between 800-1000 degrees Celsius. The product of this gasifier will be a gaseous mixture mainly composed of CO and H_2. A filtering process is done to eliminate the impurities of these gases.

3 - The methanation is completed to transform the synthetic gas in methane.

4 - The last step of the process consists in the separation of the methane from the other molecules.

- ✓ Key figures:
- ✓ Location: Saint-Fons (Rhône)
- ✓ Budget: About 60 million euros
- ✓ Project coordinator: Engie

CIMENTALGUE – Cultivating microalgae in greenhouses to protect them from external impurities and to maintain them at a controlled temperature. The gas from the cement plant which has a significant concentration of CO_2 is injected into the culture to transform the CO_2. Several technologies are being evaluated such as open and closed raceway ponds, a tubular photobioreactor, and an AlgoFilm thin layer photobioreactor (PBR)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

Key figures:

- ✓ 800 m² CimentAlgue demonstrator installed.
- ✓ capacity of about 1 t of dry microalgae/year
- ✓ Location: Montalieu-Vercieu cement plant

Source: Vicat web site
Figure 16: Picture of Cimentalgue project

HYNOVI – Production of methanol from CO_2, captured from a cement production, and hydrogen produced by a 330MW water electrolysis unit.

Key figures:

- ✓ Location: Montalieu-Vercieu, France
- ✓ Vicat Hynamics (EDF)
- ✓ 40% of the CO2 emitted by the Vicat cement plant in Montalieu-Vercieu.
- ✓ 330 MW electrolyze operating by 2025,
- ✓ The use of oxygen from hydrogen production will be used to oxy-combustion process
- ✓ Production target: over 200,000 tons of methanol per year

CEOPS – CEOPS project will focus on a sustainable approach for the production of methanol from CO2, which is a precursor for fine chemicals products. The approach will reinforce the link between large CO2 emitters and fine chemical industries at the European level. The concept relies on two chemical pathways, CO2 to CH4 and CH4 to CH3OH with the intermediate carbon vector: methane. Methane benefits from the extended and existing natural gas network infrastructure. Its distribution will prevent additional CO2 emissions (rail & road transportation). This approach will favor the emergence of small and flexible production units of fine chemicals from methanol. (Source: Cordis EU research)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

Key figures:

- ✓ Location: Grenoble
- ✓ End TRL: 5
- ✓ Project leader: CEA
- ✓ Project Budget: 3508268.0 €

Markets targeted by CCU projects in the area of our emerging CCU

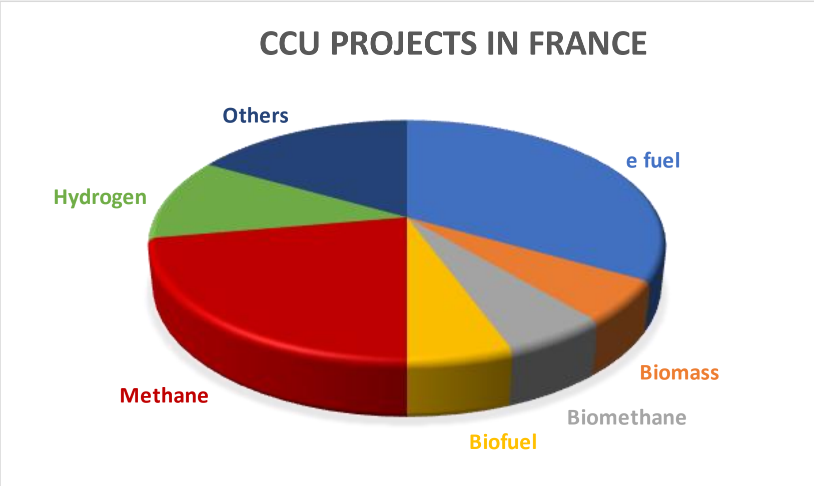


Figure 17: CCU projects profile in France

Analyzing the profile of the CCU projects carried out in France, we can see that the projects aimed at e-Fuels mainly focused on the production of e-Kerosene and e-Methanol are the most sought after. One of the reasons that can explain this behavior is the new legislation fit for 55 that establishes quotas for fuels produced from non-biological origin that will increase gradually from the next years until 2050.

In the second position, we see the methanation projects from the methanizators. Methane has the advantage of having a ready-made transport structure via pipelines, which facilitates its flow.

The production of hydrogen from renewable energy or through steam reforming of raw biogas are also considered in CCU investments, but the lack of an adequate transport infrastructure often makes the projects unfeasible. However, the electrolysis of water to produce hydrogen used in the production of e-fuel is in full growth and many investments are being made in this direction.

In the next CCU seminar that we are preparing this year, the main projects identified as having the greatest potential, especially about the production of e-methane, e-kerosene and synthetic methane will be called upon to present their projects to the companies.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

1.5 Funding Opportunities identification

1.5.1 Example of Funding opportunities in Europe (31/12/2022)

The 5th step and one of the most important steps in the project emergence process is to find the most suitable funding opportunity for each company. To find these opportunities, we complete strategic intelligence bulletins regularly and share the resulting bulletins with stakeholders. In addition, as cluster, we send to our members newsletter, containing all the relevant public national and European fundings. A template will be available on the toolbox.

Once funding opportunities have been identified, the next step will be to prepare a backup material to discuss with companies. As the main companies interested in CCU projects are already identified in the previous steps, a direct approach to these companies can be made.

You will find below a mapping of the main EU fundings opportunities for CCU projects.

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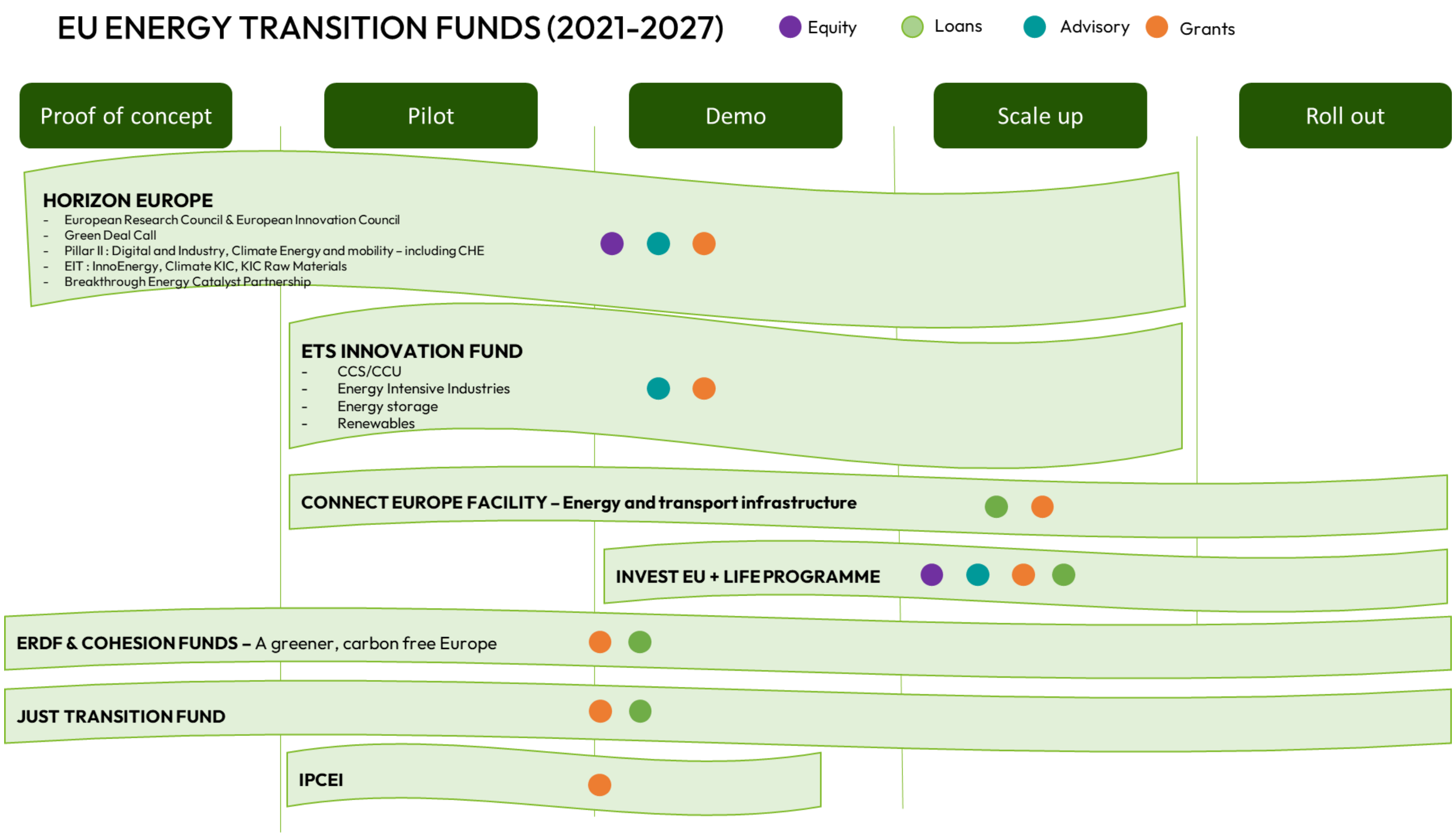

Picture 18: EU Energy Transition funds (2021-2027)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

The cluster will have for mission to introduce them the different funding opportunities and analyze which one would be the most appropriate.

In addition, we recommend to the cluster to summarize the content of the opportunities according to a specific template. This material will be part of a toolkit that will be used to approach industrial companies. AXELERA will provide a template that the clusters can used and adapt as part of the toolbox (D6.14).

Innovation Fund

axeLera

For projects enabling decarbonization

Eligibility Criteria	4 themes - Renewable Energy, CCUS, Energy storage and Energy intensive industries If project in energy intensive industry, the industry/process must be covered by the European Emissions Trading Scheme Single partner or small consortium, public or private (EU + Norway, Iceland) Project must have strong measurable before its end, which requires a significant size
Deadline	Annual: Small-scale call (CAPEX <7.5M€): August 2022; Large -scale call: Q1 2023 (March) (CAPEX >7.5M€):
Duration	Time to financial close, construction + OPEX for up to 10 years of implementation
Subvention	60% of project costs beyond business -as-usual (large-scale) 60% of CAPEX (small -scale)
Evaluation criteria	Avoidance of greenhouse gas emissions Technological maturity of the project Degree of innovation Scale-up (replicability) Cost effectiveness - cost of project per ton of CO2 equivalent avoided
Success	5% of projects funded according to the call Large-scale 2023 budget largely increased to 3Md€.

AXELERA - PÔLE DE COMPÉTITIVITÉ CHIMIE-ENVIRONNEMENT-AUVERGNE-RHÔNE-ALPES

Figure 19: Template for Funding opportunities: Innovation fund example

1.5.2 Project diagnosis

To identify the most appropriate funding opportunities, we have developed a diagnosis. It will allow to define the objectives, scope, action plan and exploitation plan. You will find this diagnosis tool in the annex 02 of this document.

This diagnosis is conducted by one of our innovation officers. They can be supported by our European Manager. Once the diagnosis is conducted, the team is able to orientate the company to the most relevant fund.

1.6 HYDROGEN INFRASTRUCTURE

The 6th step of this first part of the methodology will be about Hydrogen infrastructure.

The reaction of industrial CO_2 with Hydrogen, which is an important building block in the production of products such as methanol, aviation fuels, chemicals and many others, makes hydrogen a key raw material

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

in the context of CCU projects. This is the reason why the infrastructure hydrogen is directly linked with CCU projects. In order to have a clear view of the green hydrogen market, you have different possibilities:

- ✓ Conduct a market overview
- ✓ Industries interviews

In addition, it is crucial to understand how the future projects will be connected each other. You will find below the market information needed to understand the H2 infrastructure in the European and regional level (AURA region).

1.6.1 Infrastructure H_2 – Europe

The future European hydrogen backbone (EHB) represents the infrastructure. It should cover 28 countries and will be the future pipeline network in the EU. In April 2022, a report designing the future hydrogen network was published: https://ehb.eu/files/downloads/ehb-report-220428-17h00-interactive-1.pdf).

You will find below the map by the Horizon of 2030. The development of this map is subjected to market evolution and might change overtime.

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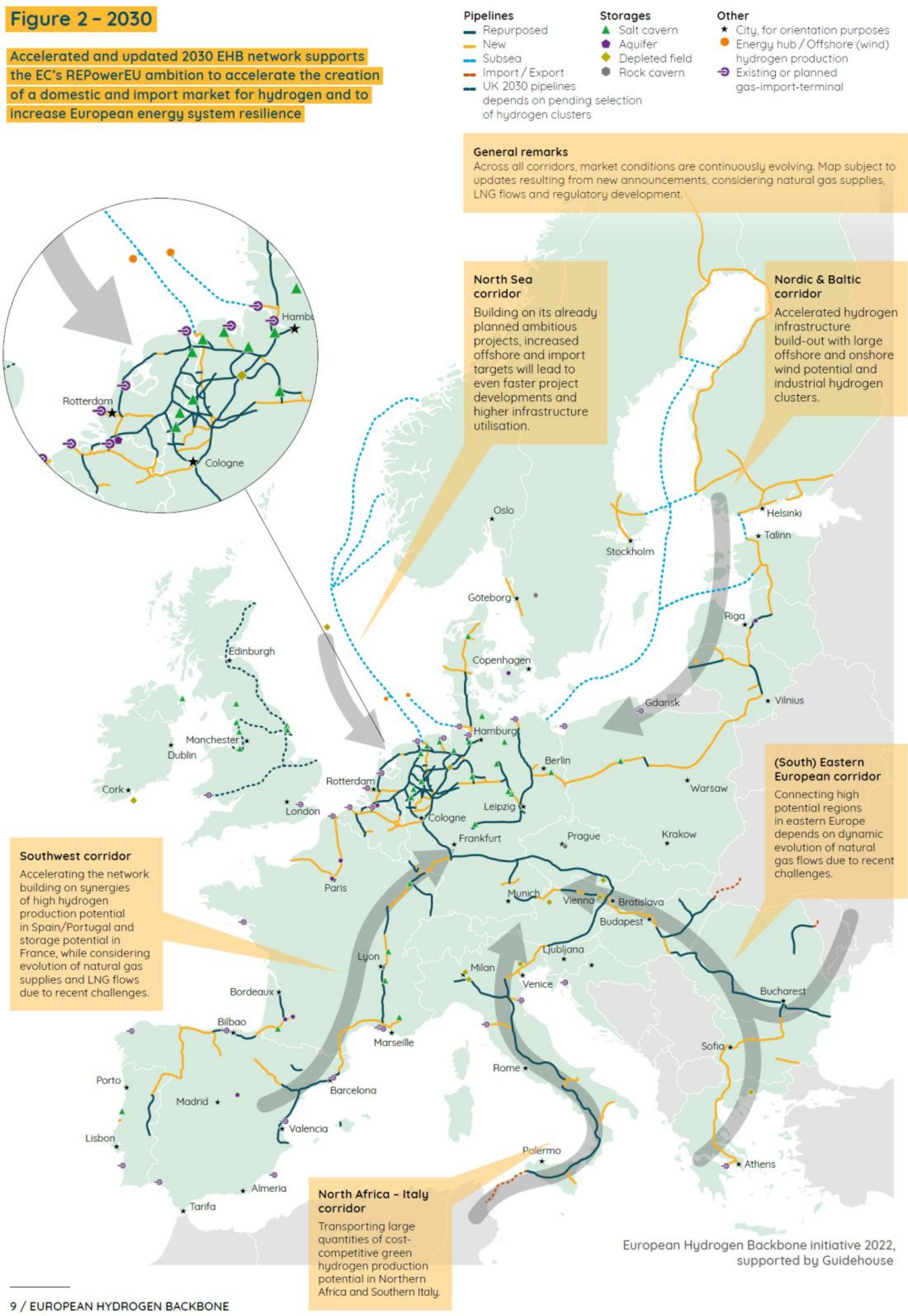

Figure 20: Hydrogen backbone in the European level

The map is composed of 5 main corridors:

North Sea corridor: this corridor is also linked to CCU Projects, such as the North Sea Port project. See the link: https://northccuhub.eu/

Nordic & Baltic corridor: Accelerated hydrogen infrastructure build-out with large offshore and onshore wind potential and industrial hydrogen clusters.

Southwest corridor: high hydrogen production potential in Spain/Portugal and storage potential in France

South Eastern European corridor: connecting high potential regions in eastern Europe

North Africa-Italy corridor: it will be used to transport large quantity of cost competitive green hydrogen production in Northern Africa and Southern Italy.

According to the EHB initiative, the mature infrastructure should be ready by end of 2040.

Follow below the map with the potential infrastructure by 2040:

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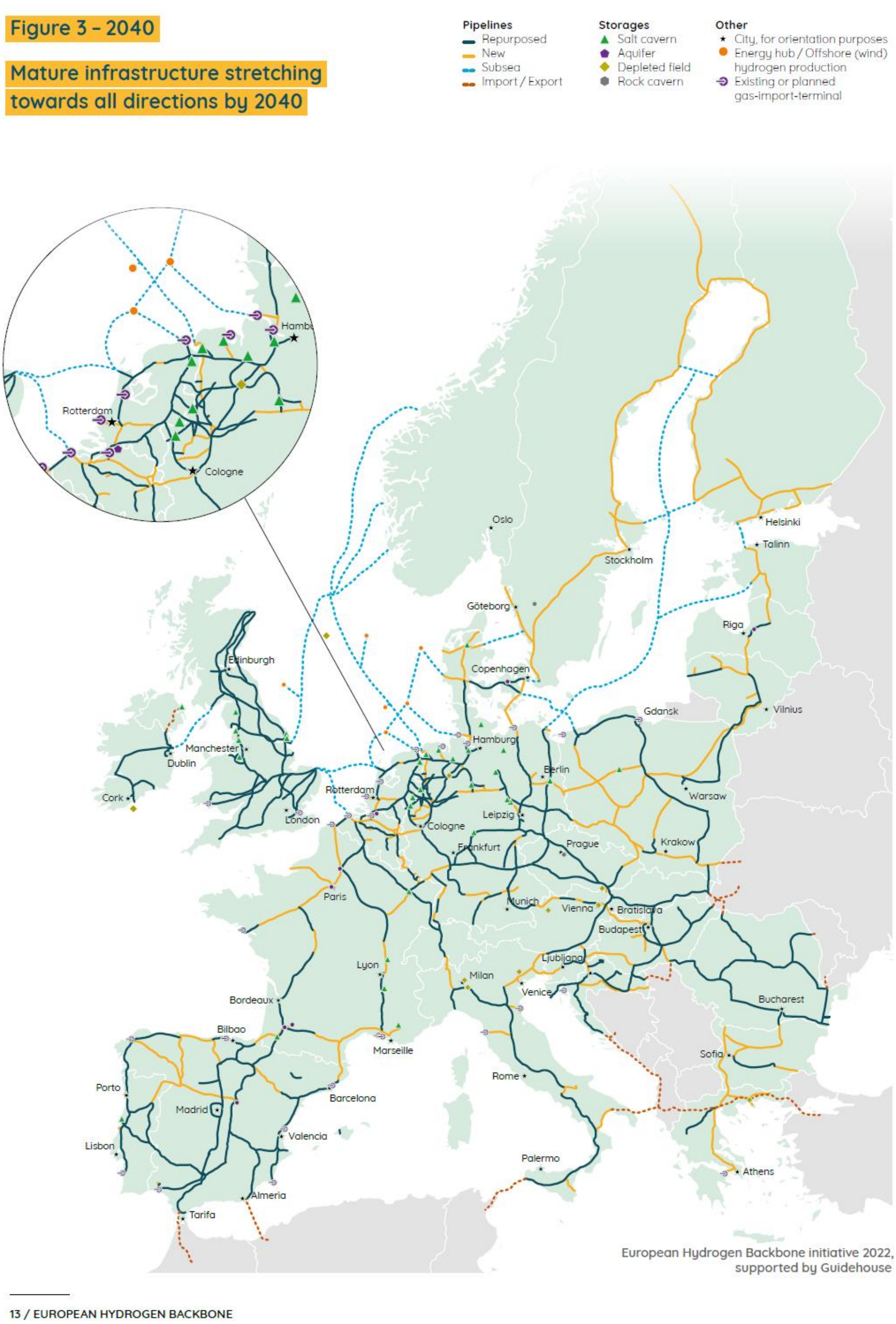

Figure 21: European hydrogen backbone initiative 2022

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

You can also have access to an interactive map to identify the different European infrastructures:

https://ehb.eu/page/european-hydrogen-backbone-maps

The backbone will play a major role in CCU project development. These routes can act a major role to encourage industrial companies to invest in Carbone Capture and Utilization.

1.6.2 Infrastructure H_2 in the region

You will find below, the first draft of the map with the future hydrogen infrastructures in the region of our emerging project:

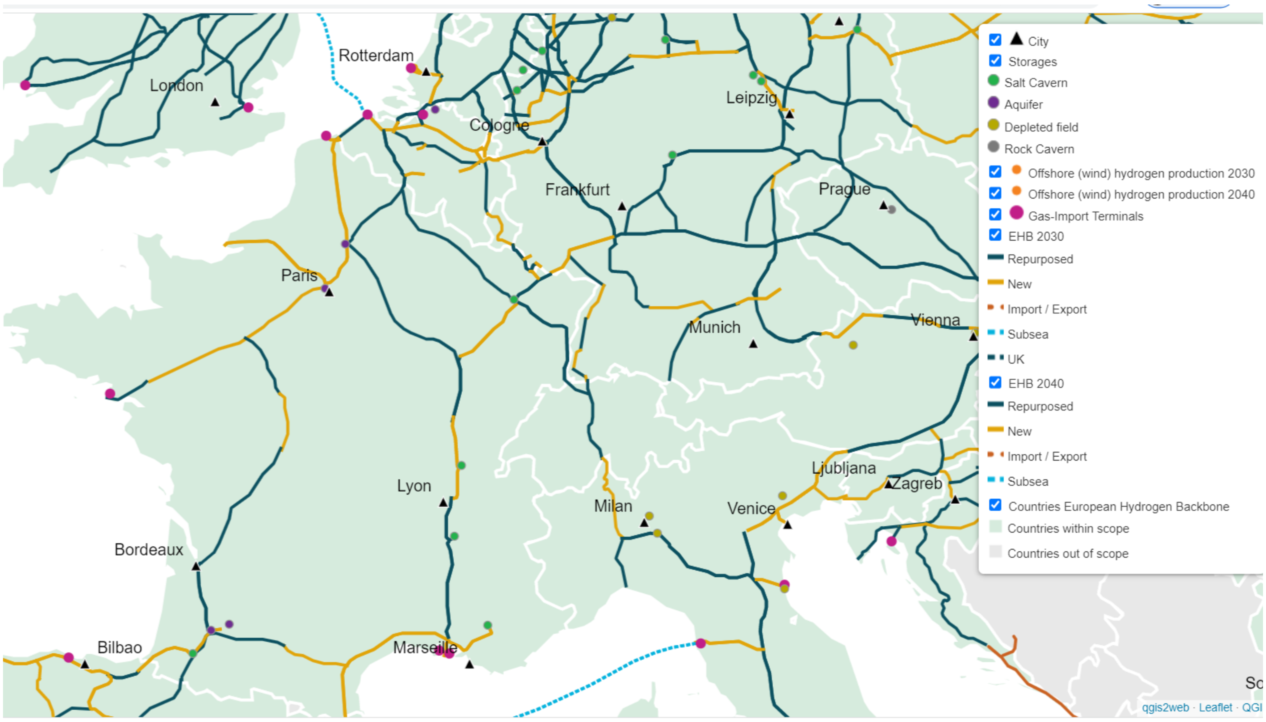

Figure 22: European hydrogen backbone initiative 2022, France overview

In France, to build a new infrastructure the deadline is quite long. You will find below a typical schedule:

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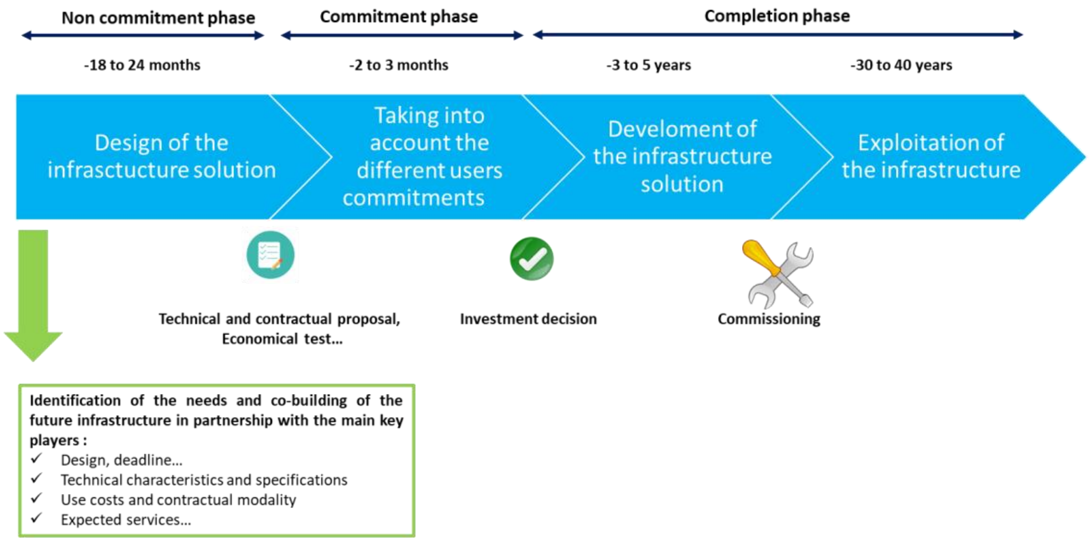


Figure 23: Timeframe to development of a new hydrogen infrastructure in the region according to hydrogen distribution and networking companies

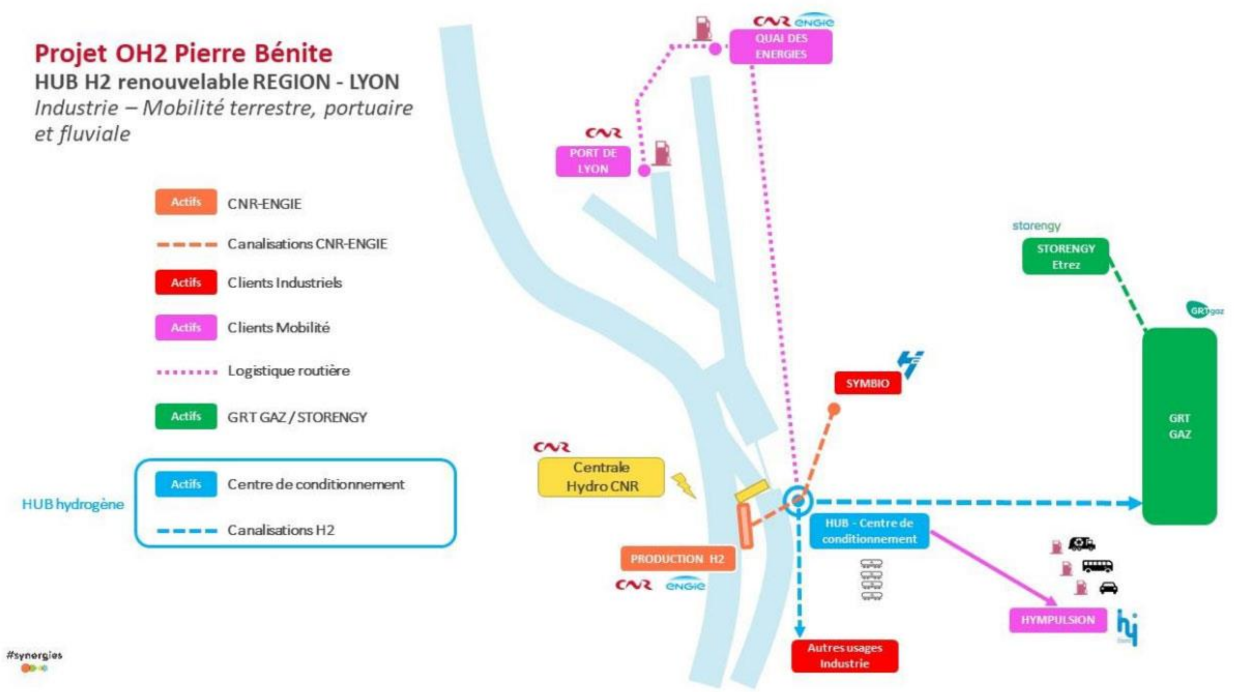
This is why to be committed in the EU hydrogen backbone plays a major role. The main distribution network key players, such as GRT Gaz and Storengy, have launched a survey to identify the different needs and design the future design. Several reports have been published. This still needs to be improved.

A regional approach is also ongoing. On your side, we advise you to get in touch with the electricity and gas providers in order to have in mind the different deadlines that are different in each country. Work with them will help you to raise industrial companies awareness on this challenge. The pipeline will be linked to hydrogen storage. In the AURA region, we have the first hydrogen storage pilot, called HyPSTER. HyPSTER stands for Hydrogen Pilot Storage for large Ecosystem Replication and it aims to use salt cavern storage to connect hydrogen injection by electrolysis to industrial and mobility uses. The demonstration facility will be located in Etrez, France. More information about the project: https://hypster-project.eu/about-the-project/

By connecting pipes to hydrogen storage, we will be able to ensure delivery flexibility.

On 10th October 2022, the Auvergne Rhone Alpes Region announced the creation of the first hydrogen pipeline. It will be linked to a hydrogen 20MW electrolyser and will supply various actors located the Chemical Valley (Vallée de la Chimie):

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.



Source: https://www.h2-mobile.fr/actus/premier-pipeline-hydrogene-region-auvergne-rhone-alpes/
Figure 24: Development of new hydrogen pipeline in the Auvergne Rhône Alpes region

This pipeline will have 1 km away and it will be ready in 2025. All these actions are the first start point for the set-up of a hydrogen regional ecosystem. Engaging in actions aiming at the deployment of green hydrogen in the region together with industries and regional institutions will be a crucial job for clusters to facilitate CCU projects.

1.6.3 Identify the possibilities of H_2 infrastructure in your region

Several Hydrogen projects were identified in the region. Below a map with the projects which were disclosed

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

Figure 25: Hydrogen projects in Auvergne Rhône Alpes Region in 2022

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

Most of the projects are still under development and waiting for additional fundings. However, they are aware of the necessity to include in their business plan Carbon Emissions Management.

1.7 DEFINITION OF THE TARGET COMPANIES TO BE APPROACHED

After gathering all information about the 6 steps before, we are now able to define the best strategy to use to approach industrial companies. The definition of the industries to be approached were defined according to the following criteria:

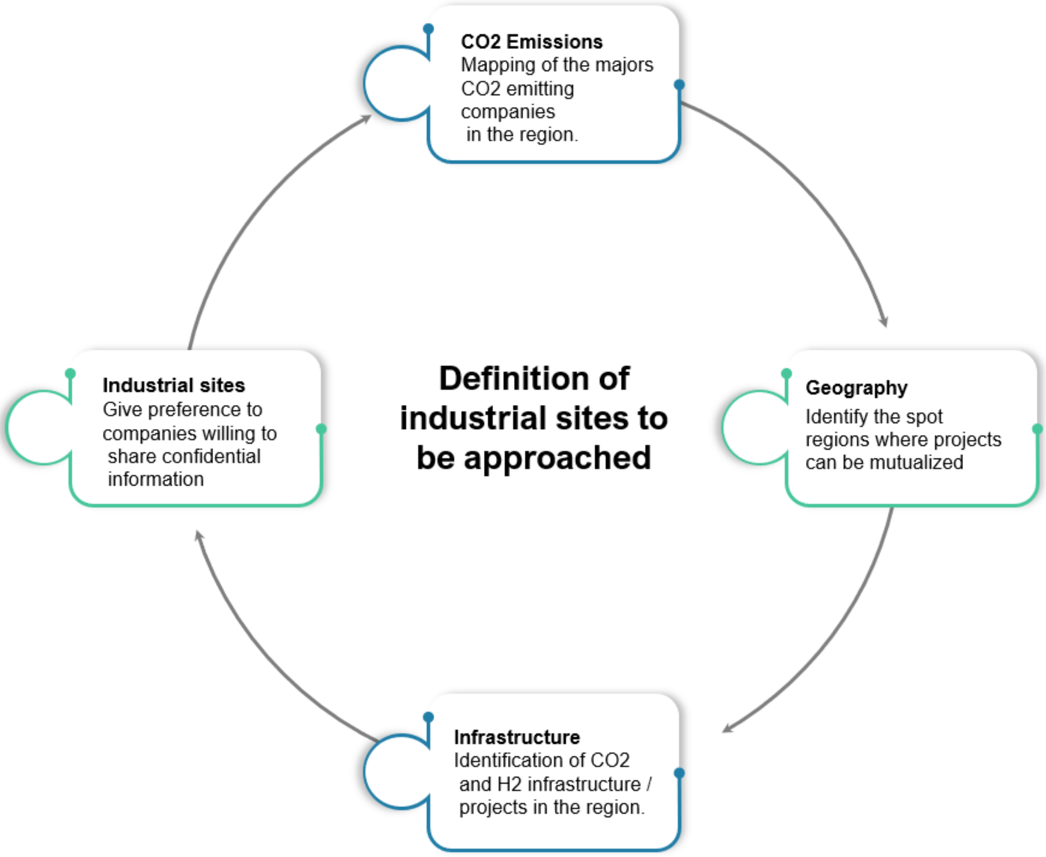


Figure 26: Strategy to define the industrial sites to be approached.

Criteria taken into consideration for definitions of industrial sites to be approached:

CO_2 emissions – It means companies with a major potential to reduce CO_2 emissions.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

Geography – Map the companies by geography in order to identify clusters where companies can work together in mutualized projects. The possibility to have a supplier of renewable energy, H2, companies that emit CO2 and end users of possible CCU products would be the ideal scenario.

Hydrogen infrastructure – Infrastructure to have access to green hydrogen and others raw materials needed in the CCU process.

Companies willing to share information – A Confidentiality agreement with the companies involved in the process will facilitate the obtention of information. No confidential information from companies will be shared in this report. The information discussed with companies is being used just to find the best opportunities to develop CCU projects/hubs.

1.8 TOOLKIT TO APPROACH INDUSTRIAL COMPANIES WITH INVESTMENT DECISIONS

1.8.1 Toolkit development

The purpose of the toolkit is to facilitate the work of companies by bringing together the key information needed to understand and be able to emerge a CCU project. It is worth noting that companies are overloaded with activities related to their core business and it is up to the facilitators to create mechanisms and tools that facilitate access to essential information.

The toolkit has been developed using all the previous information discussed in this report to produce a clear concise material that can be used in discussions with companies: Information on CCU Legislation – (Presentation of the CCU legislation as well as the challenges, opportunities and risks). CCU technologies – (Presentation of the technologies adapted to each situation depending on a series of factors like gas concentration, volume, pollutants, energy price, hydrogen availability etc.) Regional and European opportunity funding – (Presentation of funding opportunities taking into account the possibility of mutualization of projects through a common call for proposals).

The toolkit will be part of the toolbox which will be presented in the PYROCO2 project month 24. In the next chapters we will discuss the use of this material (toolkit) during the discussions with the companies.

1.9 STRATEGIC INTELLIGENCE BULLETINS

In order to ensure that companies have up-to-date information on the constant changes in CCU technologies, new funding opportunities at French and European level as well as changes in legislation, it is interesting to release the strategic intelligence bulletins every three months. The example of this document is presented in the annex 1. It is important to point out that companies have difficulties in making their workforce available for these tasks. We performed four Strategic intelligence bulletins in the year of 2022 and disclose them with the industrial cluster in AURA region.

The complete Strategic Intelligence Bulletins will be available on the Toolbox (D6.14) too. One example of the strategic bulletin will be available in the Annex 01 of this document.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

2 ACTIONS TO IMPLEMENT CCU PROJECTS IN THE REGION

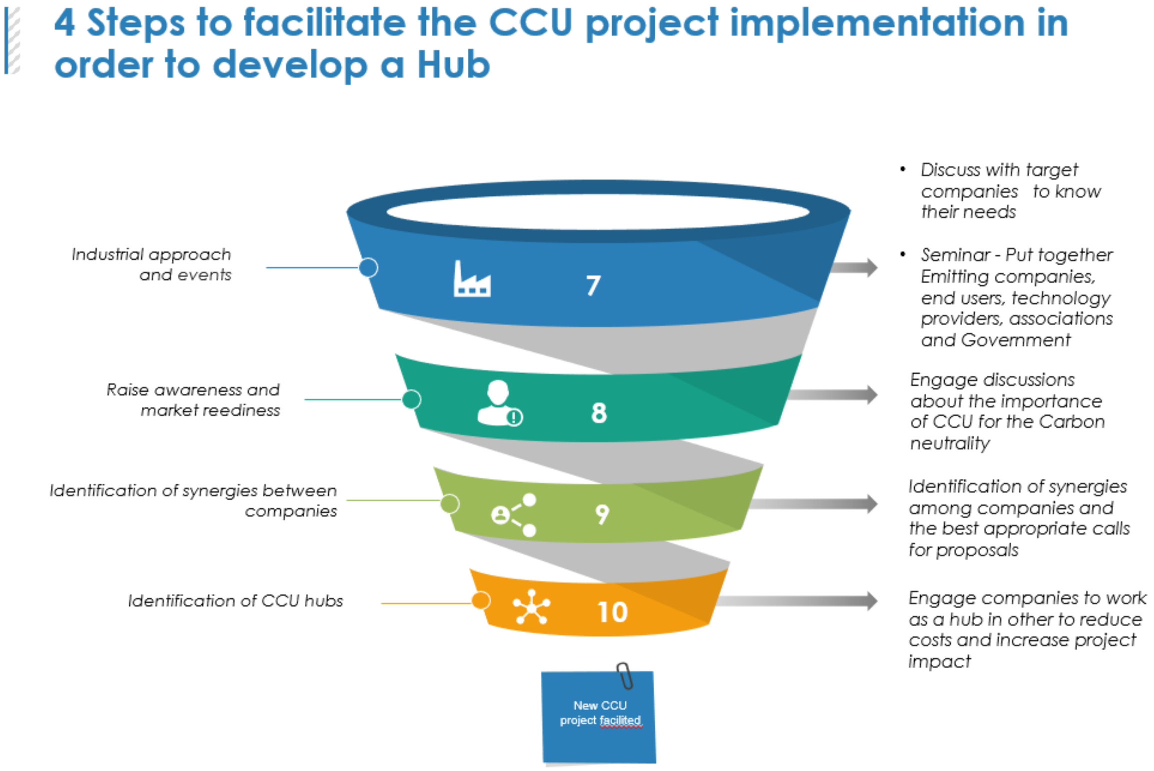


Figure 27: Four steps to facilitate the CCU hub implementation

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2.1 INDUSTRY INTERVIEWS BASED ON THE CO_2 BIGGEST EMITTING COMPANIES AND CCU EVENTS

After defining the strategy of which companies to focus on, the next step is to interview these companies in order to know their needs, their decarbonation strategy, their CO_2 emissions profile and other important information in order to identify potential CCU projects in which these companies can take part. A template questionnaire was prepared with the most relevant information that should be discussed in these interviews.

2.1.1 Industry interviews done in the scope of the emergence of the AURA CCU hub

The database of the French Administration (IREP) was used to find the main CO2 emitting companies at regional and national levels. Two areas in the AURA region were identified as having strong potential for CCU projects: the "Chemical Valley" (Vallée de la Chimie) and the Grenoble area. To date, interviews have been carried out with 42 companies in these areas.

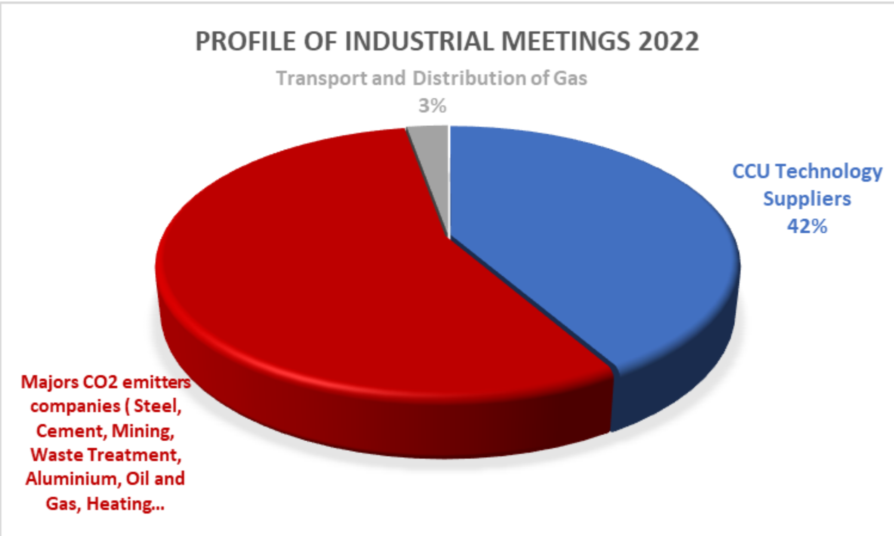

Figure 28: Profile of industrial interviews performed during the year of 2022

A questionnaire was used to collect the important information that will be needed to understand the needs of these companies for new CCU projects as well as to identify potential synergies with other companies. The template is available in appendix 03 and will be also included in the Toolbox (D6.14).

2.1.2 CCU seminar

Seminars unite the main actors of the CCU value chain to discuss (Industrial sites, Governments, Technology suppliers, End users, Associations, Universities, Research centers etc...). The results of the seminar are:

- ✓ Discussions among companies and the relevant regulatory agency in order to influence the current legislation for the benefit of CCU projects
- ✓ Contacts made for the introduction of CCU technological innovations
- ✓ Discussions for the emergence of potential CCU projects

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- ✓ Raised awareness about CCU
- ✓ Emergence of one CCU project

AXELERA organized on 8th September 2022 a seminar dedicated to the deployment of CCU technologies on a regional scale with the aim of bringing together players interested in these technologies, to provide information about funding opportunities, to discuss about CCU regulatory framework issues and to meet other players in the value chain. 93 people attended the seminar. The program was established to discuss CCU market challenges and to present some innovative technologies (including PYROCO2 technology). In addition, the event was developed in partnership with Club CO_2. Keynote speakers included the French Environmental Agency, ADEME and CO_2 Value Europe. The program was divided into 4 main sessions:

- ❖ CCU – Legal framework and funding opportunities
- ❖ Supply of products manufactured from industrial CO_2
- ❖ Networking
- ❖ CO_2 capture and use technologies – (including a presentation of PYROCO2)

The CCU seminar agenda is presented in the annex 04 of this document.

Results of the survey performed after the seminar

After the seminar, we addressed a survey to identify the main bottlenecks in the deployment of CCU technologies. Please find below some of the survey questions and answers.

What support do you need to setup CCU projects?

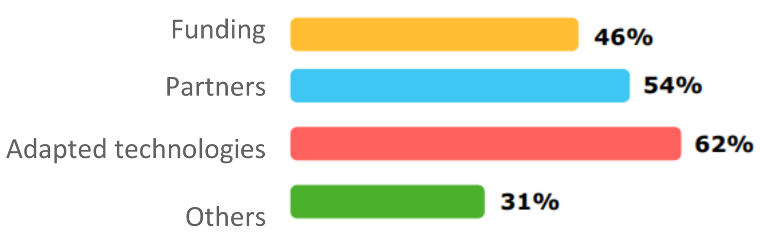

Figure 29: Survey results about industry needs for setting-up CCU projects.

The companies present to the seminar mentioned the main supported needed for CCU projects is to identify the best available technology for their needs. As most of the CCU technologies are not yet mature, it is currently difficult to know which technology will be the most appropriate for each sector, taking into account the specificities of each industry. Moreover the demand for products produced from industrial CO_2 is currently emerging and how it will evolve is unknown. The second most critical point identified was finding committed partners for the execution of the CCU projects. Developing joint projects between industrial sectors is still a difficult task since confidentiality and competition are often an obstacle to forming consortiums. In third position is the funding opportunities which are often not adapted to the needs of the companies. In some cases, companies do not have easy access to these

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funding opportunities and supporting these companies is necessary to ensure that they have the needed information to finance their projects.

What are the main barriers for the CCU deployment in the region?

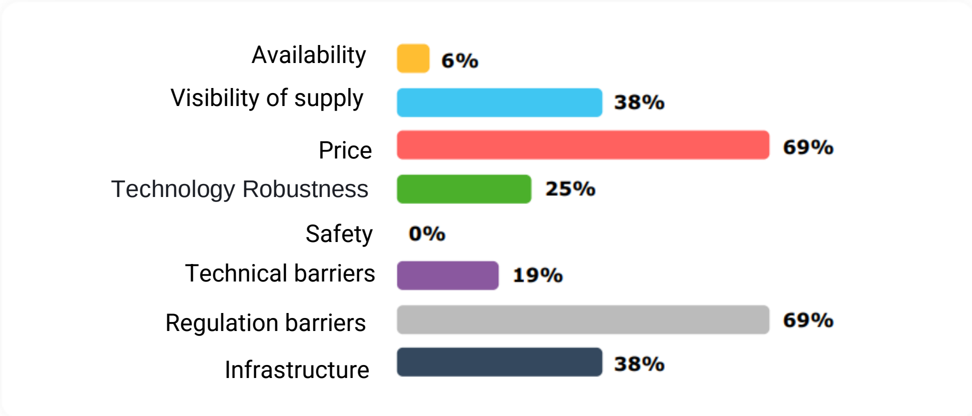

Figure 30: Survey main barriers for CCU implementation in the region

Two points appear as the main barriers in the development of CCU projects: The first is the price of the current technologies and their financial viability. The production of products from the industrial CO_2 and its transformation into new products such as e-fuels or e-methane are dependent on the availability of green hydrogen at a reasonable cost. This hydrogen produced by the electrolysis of water from renewable energies is highly sensitive on the energy price. Electricity prices in Europe are currently very high which leads these projects to face economic barriers. According to the French Stastic Institute (INSEE), the price of electricity increased of 22% in 2022. It expected a new increase by 2024 of 83%. Sometimes the price of CCU products can be 2, 3 or even 4 times higher than the same products produced from fossil fuels.

Another barrier concerns regulatory issues that change very often, not providing a secure environment for investments. CCU projects require expensive investments, and their implementation takes from 3 to 7 years, which makes it difficult to commit to these projects. Thirdly, there are the infrastructure problems which are currently not adapted to the transport of CO_2 and hydrogen. All these issues make the economic viability of projects difficult and hinder the development of new business models.

What are the key factors that will make CCU technologies viable in the marketplace?

Almost all answers related to this question were related to the legislation framework:

- ✓ Double counting of CO_2 emissions
- ✓ Taxation of fossil fuels to be reinforced
- ✓ Subsidies to be put in place for the launch of the sector
- ✓ The proposed sunset date (2035) for the use of industrial CO_2 sources would immediately lead to a halt in CCU investments today

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2.2 RAISE AWARENESS AND MARKET READINESS - PARTICIPATION OF CCUS DISCUSSIONS

Participation in discussions at regional, national and European levels will give visibility to your project and can help new projects emerge. In these discussions you will be able to follow changes in the market, legislation and identify potential partners. Working together within working groups will support the development of CCU, the development of strategies at regional, national and European levels and finding the best alternatives to leverage CCU projects with industries, associations and governments.

The definition of a European and national strategies for CCU projects will be fundamental to leverage new projects and establish an enabling environment for CCU. In this way, we have joined the main associations and bodies that are engaged with CCU in order to support and developing new projects.

In the next chapter, we will present the working groups which we are working with.

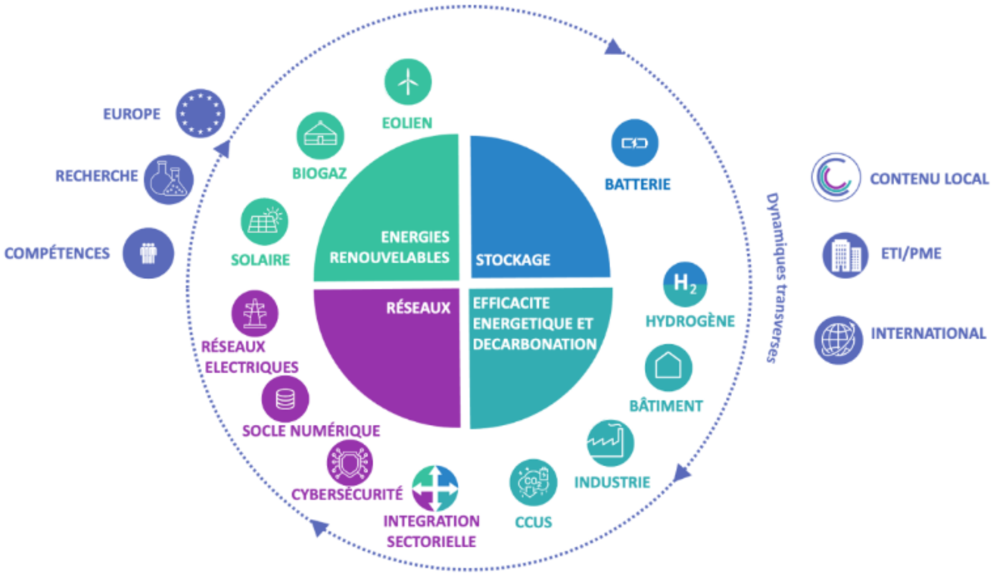
2.2.1 Examples of mains work group discussions in the region and in Europe

CO_2 Value Europe: CO_2 Value Europe is an association with a European scope founded in November 2017 and it has become the legitimate representative of the **Carbon Capture & Utilization** (CCU) community in Europe. They developed in 2022 together with several experts the CCU European roadmap which aims at developing a structured plan to guide stakeholders by laying down the actions that need to be undertaken to help CCU realise its potential. AXELERA and CO_2 value Europe are also both partners in the European project, CCUS ZEN. CO_2 Value has developed a worldwide CCU Projects database. AXELERA is member of CO_2 Value Europe. You will find below the database link.

https://database.co2value.eu/

Club CO2: This association is a place for exchanges, information and initiatives among industrial and research players interested in CO_2 capture, storage and use (CCUS) in the region. The CO_2 club currently brings together the largest CO_2 emitting companies in France as well as CCUS technology providers and other members interested in this topic. AXELERA is member of the club CO_2.

'Nouveaux système Energétique, Comité stratégique de Filière' – Working group CCUS: The purpose of the strategic sector committees (CSF) is to develop industries in France. The strategic sector committees bring together manufacturers, the state and trade unions within the national Industry council, chaired by the Prime Minister. The work of this working group covers the sectors of renewable energy, storage, energy efficiency and energy networks. The scaling up of decarbonation technologies is at the heart of the approach.



Source: Nouveaux Systèmes Energétiques website.

Figure 31 : Working axes of Strategic Committee dedicated to new energy systems (Nouveaux systèmé énergétique CSF-NSE)

Within the subjects treated 31within the scope of the 'comité strategique de la filiere', a new industry contract was signed in November 2021 related the work group CCUS. The Objective was: Develop in France, by 2030, at least two industrial-scale CO_2 capture, storage and utilization projects. In terms of CCU the project aims to define a CCU-oriented roadmap for France and define the constraints and needs for the successful implementation of the CCU. AXELERA is engaged in this working group on CCUS.

Working group CCU industry - Coordinated by Axelera, this working group aims to discuss CCU related issues with the main CO_2 emitting companies in the region in order to develop CCU projects. The meetings take place every three months and the main topics are : New call for proposals (Europe), new regulations , new CCU technologies, demand for products from industrial CO_2 (eg: SAF), CCU Hub in Europe etc..

2.3 Synergies among companies for CCU projects / CCU Hubs identification

The ninth and tenth steps are to find synergies among several companies for the consortium development. In order to consolidate this set of companies a call for proposals is needed that meets the needs of these companies. Several previous steps of the methodology will support us with this task:

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- **Interview the CO_2 emitters to know their needs**

The interviews as mentioned in the previous chapters will be crucial to identify the CO_2 emission needs of each company, the funding needs and the potential projects for a pooling of efforts for new CCU projects

- **Finding the most suitable calls for proposals to cofound projects**

Through the work carried out in the development of the Strategic Intelligence Bulletins all funding opportunities at local, reginal and European level is catalogued. This compilation will be important to have access to all the means of public funding needed. The diagnostic tool prepared by AXELERA is useful to ensure that a project is well-positioned to be competitive in a given call, for example Innovation Fund in the case of the diagnostic form .

2.4 CONTACT KEY COMPANIES TO FORM A CONSORTIUM / CONSORTIUM DEVELOPMENT

The last step in developing a CCU hub will be the development of the consortium.

After analyzing the best subsidy or call for proposals and having defined the main companies to participate in the consortium, the next step will be the direct contact with these companies. A pitch to the potential consortium members needs to be prepared. The next step will be to work on the documentation needed according to the call. The role of the facilitator in this case will be:

- ✓ Bring together the companies to be part of the consortium.
- ✓ Work closely with the project coordinator to drive the process forward and commit partners to an action plan and schedule
- ✓ Conduct regular meetings to prepare all required documents for timely submission
- ✓ Ensure correct application of NDA (Non-disclosure agreements) to ensure that confidentiality issues are taken into consideration for all involved
- ✓ Define objectives, KPIs, scope, methodology, action plan, risks, contingency plans, impacts, technico-economic analyses and budgets for the project

In some cases, companies will need to hire specialized companies to support the process of engineering and developing a strategy involving all partners.

It is important to take into consideration that the project coordinators are often industrial companies and do not have much experience in setting up projects. Thus the role of the cluster facilitator will be to support them to obtain proposal funding.

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3 CONCLUSION

Work is ongoing in the AURA to support the emergence of a CCU hub in the region. a. Replication of this approach is enabled by the strategy defined herein. Our next step will be deliver a toolbox (D6.14) that will help the clusters in facilitating systemic investment decisions, which will include the relevant objective criteria that are needed to derisk investments in the eyes of companies and regions. All the tools will be available via a specific link that will be available on the PYROCO2 website. We will deliver also an investment plan and roadmap for a CCU Hub in the AURA region. Therefore the replication Methodology, toolbox and the roadmap will be supporting materials that can be used by clusters and innovation support agencies across Europe for the development of other CCU hubs. AXELERA will work in close collaboration with 3 other clusters in Europe through mentoring and partnerships in order to support them in their CCU hub development. These three European regions are currently being defined.

4 APENDIX

Annex 01 - Strategic intelligence bulletin (January 2023)

Annex 02 - Diagnostic - projects evaluation and/or investments susceptible to be funded by an external grant

Annex 03 - Questionnaire for the industrial's interviews

Annex 04 - Seminar CCU (agenda)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

Annex 01 - Strategic intelligence bulletin (January 2023)

Demonstrating sustainable value creation from industrial CO2 by its thermophilic microbial conversion into acetone

Project type: IA – Innovation Action
Start date of the project: 01/10/2021
Duration: 60 months

STRATEGIC INTELLIGENCE BULLETIN 05

Due date		**Delivery date**	January 2023
Work package	WP 6 – Exploitation, Replication, Communication and Dissemination		
Responsible Author(s)	AXELERA		
Contributor(s)	AXELERA		
Dissemination level	Consortium and AXELERA Cluster		

Version and amendments history

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01	27/01/2023		

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TABLE OF CONTENTS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

FOREWORD

We are delight to release the fifth strategic intelligence bulletin.

The current scenario shows a change in the market with regard the electricity energy price, which is returning to more reasonable levels, although still higher than pre-war levels.

Another major change that took place in the last two months was the fact that EU policy makers have agreed on some points of the ‘Fit for 55’ document. Below, it is presented some points agreed in these discussions :

Emission trade systems revision (ETS) - The new revision sets new very ambitious goals for reducing ETS emissions by 62% by 2030 compared to 2005 by:

- Reducing progressively the number of free allowances as well as the total number of allowances available on the market.
- Including unprecedented incentives for CCU mineralisation, in which companies that are mineralising CO2 from industrial point sources will not need to surrender ETS allowances.
- Ending double-counting for CCU fuels and chemicals.
- Provide new funding support for defossilisation in particular via the Innovation Fund.

New rules for ETS in aviation:

- ETS-free allowances will be completely phased out for aviation: 25% in 2024, 50% in 2025 and 100% in 2026. In other words, as of 2027, airlines will need to pay their ETS fees in full.
- 5 million allowances from revenues collected will go to the Innovation Fund, which represents 450 million euros in today’s ETS prices.
- 20 million allowances (in today’s prices: about 1.8 billion euros) will be allocated to support the sector’s transition to sustainable aviation fuels between 2024 and 2030. It will in particular cover 95% of the price differential between RFNBOs (CCU fuels) and fossil equivalents.

The EU policy makers also agreed on a new carbon tax at the boarders of EU (CBAM). More detailed information can be found in this document. In the next months, new fit for 55 legislations should be adopted in order to complete the regulatory framework. Special attention should be done for the RED II delegated Acts (it will determine the conditions to account for the electricity used in the RFNBO as renewable) and RED III (new quotas and targets for the use of CCU fuels in transport and industry). Both of them will have a strong impact on new CCU projects.

Do not hesitate to send us any comments to improve this document by writing or sharing information that could be relevant for the next bulletin to marcos.versiani@axelera.org

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101037009.

MARKET INFORMATION

Project Air receives €97 million grant from EU Innovation Fund
World Ports Org, January 2023

Perstorp, a wholly-owned subsidiary of PETRONAS Chemicals Group Berhad (PCG), Uniper, a Germany-based energy company, and the European Climate, Infrastructure, and Environment Executive Agency (CINEA) have signed an agreement granting €97 million in funds to Project Air from the Innovation Fund. For more information

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ArcelorMittal inaugurates European steel industry's first CCU project at Belgium plant
HP Green steel world, December 2022

ArcelorMittal's €200 million 'Steelanol' project is a first of its kind for the European steel industry, utilising cutting-edge carbon recycling technology developed by project partner LanzaTech. At an event held at its steel plant in Ghent, Belgium, attended by the Prime Minister of Belgium, Alexander De Croo, Flemish Minister-President Jan Jambon, members of the Belgian and Flemish governments, European Investment Bank Vice-President Kris Peeters, ArcelorMittal Executive Chairman, Lakshmi Mittal, and ArcelorMittal Europe CEO, Geert Van Poelvoorde, ArcelorMittal ('the Company') successfully inaugurated its flagship carbon capture and utilisation ('CCU') project. For more information

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World's largest CO2-to-methanol plant starts production
HP Hydrocarbon processing, October 2022

The world's first commercial scale CO2-to-methanol plant has started production in Anyang, Henan Province, China. The cutting-edge facility is the first of its type in the world to produce methanol — a valuable fuel and chemical feedstock — at this scale from captured waste carbon dioxide and hydrogen gases. For more information

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Scaling the CCUS industry to achieve net-zero emissions
McKinsey & Company, October 2022

Carbon capture, utilization, and storage can help hard-to-abate industries achieve net-zero emissions. Scaling the industry will require action by governments, investors, and industrial players. For more information

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EU Commissioner For Energy Announces 'Strategic Vision' For Carbon Capture In 2023
Carbon Herald – October 2022

The European Commission will table a communication on a strategic vision for carbon capture, usage and storage (CCUS) in 2023, the EU Commissioner for Energy Kadri Simson said on Oct. 27. She spoke at the CCUS Forum in Oslo, Norway. According to European Commission modeling, the EU will have to capture and utilize or store 300 to 640 million metric tons of CO2 per year by 2050 to meet net zero goals.. For more information

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Germany and Norway will build a big hydrogen pipeline
CNN, January 2023

Germany just took a step closer to finding a long-term, greener replacement for Russian natural gas and coal. German power producer RWE (RWEOY) and Norwegian state-owned energy firm Equinor on Thursday announced plans to build hydrogen-fueled power plants in Germany over the next few years, as well as a major pipeline between the two countries to feed them. The agreement — which is not yet legally binding — is part of Germany's efforts to phase out all coal-fired power stations by 2030 and decarbonize its energy sector. Berlin has pivoted dramatically away from Russia as a source of energy since its invasion of Ukraine, and needs to find secure alternative suppliers. "Through this collaboration we will strengthen the long-term energy security for Europe's leading industrial country," Anders Opedal, Equinor's CEO and president, said in a joint statement. For more information

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Global Status of CCS
Global CCS institute , January 2023

New CCS projects have been announced each month in 2022. As of September 2022, there are 196 (including two suspended) projects in the CCS facilities pipeline. This is an impressive growth of 44 per cent in the number of CCS facilities since the Global Status of CCS 2021 report and continues the upward momentum in CCS projects in development since 2017. For more information

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Porsche begins production of 'e-fuel' that could provide gas alternative amid EV push
CNBC, December 2022

Porsche and several partners have started production of a climate neutral "e-fuel" aimed at replacing gasoline in vehicles with traditional internal combustion engines. The German automaker, owned by Volkswagen, said Tuesday that a pilot plant in Chile started commercial production of the alternative fuel. By mid-decade, Porsche is planning to produce millions of gallons of the e-fuel. Porsche expects to initially use the fuel in motor sports and at its

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

performance experience centers, followed by other uses in the years to come. Ultimately, the plan is for the fuel to be sold to oil companies and others for distribution to consumers. For more information

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EU to fund Holcim Decarbonization projects
Press release Holcim website , January 2023

The European Union (EU) Innovation Fund announces funding of EUR 328 million in two Holcim decarbonization projects at the Financing Innovative Clean Tech Conference in Brussels. The grants will accelerate the development of Holcim's breakthrough carbon capture utilization and storage (CCUS) projects in Germany and Poland. These projects are part of Holcim's net-zero roadmap, including over 50 CCUS projects worldwide, to decarbonize its business. They contribute to the EU's Green Deal, putting clean technologies to work for a climate-neutral economy by 2050.For more information

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This company wants to make air travel sustainable
CNN Business, October 2022

In 2019, Air Company made a splash when it launched vodka derived from recaptured carbon, in an effort to reduce the amount of the harmful greenhouse gas in the atmosphere. Today, the Brooklyn-based startup has begun using the same process to make fuel for airplanes. Air Company's sustainable aviation fuel, which was recently tested by the US Air Force, could ultimately help the airline industry hit its goal of net zero carbon emissions by 2050. Currently, the airline industry accounts for about 3% of total global carbon emissions each year, and mostly relies on traditional, fossil-based fuels that require various forms of environmental disruption to produce. For more information

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Rewriting the Story of CO_2 – Call for Innovations "Best CO_2 Utilisation 2023"
Renewable carbon news, January 2023

Innovators in the field of carbon capture and utilisation are invited to present their breakthrough technology or product at the Conference on CO2-based Fuels and Chemicals 2023. Applications for the CO2 Innovation Award "Best CO2 Utilisation 2023" are open until 13 February 2023. Access here

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

TECHNOLOGY WATCH

Proposing a new process for methanol production based on renewable hydrogen

Haoran Wei, Chenqing Su, Jie Dai, Mahmood Shaker Albdeiri, Theyab R. Alsenani, Samia Elattar, Ahmed M. Abed, Yinhai Hua, January2023.

Abstract: Moving towards a sustainable future requires modernized and economic energy production, especially in the context of current policy incentives. In the present paper, a new integrated process using flue gas leaving a power plant is projected and studied. The proposed process consists of a carbon dioxide (CO2) capture unit (CCU), a water electrolyzer unit (WEU) for renewable hydrogen production, a power generation unit (PGU), a heat generation unit (HGU), and a methanol production unit (MPU). The designed structure has low CO2 emission, low production cost, and high thermodynamic efficiency. This process is simulated using Aspen HYSYS. The simulation results show that the methanol production in this process is equal to 606,228 ton/year (methanol with a purity above 99% mole), and according to the environmental analysis, the intensity of CO2 emission is 0.61, which is lower compared to that of bi- and tr-reforming processes. The results indicate that the overall exergy and energy efficiencies of the proposed process are 71.97% and 56.74%, respectively.
For more information

Surface charge as activity descriptors for electrochemical CO2 reduction to multi-carbon products on organic-functionalised Cu

Carina Yi Jing Lim, Meltem Yilmaz, Juan Manuel Arce-Ramos, Albertus D. Handoko, Wei Jie Teh, Yuangang Zheng, Zi Hui Jonathan Khoo, Ming Lin, Mark Isaacs, Teck Lip Dexter Tam, Yang Bai, Chee Koon Ng, Boon Siang Yeo, Gopinathan Sankar, Ivan P. Parkin, Kedar Hippalgaonkar, Michael B. Sullivan, Jia Zhang & Yee-Fun Lim, January 2023.

Abstract: Intensive research in electrochemical CO2 reduction reaction has resulted in the discovery of numerous high-performance catalysts selective to multi-carbon products, with most of these catalysts still being purely transition metal based. Herein, we present high and stable multi-carbon products selectivity of up to 76.6% across a wide potential range of 1 V on histidine-functionalised Cu. In-situ Raman and density functional theory calculations revealed alternative reaction pathways that involve direct interactions between adsorbed histidine and CO2 reduction intermediates at more cathodic potentials. Strikingly, we found that the yield of multi-carbon products is closely correlated to the surface charge on the catalyst surface, quantified by a pulsed voltammetry-based technique which proved reliable even at very cathodic potentials. We ascribe the surface charge to the population density of adsorbed species on the catalyst surface, which may be exploited as a powerful tool to explain CO2 reduction activity and as a proxy for future catalyst discovery, including organic-inorganic hybrids. For more information

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

A Brief Review of Hydrogen Production Methods and Their Challenges

MDPI Open access Journals , January 2023

Abstract: Hydrogen is emerging as a new energy vector outside of its traditional role and gaining more recognition internationally as a viable fuel route. This review paper offers a crisp analysis of the most recent developments in hydrogen production techniques using conventional and renewable energy sources, in addition to key challenges in the production of Hydrogen. Among the most potential renewable energy sources for hydrogen production are solar and wind. The production of H2 from renewable sources derived from agricultural or other waste streams increases the flexibility and improves the economics of distributed and semi-centralized reforming with little or no net greenhouse gas emissions. Water electrolysis equipment driven by off-grid solar or wind energy can also be employed in remote areas that are away from the grid. Each H2 manufacturing technique has technological challenges. These challenges include feedstock type, conversion efficiency, and the need for the safe integration of H2 production systems with H2 purification and storage technologies. For more information

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Decarbonization of Mining and Metals Industry. A Critical Overview

Ashok D. Dalvi, January 2023

This is a follow-up to the discussion on sustainability challenges presented during COM2020. Decarbonization of mining and metals industry is a major challenge of the twenty-first century. In this paper, the targets related to the decarbonization of mining and metals industry are quantified – specifically for steel, aluminium, copper and nickel. Corresponding technologies are identified based on a literature review and the author's experience. Implementation of these technologies is discussed based on the author's 40+ years of hands-on experience in the industry involving all stages of projects from conceptual design to commercial-scale implementation. Potential timelines for implementation as well as technological, regulatory and other constraints are discussed. Metals have been an important part of the circular economy; the end-of-life recycling rates for most common metals are greater than 50%. Recycling is an important part of decarbonization and there is scope for increasing it. For more information

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Advances in Carbon Capture and Use (CCU) Technologies: A Comprehensive Review and CO2 Mitigation Potential Analysis

Christiano B. Peres ,Pedro M. R. Resende ,Leonel J. R. Nunes and Leandro C. de Morais , October 2022

One of society's major current challenges is carbon dioxide emissions and their consequences. In this context, new technologies for carbon dioxide (CO2) capture have attracted much attention. One of these is carbon capture and utilization (CCU). This work focuses on the latest trends in a holistic approach to carbon dioxide capture and utilization. Absorption, adsorption,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

membranes, and chemical looping are considered for CO2 capture. Each CO2 capture technology is described, and its benefits and drawbacks are discussed. For more information

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IPCC Report: The Role of Carbon Capture and Utilisation (CCU) to Mitigate Climate Change
CO2 value Europe , November 2022 (Videos)
On the occasion of the Sharm el-Sheikh Climate Change Conference (COP27), It WAS highlighted once again the role of Carbon Capture and Utilisation (CCU) as a solution to mitigating climate change as assessed in the last IPCC report. For the first time in 30 years, CCU is discussed in the IPCC report as a solution to decrease net CO2 emissions, as well as a potential technology to move away from fossil carbon by using CO2 as an alternative feedstock for the production of renewable chemicals and fuels.. For more information
For more information

Sustainability analyses of CO2 sequestration and CO2 utilization as competing options for mitigating CO2 emissions
Anirudh Parekh, Gauri Chaturvedi, Arnab Dutta, January 2023

Abstract: CO2 capture and sequestration (CCS) and CO2 capture and utilization (CCU) are potential alternatives to mitigate CO2 emissions. There have been concerns regarding long-term geological impact of CCS and CCU requires co-reactant(s) for converting CO2 into value-added products. In this work, sustainability of CCS and CCU are assessed by simulating three processes. Each of these processes used post-combustion amine technique to capture CO2 from flue gas stream coming out of natural gas-based power plant. In the first process (CCS), captured CO2 undergoes sequestration whereas in the other two processes (CCU) CO2 reacts with hydrogen to produce methanol and dimethyl ether. For more information

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Carbon capture and utilization for industrial applications
Science Direct, January 2023

Abstract: Heavy industries such as cement, iron and steel, oil refining, and petrochemicals are responsible for about 22% of global carbon dioxide (CO2) emissions. There are several pathways for global CO2 mitigation. Capturing, storage, and utilization of CO2 (CCS and CCU) provide an operational solution for significant emission mitigation. High purity CO2 streams are the most interesting points for CCS and CCU. Pure CO2 streams are suitable for compression, transport, and storage. Capture technology categories are typically pre-combustion, oxy-fuel combustion, and post-combustion processes. Moreover, the main challenges of the robust industrial CCS/U development are the high costs of CO2 separation from flue gas or ambient air and the conversion of CO2 in various utilization pathways. This research study includes a summary of several CCS technologies and CCU pathways, their current status, cost, and industrial deployment. For more information

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

Climate change impacts of e-fuels for aviation in Europe under present-day conditions and future policy scenarios

Department of Energy and Process Engineering, Norwegian University of Science and Technology, January 2023

Abstract: 'E-fuels' or 'synthetic fuels' are hydrocarbon fuels synthesized from hydrogen (H2) and carbon dioxide (CO2), where H2 can be produced via electrolysis of water or steam reforming of natural gas, and CO2 is captured from the combustion of a fossil or biogenic source or directly from the atmosphere. E-fuels are drop-in substitutes for fossil fuels, but their climate change mitigation benefits are largely unclear. This study evaluates the climate change impacts of e-fuels for aviation by combining different sources of CO2 and H2 up to 2050 under two contrasting policy scenarios. The analysis includes different climate metrics and the effects of near-term climate forcers, which are particularly relevant for the aviation sector. Results are produced for European average conditions and for Poland and Norway, two countries with high and low emission intensity from their electricity production mix. E-fuels can either have higher or lower climate change impacts than fossil fuels, depending on multiple factors such as, in order of importance, the electricity mix, the origin of CO2, the technology for H2 production, and the electrolyzer efficiency. For more information

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IEA - CO2 Capture and Utilisation - an overview

IEA (2022), CO2 Capture and Utilisation, IEA, Paris, October 2022

Carbon capture and utilisation refers to a range of applications through which CO2 is captured and used either directly (i.e. not chemically altered) or indirectly (i.e. transformed) into various products. Around 230 Mt of CO2 are currently used each year, mainly in direct use pathways in the fertiliser industry for urea manufacturing (~130 Mt) and for enhanced oil recovery (~80 Mt). New utilisation pathways in the production of CO2-based synthetic fuels, chemicals and building aggregates are gaining momentum. By 2030 the current project pipeline shows that around 5 Mt of CO2 could be captured for synthetic fuel production. While this level of deployment is not far from the 7.5 Mt of CO2 used in synthetic fuels production in 2030 in the Net Zero Scenario, half of announced projects are at early stage of development and will likely require further support to proceed towards operation.. For more information

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The chemical engineering aspects of CO2 capture, combined with its utilization

Abriele Centi, Siglinda Perathoner, January 2023

CO2 carbon capture and utilisation (CCU) technologies are discussed from the chemical engineering perspective of their role in a future low-carbon scenario. We highlighted that current techno-economic assessment procedures have limits in predicting the role of CCU technologies. There is a need to pass from current 1st-generation power-to-X technologies to synthesise e-fuels to the 2nd-generation solar fuel technologies. The hard-to-abate sector,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

particularly steel and cement production, is also shortly analysed, remarking on the necessity to overcome current approaches starting from analysing the critical aspects limiting feasibility and economics.
. For more information

PlasCO2 project: Greenhouse gas transformed into a raw material
Press release Evonik website, January 2023

Evonik has launched the PlasCO2 project together with three partners. The aim is to use carbon dioxide (CO2) as a raw material in the production of C4 chemicals. Evonik is working with three partners on processes for using CO2 by means of plasma reactors. Innovative process could significantly reduce energy requirements for the production important chemical products
German Federal Ministry of Education and Research funds project with more than 1.8 million euros. For more information

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Energy Sector Derived Combustion Products Utilization—Current Advances in Carbon Dioxide Mineralization
MDPI open access journals, October 2022

Carbon dioxide and combustion products are among the main waste streams deriving from the energy sector. Efficient and cost-effective methods of solid waste valorization and carbon capture, storage and utilization are needed in the transition period towards carbon neutrality in light of the recent scenarios forecasting energy demand and energy supply mix under dynamic social, economic and political circumstances. Within this paper, the current advances in carbon dioxide mineralization, combining carbon dioxide utilization and combustion products valorization, are presented in terms of the recognized methodological options of carbonation methods, process efficiency and effects on the process product properties. Special attention is given to the studies on the valorization of fluidized bed boilers fly ash, differing in a range of parameters from the conventional boilers fly ash, as well as the effects of the carbonation process on the stabilization and improvement of its properties and the resulting extended range of applicability. The relevant research fields needing further investigations, as well as the desired decision makers' supporting actions, are also specified. For more information

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Toward economical application of carbon capture and utilization technology with near-zero carbon emission
Nature, December 2022

Abstract: Carbon capture and utilization technology has been studied for its practical ability to reduce CO2 emissions and enable economical chemical production. The main challenge of this technology is that a large amount of thermal energy must be provided to supply high-purity CO2 and purify the product. Herein, It is proposed a new concept called reaction swing absorption, which produces synthesis gas (syngas) with net-zero CO2 emission through direct electrochemical CO2 reduction in a newly proposed amine solution, triethylamine. Experimental investigations show high CO2 absorption rates (>84%) of triethylamine from low CO2 concentrated flue gas. In addition, the CO Faradaic efficiency in a triethylamine supplied membrane electrode assembly electrolyzer is approximately 30% (@−200 mA cm−2), twice higher than those in conventional alkanolamine solvents. Based on the experimental results and rigorous process modeling, we reveal that reaction swing absorption produces high pressure syngas at a reasonable cost with negligible CO2 emissions. This system provides a fundamental solution for the CO2 crossover and low system stability of electrochemical CO2 reduction. For more information

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Techno-economic and environmental assessment of CCU options

Adelung, Sandra and Dietrich, Ralph-Uwe and Habermeyer, Felix and Heimann, Nathanael and Maier, Simon and Moser Rossel, Francisco Tomas and Raab, Moritz and Rahmat, Yoga Pranata and Weyand, Julia, October 2022

Abstract: If the transport sector, especially aviation, shipping and heavy load, will continue to rely on liquid fuels, carbon-based fuels might be unavoidable for the foreseeable time. With countless options of sustainable fuels, feedstocks and production routes, its difficult to determine preferences of one over the others. This paper presents a methodology to assess these options fair and transparent simultaneously technically, economically as well as environmentally for comparison and selection. Because aviation is one of the fastest growing sectors in terms of CO2 emissions, the regulatory initiative ReFuelEU Aviation was introduced to mitigate the impact of aviation on the environment. Significantly reduced GHG emissions and lower abatement costs require technological innovations of Power-to-liquids, Biomass-to-liquids and Power enhanced Biomass-to-liquids processes. A detailed discussion of sustainable aviation fuels prospects will be presented. For more information

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Climate Change Mitigation: The contribution of Carbon Capture and Utilisation (CCU)

Célia J. Sapart Katrin Arning, André Bardow, Christian Breyer, Angela Dibenedetto, Colin D. Hills, Suren Erkman, October 2022

Carbon Capture and Utilisation (CCU) is a broad term that covers processes that capture CO2 from flue and process gases or directly from the air and convert it into a variety of products such as renewable electricity-based fuels, chemicals, and materials. No precise estimate of the potential mitigation role of CCU technologies exists to date, because of uncertainties in renewable electricity cost scenarios and the low granularity of models that simulate different CCU options. For more information

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101037009.

EU POLICIES & LEGISLATION

Regulatory limbo leaves EU heavy emitters in the dark on net zero

Politico working group , January 2023

The climate clock is ticking — and industry is begging for clarity before making massive investments.
"We are less than 30 years away from that objective and as an industrial sector we don't even know when our sector needs to be climate neutral in order to do our share," said Florie Gonsolin, climate change transformation director at Cefic, the chemicals industry group. "Given the long investment cycles in this industry ... if we don't have regulatory clarity about eligible solutions, we are going to be left wondering, 'What are the tools we are allowed to use?'" Gonsolin added. "This is why we have been asking desperately for a roadmap" from the Commission. For more information

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A final sprint to make the EU Fit for 55

Euractiv, January 2023

As 2022 recedes into the history books, a new dawn – albeit one with ubiquitous grey cloud cover – is breaking over Brussels. Welcome to 2023, the year in which the contours of the EU's flagship climate laws package (which still sports the questionable moniker 'Fit for 55') will be finalized. For more information

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Committed to implementing CCU? A comparison of the policy mix in the US and the EU

Sonja Thielges, Barbara Olfe-Kräutlein, Alexander Rees, Joschka Jahn, Volker Sick and Rainer Quitzow, October 2022

Carbon capture and utilization (CCU) technologies aim to use carbon dioxide (CO2), either captured from industrial point sources or from the atmosphere, instead of fossil carbon in the production of a variety of valuable goods. CCU has the potential to contribute to emission reductions and to lower raw material consumption as well to foster transitional processes toward a circular economy. To enable societies to take full advantage of this potential, policy support is needed in overcoming current barriers and fostering CCU implementation as a feasible option for the industry. Based on a literature and online investigation, this paper identifies and compares the current policy mixes for CCU in the US and the EU, focusing on policy strategies and existing and proposed policy instruments. The analysis shows that US strategy documents, with very few exceptions, do not mention CCU specifically in the context of the country's 2030 or 2050 climate targets. In the EU, in contrast, the future role of CCU is clearly linked to achieving climate-neutrality by 2050. For more information

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

EU Reaches First Milestone Agreements on Fit-for-55, with Key Provisions for CCU

CO2 Value Europe, December 2022

Over the last weeks, EU policymakers have struck several major deals in interinstitutional negotiations (known as "trilogues"), with immediate and unprecedented implications for Carbon Capture and Utilisation (CCU) projects. The EU institutions agreed on a new emission trading system (ETS) revision. The new revision sets new very ambitious goals for reducing ETS emissions by 62% by 2030 compared to 2005 .For more information

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Federal cabinet adopts evaluation report on the Carbon Dioxide Storage Act

Federal ministry for economic affairs and climate action, December 2022

The Federal Government adopted the evaluation report on the Carbon Dioxide Storage Act in December 2022. The report describes the advances in technology, the latest scientific findings and the potential contribution from carbon capture and storage (CCS) to climate change mitigation. The Act requires the Federal Government to present the evaluation report every four years. The new report covers both CCS and carbon capture and utilisation (CCU). In contrast to CCS, in the case of CCU the CO2 is not stored, but used – e.g. in the chemical industry. Further to this, the report looks ahead to the carbon management strategy which the Federal Government intends to draw up in 2023.For more information

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Reducing Emissions from Aviation in the EU

The New Federalist, October 2022

The aviation sector contributes 4.6% to global warming. In 2015, aviation accounted for 2.1% of global CO2 emissions. Aviation does not only emit CO2 emissions but also other potent GHG emissions, including nitrogen oxides, water vapour and soot. To recap, the European Commission proposed the 'Fit for 55 package' on the 14th of July 2021, which includes policies to achieve the ambitious goal of carbon neutrality in Europe by 2050. It also involves concrete measures to reduce the emissions of the aviation sector. The three particularly noteworthy measures are ReFuelEU, a revision in the European Emissions Trading System, and the Energy Taxation Directive. For more information

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

FUNDING & TENDER OPPORTUNITIES

FRANCE

Appel à projets (IBAC) Stratégie d'accélération décarbonation
ADEME

Deadline date: 17/04/2023, 16/10/2023 (The dates have changed by ADEME)

This call for proposals aims to support projects led by SMEs developing innovative, competitive and sustainable methodologies, technologies, industrial solutions and services in the field of industrial decarbonization. For more information

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Appel à projets (DEMIBAC) Stratégie d'accélération décarbonation
ADEME

Deadline date: 17/04/2023, 16/10/2023 (The dates have changed by ADEME)

This call aims to support innovation projects led by companies which accelerate in the market the implementation of sustainable technologies and/or solutions to decarbonize industry, from the industrial research phase to the demonstration phase. For more information

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Favoriser le développement de Zones Industrielles Bas Carbone (ZIBAC)
ADEME

Deadline date: 15/05/2023 (The dates have changed by ADEME)

This call aims to support industrial territories in their ecological and energy transformation in order to gain in competitiveness and attractiveness. For more information

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

FUNDING & TENDER OPPORTUNITIES

EUROPE

Breakthrough Energy Catalyst

Deadline date :13/05/2022 - Submissions received after 15 June 2022 will be evaluated on a rolling basis, but no less frequently than semi-annually

Commission President Ursula von der Leyen and Bill Gates have announced a pioneering partnership between the European Commission and Breakthrough Energy Catalyst to boost investments in the critical climate technologies that will enable the net-zero economy. Presented on the occasion of the sixth Mission Innovation Ministerial meeting, the new partnership aims to mobilize new investments of up to €820 million/$1 billion between 2022-26 to build large-scale, commercial demonstration projects for clean technologies – lowering their costs, accelerating their deployment, and delivering significant reductions in CO2 emissions in line with the Paris Agreement. For more information

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Innovation fund - Small-Scale Projects

Deadline date: March 2023 (forecast)

The second call for small-scale projects was launched on 31 March 2022 with a budget of EUR 100 million. The call text and application process remained largely similar to those of the first call and applicants have five months to prepare their application (until 31 August 2022). For more information

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Innovation fund - large-Scale Projects

Deadline date: March 2023 (forecast)

With a budget of EUR 1.5 billion, which is increased by 50% compared to the previous call, it will finance breakthrough technologies for renewable energy, energy-intensive industries, energy storage, and carbon capture, use and storage. For more information

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

HORIZON EUROPE – WORK PROGRAM 2023-2024

Turning CO2 emissions from the process industry to feedstock

Projects outcomes will enable achievement of the objectives of Processes4Planet partnership by developing efficient CO/CO2 capture and purification technologies, in combination with valorisation routes; that will drive the partnership's innovation portfolio towards first of a kind demonstrator and de-risk investment (related P4Planet operational objectives 3, 4 and 9). For more information

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CCU for the production of fuels

Conversion of captured CO2 is not only a means to replace fossil fuels, but also a promising solution for seasonal energy storage. There are still some scientific and technological challenges to overcome to be able to exploit CO2 as a fuel feedstock, the main challenge being that the utilisation of CO2 is limited by the highly energy intensive conversion process. New solutions for the conversion of captured CO2 from different sources to fuels will create new markets for innovative industrial sectors and diversify the economic base in carbon intensive regions, as well as contribute to achieving a Circular Economy. The project should evaluate the possibility for industrial CO2 use/reuse through the combination of processes (industrial symbiosis) and the efficient integration of CO2 capture and conversion to combine and/or reduce stages. For more information

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DACCS and BECCS for CO2 removal/negative emissions

The project is expected to develop highly innovative CCUS /carbon negative technologies leading to CO2 removal. It should enable the cost-effective deployment of technologies such as (DACCS), (BECCS) ideally linking them to industrial clusters with special emphasis of these technologies to safe CO2 underground storage and CO2 utilization. For more information

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

CCU ONGOING PROJECTS - *HORIZON 2020*

Providing access to cost-efficient, replicable, safe and flexible CCUS

Project Information

ACCSESS

Grant agreement ID: 101022487

Start date 1 May 2021

End date 30 April 2025

Funded under
H2020-EU.3.3.
H2020-EU.3.3.2.

Overall budget
€ 18 427 186,75

EU contribution
€ 14 983 874

Coordinated by
SINTEF ENERGI AS
Norway

The ACCSESS concept is centered around the project vision to Develop replicable CCUS pathways towards a Climate Neutral Europe in 2050. ACCSESS will improve CO2 capture integration in industrial installations (20-30% cost cuts) as a key element to accelerate CCUS implementation, address the full CCUS chain and the societal integration of CCUS. ACCSESS has the ambition unleash the ability of CCUS to contribute to the ambitious EU Green Deal transformation strategy. The project is dedicated to developing viable industrial CCUS business models. ACCSESS will engage with citizens and citizens, explaining how CCUS can contribute to the production of climate neutral or climate positive end-products in a sustainable cities' context. For more information

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Demonstrating a refinery-adapted cluster-integrated strategy to enable full-chain CCUS

Project Information

REALISE

Grant agreement ID: 884266

Start date 1 May 2020

End date 30 April 2023

Funded under
H2020-EU.3.3.2.

Overall budget
€ 7 131 752,50

EU contribution
€ 6 444 163,75

Coordinated by
SINTEF AS
Norway

Almost everyone now agrees that we should decrease the amount of atmospheric carbon dioxide (CO2) to mitigate climate change. Reducing CO2 production is not the only way to reduce emissions. Carbon capture, use and storage (CCUS) refers to an integrated set of technologies to prevent the CO2 produced during the combustion of fossil fuels from entering the atmosphere. Currently, these technologies focus on the greatest sources of CO2 in a process, ignoring smaller ones. The EU-funded REALISE project is developing a way to capture up to 90 % of CO2 from multiple sources in operating refineries at a cost that is 30 % lower than existing capture methods. The project will include the evaluation of the entire CCUS chain from emitter to storage as well as socio-political aspects and social readiness assessments based on three business cases in the EU and China. For more information

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

Advanced carbon capture for steel industries integrated in CCUS Clusters

The Paris Agreement sets out a global framework to avoid dangerous climate change by limiting global warming to well below 2 °C and pursuing efforts to limit it to 1.5 °C. Without carbon capture, utilisation and storage (CCUS), it is difficult to realise the temperature levels indicated in the Paris Agreement. In the context of the European Energy Union, CCUS is a vital research and development priority to achieve 2050 climate objectives in a cost-effective way. With the focus on the iron and steel industry as part of the CCUS chain, the EU-funded C4U project will work with eight European countries and Mission Innovation countries (Canada, China and the United States) to address all the essential elements required for optimal integration of CO2 capture into the North Sea Port CCUS cluster. For more information

Project Information

C4U
Grant agreement ID: 884418

Start date
1 April 2020

End date
31 March 2024

Funded under
H2020-EU.3.3.
H2020-EU.3.3.2.

Overall budget
€ 13 845 496,89

EU contribution
€ 12 499 083,27

Coordinated by
UNIVERSITY COLLEGE LONDON
United Kingdom

Creating added-value chemicals from bio-industrial CO2 emissions using integrated catalytic technologies

The European Green Deal sets the blueprint for making Europe the first climate neutral continent in the world. The goal is to reduce greenhouse gas emissions (GHGs) to at least 55 % below 1990 levels by 2030. The EU-funded CATCO2NVERS project will develop and optimize technologies that convert waste CO2 into useful bio-origin chemicals to produce plastics, methanol, cosmetics, and renewable feedstocks for industrial processes. The project's overall vision will be to use waste CO2 energy- and resource-efficiently in bio-based industries to produce zero GHGs and reduce the quantity of CO2 released into the atmosphere. For more information

Project Information

CATCO2NVERS
Grant agreement ID: 101000580

Start date
1 May 2021

End date
30 April 2025

Funded under
H2020-EU.3.2.4.2.
H2020-EU.3.2.

Overall budget
€ 6 641 111,25

EU contribution
€ 6 641 110,75

Coordinated by
FUNDACION PARA EL DESARROLLO Y LA INNOVACION TECNOLOGICA
Spain

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

Production of synthetic renewable aviation fuel from CO2 and H2

Aviation fuels derived from non-fossil resources are the only way to diminish the hefty carbon footprint of air transport. The EU-funded TAKE-OFF project will bring together leading industrial players and prominent research institutes to develop an innovative process for producing sustainable aviation fuels with higher efficiency and lower costs compared to other power-to-liquid alternatives. State-of-the-art successful attempts to turn carbon dioxide into jet fuel involve complex processes such as the Fischer-Tropsch process. The unique TAKE-OFF technology will be based on converting carbon dioxide and green hydrogen into fuel via ethylene as an intermediate. In this process, carbon dioxide is captured from industrial flue gases and reacts with hydrogen produced by renewable electricity to create light olefins. For more information

Project Information

TAKE-OFF
Grant agreement ID: 101006799

Start date 1 January 2021
End date 31 December 2024

Funded under
H2020-EU.3.3.3.

Overall budget
€ 5 340 538,75

EU contribution
€ 4 998 788,25

Coordinated by
NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO
Netherlands

Creating value from industrial CO2 sources

Twenty leading industrial and research partners from 11 countries have teamed up to prove that large-scale conversion of industrial carbon emissions into value-added chemicals and materials is possible. As a game changer for European carbon-intensive industries, the EU-funded PYROCO2 project will pave the way for the sustainability of Europe's chemical industry. It will demonstrate the scalability and economic viability of carbon capture and utilisation to generate climate-positive acetone from industrial CO2 and renewable electricity-derived hydrogen. The project will demonstrate that the acetone produced is an ideal platform for the catalytic synthesis of a range of chemicals, synthetic fuels and recyclable polymer materials from CO2 for viable business cases and pre-developed processes for replication and commercialization. For more information

Project Information

PYROCO2
Grant agreement ID: 101037009

Start date 1 October 2021
End date 30 September 2026

Funded under
INDUSTRIAL LEADERSHIP - Leadership in enabling and industrial technologies

Total cost
€ 43 887 817,75

EU contribution
€ 39 999 561,18

Coordinated by
SINTEF AS
Norway

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

CO2 capture, utilisation and storage for a net-zero carbon future

With climate change putting people worldwide in danger and nations taking steps to decrease its effects, new innovations regarding green solutions are more welcome than ever. The EU-funded ConsenCUS project aims to assist in this goal by providing an industrial plan for a net-zero carbon reality. To this aim it will utilise 3 electricity-based innovations: carbon capture based on alkali absorption, methods for conversion of CO2 to formate and formic acids for market uses and finally a safe cyclic loading system of CO2 into salt formations and aquifers for storage purposes. These innovations should greatly benefit the EU in reaching its net-zero carbon goal. [For additional information]

Project Information

ConsenCUS
Grant agreement ID: 101022484

Start date 1 May 2021
End date 30 April 2025

Funded under
SOCIETAL CHALLENGES - Secure, clean and efficient energy

Total cost
€ 13 905 272,50

EU contribution
€ 12 862 331,88

Coordinated by
RIJKSUNIVERSITEIT GRONINGEN
Netherlands

CCU ONGOING PROJECTS - *INOVATION FUND*

K6 Program

The project will deploy a first-of-its-kind industrial-scale combination of an oxy-fuel kiln and carbon capture technology. The captured CO2, otherwise emitted to the atmosphere, will be finally stored in a permanent storage site in the North Sea (although this part of the technology chain falls outside the Innovation Fund project boundary, the storage location will most probably be located in Western Norway). The project will result in the avoidance of 8.1 Mt CO2e emissions over its first ten years of operation. The integration of the K6 Program project with the nearby Port of Dunkirk will foster the development of the port as a future European CO2 hub. [For more information]

Project information

Acronym
K6

Project ID
101051358

Start date
01 April 2022

End date
31 December 2037

Coordinated by
EQIOM

Funded under
Innovation Fund (InnovFund)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

AGGREGACO2

AGGREGACO2 project targets the aggregates industry for a revolution through the successful commercial deployment of a sustainable aggregate as a solid alternative of conventional aggregates not fully environment-friendly. The AGGREGACO2 proposes a FOAK innovation through the introduction of CO2 captured of refinery processes in an Accelerated Carbonation Technology (ACT), that revalorise Air Pollution Control residues (APCr), which are hazardous residue nowadays stored after treatment, for the fabrication of carbon negative aggregates. For more information

Project information

Acronym	Project ID
AGGREGACO2	**101038931**
Start date	End date
01 April 2021	**31 December 2027**

Coordinated by
PETROLEOS DEL NORTE SA

Funded under
Innovation Fund (InnovFund)

Kairos-at-C

The main objective of the Kairos@C project is to create the first and largest cross-border carbon capture and storage (CCS) value chain to capture, liquefy, ship and permanently store CO2. Located in the Port of Antwerp, Kairos@C will establish a regional hub for innovative energy and carbon value chains. Kairos@C will develop a full industrial-scale CCS project that will encompass the CO2 capture from various industrial sources on the Zandvliet industrial platform, the CO2 transport by pipeline to the liquefaction and export terminal located in the same port, the shipping towards CO2 subsea storages in the North Sea and the permanent sequestration of the CO2 in these storages. For more information

Project information

Acronym	Project ID
Kairos-at-C	**101051344**
Start date	End date
01 November 2020	**31 July 2035**

Coordinated by
AIR LIQUIDE LARGE INDUSTRY

Funded under
Innovation Fund (InnovFund)

Beccs Stockholm

The Beccs Stockholm project will create a world-class, full-scale Bio-Energy Carbon Capture and Storage (BECCS) facility at its existing heat and power biomass plant in Stockholm. The project will combine CO2 capture with heat recovery, making the process much more energy-efficient than the process in a usual CCS plant. It will capture and permanently store large quantities of CO2 from biological sources, leading to carbon removals from the atmosphere, also called negative emissions. For more information

Project information

Acronym	Project ID
Beccs Stockholm	**101051202**
Start date	End date
01 July 2021	**31 August 2036**

Coordinated by
STOCKHOLM EXERGI AB

Funded under
Innovation Fund (InnovFund)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

Project Syverstone

Project Silverstone offers permanent CO2 capture and mineral storage (CCMS) through a safer and more economical technology than provided by alternative Carbon Capture and Storage (CCS) solutions. The Carbfix technology imitates and accelerates geological processes that nature has applied for millions of years to regulate long-term CO2 levels in the atmosphere, turning CO2 into solid carbonate minerals underground. The project will deploy full-scale CCMS at one of the largest geothermal power plants in the world, reaching a near-zero carbon footprint. The technology is proven at the project site to be safe, efficient, and environmentally friendly For more information

Project information

Acronym	Project ID
Silverstone	**101038888**
Start date	End date
01 December 2021	**31 December 2030**

Coordinated by
CARBFIX OHF

Funded under
Innovation Fund (InnovFund)

CCGeo (Closed Carbon Geothermal Energy)

Continental Croatia has vast geothermal potential; however, only a negligible share of it is exploited for energy generation. The proposed Project, located in north-west Croatia, aims to make a difference in the geothermal sector and support Croatia on an energy transition pathway. The objective of the Project is to implement one line for the production of power and heat from the gas dissolved in the geothermal water using the internalization of carbon compounds. The proposed Action is a part of a fully planned advanced geothermal power plant using the internalization of carbon compounds (ICC), which would result in nearly zero GHG emissions throughout the Project lifetime and add to the net-carbon removal efforts.

For more information

Project information

Acronym	Project ID
CCGeo	**101038843**
Start date	End date
01 January 2022	**31 March 2026**

Coordinated by
AAT GEOTHERMAE DOO

Funded under
Innovation Fund (InnovFund)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

SHARC

The SHARC (Sustainable Hydrogen and Recovery of Carbon) project will reduce emissions at the Porvoo oil refinery in Finland, by moving away from the production of grey (fossil-fuel based) hydrogen towards both green hydrogen production (through the introduction of electrolysis facilities) and blue hydrogen production (by applying carbon capture technology). Combined with the offshore storage of carbon dioxide (CO2), this project will maximize the environmental impact and development of a strong supply chain covering the oil refinery, the CO2 capture and transport facilities and the storage site. It will also lay the foundation for a European hub for renewable hydrogen and CO2 utilization. For more information

Project information

Acronym	Project ID
SHARC	**101051125**
Start date	End date
01 March 2022	**31 July 2035**
Coordinated by	
NESTE OYJ	
Funded under	
Innovation Fund (InnovFund)	

CCU PROJECTS IN FRANCE

C2FUEL

Production of two promising energy carriers: Formic acid and dimethyl ether using CO2 from the steel industry and hydrogen produced from water electrolysis using surplus electricity from renewable energies

- Location: Dunkirk harbor
- 2.4 million tons of formic acid
- 100.000 tons of green hydrogen
- 1.8TW/h of green electricity
- 1.2 million tons of DME
- 320.000 ton of green hydrogen
- 11TW/h of renewable electricity

For more information

REUZE

This project aims to produce 100,000 tons of electro-fuels and naphtha using 300,000 tons per year of CO2 from the local steel production industry. This project will also produce steam to satisfy the needs of the local industries. The production of hydrogen will be done by the electrolysis of water using renewable energy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

- Location: Dunkirk harbor;
- CO_2 captured and utilized by year: 300.000 tons;
- Total production of Electrofuel and naphtha per year: 100.000tons.

For more information

VALORCO

The project aims to reduce CO_2 emissions in the steel making industry through CO_2 capture and valorization. The project objectives are to develop laboratory-scale reduction and recovery of CO_2 from industrial processes to quantify the degree of profitability and implement the most promising in the form of a laboratory-scale pilot.

- CO_2 Source: Steel production;
- CCU Technology Category: Capture (Point sources) ;
- Start TRL: 4 ; End TRL: 5.

CarBioRed

Design of a catalyst made from non-noble metals, based on CO_2 electro-reduction catalysts ;

- Timeline Start - End: 2012-2016 ;
- Project Status: Completed ;
- Project Budget: 556916.0 € ;
- Funding source: ANR.

For more information

Hycanais

Project led by Storengie. Synthesis methane production from CO_2 using a water-based electrolysis system to provide the necessary hydrogen. The energy required to power the electrolysis will be from wind energy. The electrolysis will be of 1 to 2MW. The methane produced will be injected into the grid.

CO_2 reduction: 1522 teq/year.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

KerEauZen

Production of e-kerosene from biogenic CO2, renewable electricity and water . Aim to find an alternative support for biokerosene . The e-kerosene should be blended with fossil aviation kerosene in order to meet the decarbonization targets of the aviation industry. Part of the e-kerosene produced will be used for research and certification purposes by French players in the aviation sector. For more information

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Salamandre

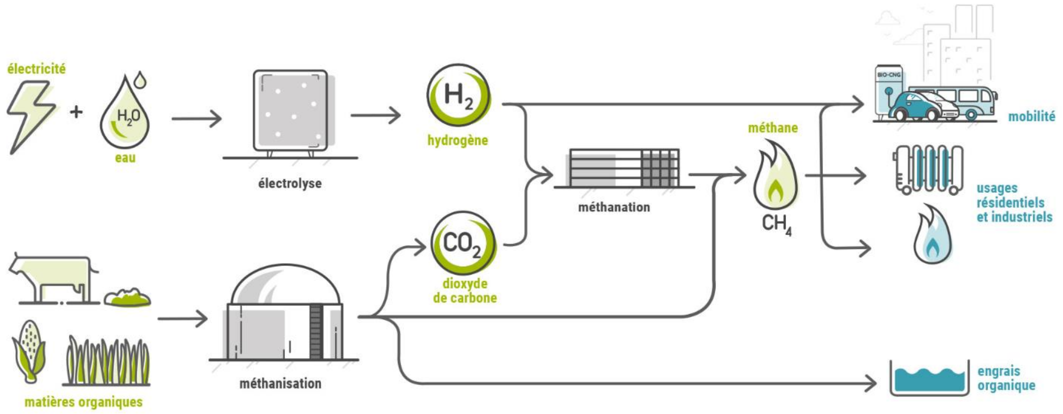
Project based on the pyrogazeification process followed by a methanation process for biomethane production with subsequent injection of the produced methane into the grid. The unit will be fueled by dry biomass from local wood-waste sources ;

- Location : Le Havre ;
- Project led by Engie ;
- Site production expected: 11,000 tons of biomethane annually, starting in 2026 ;
- Total investment of €150 million.

For more information

Methycentre

The project will have an equipment for performing the water electrolysis for hydrogen production that will be needed for the methanation process. The methanizers will supply the CO2. The hydrogen + CO2 will be transformed into methane by the methanation process and this methane will then be injected into the grid. MéthyCentre will consume 1 GWh per year of electricity from the grid, accompanied by certificates of guaranteed renewable origin . For more information



Source : https://methycentre.eu/projet/

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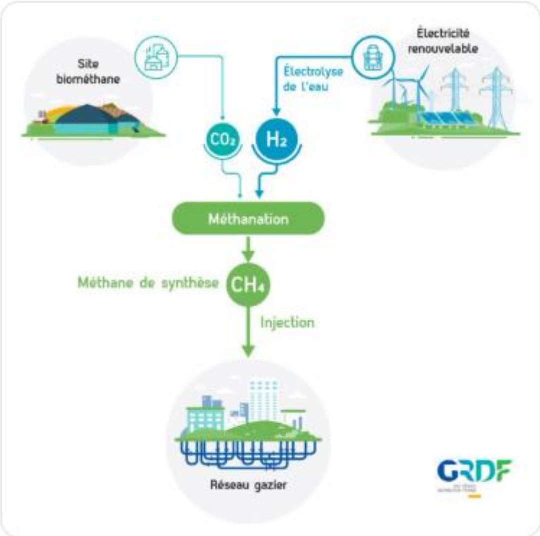
Step Pau Lescar

utilization of the CO2 from the methanization units (sludge from wastewater treatment plants) for the methanation process. In this process the necessary hydrogen will be obtained through the electrolysis of water. The product of the methanation will be the methane synthesis which will then be sent to the network. As a sub product of the electrolysis, the oxygen will be used for the oxygenation of the wastewater treatment basins. Valorization of 100% of the CO2 from methanization ;

- Complete balance of -550 tons of CO2 per year for the plant, which is therefore a carbon sink
- -2,300 tons of CO2 per year compared to the past site thanks to methanation
- Location : Agglomeration of Pau Béarn Pyrénées

For more information



Source: GRDF website

VABHYOGAZ3

Hydrogen production units by steam reforming of raw biogas ;

- Project coordinator : Hera ;
- Location : Labessière-candeil, Tarn ;
- TRL: 9 ;
- Production Volume: 3 ktonnes/year ;
- Timeline Start - End: 2016-2020 ;
- Project Budget: 11500000.0 €

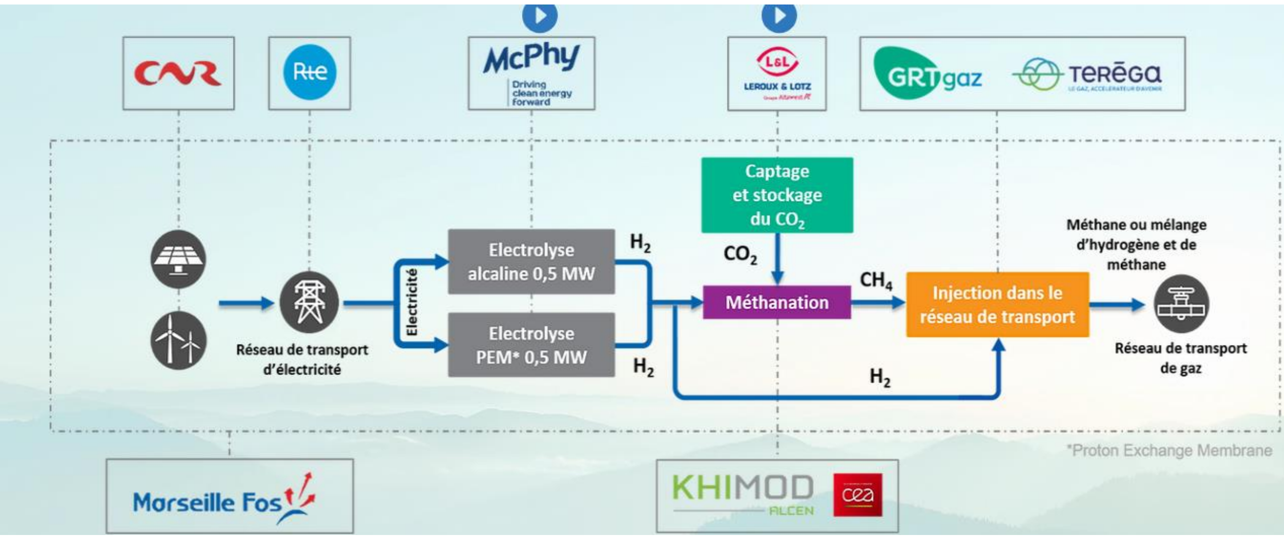
For more information

Jupiter1000

The project consists in transforming renewable electricity into gas in order to store it. Surplus electricity will be converted into hydrogen by two electrolyzers and also into synthetic methane by means of a methanation reactor. the project also has a CO2 capture structure from the gases emitted by nearby industries

- Location: Fos-sur-Mer (Bouches-du-Rhône)
- Project coordinator : GRTGAZ
- 1 MWe hydrogen production, consisting of two electrolyzers
- Eletrolysis technology : PEM (membrane) et Alcaline
- Methane production up to 25 m3/h
- Hydrogen injection up to 200 m3/h

For more information



HYNOVERA

Torrefaction and subsequent gasification of biomass from forests in order to produce initially a synthesis gas that will be the basis for the subsequent production of kerosene or diesel. In this project it is considered in a second phase in 2030 the production of methanol from renewable energy

- Budget: Approximately 460 million euros
- Production of Kerosene/ Diesel (2027) : 16.000ton/year
- Oxygen production (2027): 97.000 ton/year
- Naphtha paraffinic production (2027) : 9.000Ton/Year
- Methanol production (2030) : 70.000ton/Year
- Location : Gardanne, Meyreuil - Bouches-du-Rhône - Provence-Alpes-Côte d'Azur
  For more information

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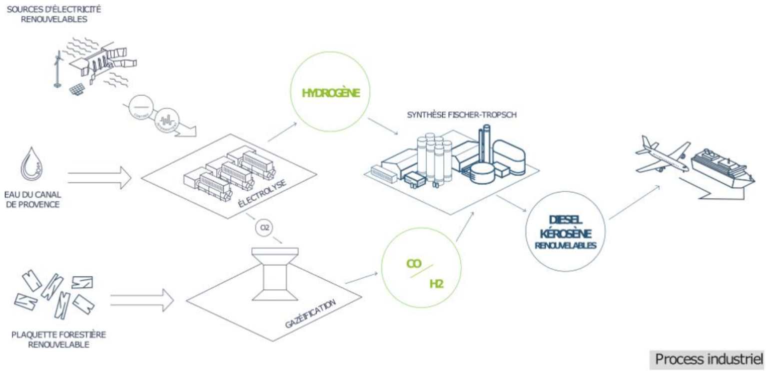

Gaya

Project for gasification of material from dry biomass (forests and agriculture) to produce biomethane. This biomethane will be produced from 100% renewable resources, which can be transported in the current networks or directly usable as fuel. the process consists of 4 phases1 - dry biomass preparation2 - Injection of the biomass into a gasifier working at a temperature between 800-1000 degrees Celsius. The product of this gasifier will be a gaseous mixture mainly composed of CO and H2. A filtering process is done in order to eliminate the impurities of these gases3 - The methanation is done in order to transform the synthesis gas in methane.4 - The last step of the process consists in the separation of the methane from the other molecules. For more information

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CIMENTALGUE

Cultivating microalgae in greenhouses in order to protect them from external impurities and to maintain them at a controlled temperature. The gas from the cement plant which has a significant concentration of CO2 is injected into the culture in order to transform the CO2. Various technologies are being evaluated such as open and closed raceway ponds, a tubular photobioreactor, and an AlgoFilm thin-layer photobioreactor (PBR). For more information

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HYNOVI

Production of methanol from CO2 captured from a cement production and hydrogen produced by a 330MW water electrolysis unit

- Location: Montalieu-Vercieu, France
- Vicat Hynamics (EDF)
- 40% of the CO2 emitted by the Vicat cement plant in Montalieu-Vercieu (38).
- 330 MW electrolyser by 2025
- the use of oxygen to make oxy-combustion
- Prodution target: over 200,000 tons of methanol

For more information

CEOPS

CEOPS project will focus on a sustainable approach for the production of methanol from CO2, which is a precursor for fine chemicals products. The approach will reinforce the link between large CO2 emitters and fine chemical industries at the European level. The concept relies on two chemical pathways, CO2 to CH4 and CH4 to CH3OH with the intermediate carbon vector: methane. Methane benefits from the extended and existing natural gas network infrastructure. Its distribution will prevent additional CO2 emissions (rail & road transportation). This approach will favor the emergence of small and flexible production units of fine chemicals from methanol. (Source: Cordis EU research)

- Location: Grenoble
- End TRL: 5
- Project leader: CEA
- Project Budget: 3508268.0 €

For more information

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UPCOMING EVENTS

EXPO NANTES – FRANCE - Bio360 Expo 2023

08-09 February 2023 - Nantes (France)

Website EXPO NANTES

It will take place from 8-9 February 2023 in Nantes, France. Bio360 Expo is an international assembly point comprising a large international exhibition and multi-track conference programme dedicated to advancing bioenergy, the bioeconomy, and atmospheric carbon removal in order to create a circular and renewable society, in contrast to the current model still dominated by dead-end fossil fuels.

2nd GREENERING INTERNATIONAL CONFERENCE

21-23 March 2023 - Valladolid – Spain

Website 2nd GREENERING INTERNATIONAL CONFERENCE

Green Chemical Engineering Network towards upscaling sustainable processes (CA18224) – GREENERING, is project (Action) funded by COST (European Cooperation in Science and Technology). The objective of GREENERING COST action is to promote and boost the industrial application of green chemistry and sustainable technologies, developing the tools for the scale-up and implementation of emerging processes into industry.

Conference on CO2-based Fuels and Chemicals

19-20 April 2023 - Maternushaus, Cologne (Germany)

Website Conference on CO2-based Fuels and Chemicals

The nova "Conference on CO2-based Fuels and Chemicals" is one of the most established worldwide and has developed into a unique meeting and networking place for the entire Carbon Capture & Utilisation (CCU) and Power-to-X industry and its customers.

CO2 Capture, Storage & Reuse 2023

16-17 may , Copenhagen, Denmark

Website CO2 Capture, Storage & Reuse 2023

The event will focus on utilisation of captured CO2 and its use for production of building materials like cement, concrete, steel, but also production of advanced fuels that will contribute to further decarbonization of other sectors. Also, as 2022 was a breakthrough year in terms of policies and regulations for green technologies we will be discussing the influence of legislation on the state of carbon capture and utilization technologies.

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INTERESTING SITES

PYROCO2 Project - https://www.pyroco2.eu/

CO2 Value Europe - https://www.co2value.eu/

CO2 Value Europe database - https://database.co2value.eu/

Club CO2 - https://www.club-co2.fr/fr

International Energy Agency - https://www.iea.org/

Zero Emission Platform - https://zeroemissionsplatform.eu/

Strategy CCUS - https://www.strategyccus.eu/

Global CCS Institute - https://www.globalccsinstitute.com

France Hydrogen - https://www.france-hydrogene.org/

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Annex 02 - Diagnostic - projects evaluation and/or investments susceptible to be funded by an external grant

Diagnostic : Demonstration projects or/and Investments

Introduction

This form allows the projects evaluation and/or investments susceptible to be funded by an external grant.

The objective of this form is :

- Evaluate the demonstration project suitability or investment with the most appropriate subsidies. Drive the companies to the more appropriate funding opportunity
- Detect the strengths points and areas for improvement of the project
- Identify the needs in terms of support for setting up and submitting a proposal in response to a call for proposals
- Define a joint action plan between the company and Axelera to carry out the project in case of the diagnosis results is a "Go" from both sides.

Axelera is committed to protecting the confidentiality of all information contained in this document in accordance with the general confidentiality framework in effect in our membership agreements. Your written consent will be requested prior to any sharing of this information with a third party.

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III – Emerging project

Project name :	
The project was already submitted in response to a call for proposals?	Number of submissions Evaluation results
Project Summary:	**Objectives:** **Approach:** **Expected results of the project:** **Main expected ecological impacts (eg. CO2 emissions, circularity, depollution...) :** **Target markets**
Does the project include the construction and monitoring of a demonstrator in the region?	Yes, it is the first project of its kind in the world No
Does the project foresee industrial investments (egg adaptation of production line) in the region?	Yes, this is the first project worldwide using this technology in the sector. Yes, but without innovation No?
Will the project have significant and measurable impacts on the reduction of greenhouse gas emissions? what will be the magnitude of this reduction?	Absolute GHG emission reduction in tons of CO2e per year or over 10 years: Relative reduction in relation to the total carbon footprint of the process :
Will the project have significant and measurable impacts on the environment? what will be the magnitude of this reduction?	e.g. reduction of Xm3 of fresh water use from a river / discharge of Y m3 of wastewater into a river)
Would the project be widely replicable at its end?	How do you consider this replication to date? • Sales of the solution by the company and its partners
Technical progress to date:	• Project idea • End-user needs / specifications for the demonstrator / well-known investments. If not, they can be obtained for the month of XY. • Competitive analysis done. If not, it can be finalized by the month of XY. • Pilot demonstrated at TRL X. • Large scale demonstration (XY) done (TRLY) • Solution already implemented in other sectors. To be adapted to the new targeted sector
Stage of economic progress to date:	• Complete market study. Alternatively, this study can be done for the month of XY. • End users of the solution are identified. If not, they will be identified for the month of XY. • Targeted early adopters are known. If not, they will be identified for the month of XY. • The Techno-Economic Analysis of the solution is complete. If not, it is planned for the month of X. • Has a risk analysis of the industrialization project been conducted? In addition to the technical and economic aspects, this involves looking at the

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	"supply chain" aspects, availability of raw materials, regulatory impact, HSE risk, risk of operating constraints due to regulations, availability of utilities, location of the plant, etc. • Complete FEED Study (Front End Engineering Design). Otherwise, it is feasible for the month of XY. • The decision has been officially made by the company to invest in Demonstrator / Industrial Investment / New Product Deployment / New Service Deployment. Otherwise, the official decision is expected in the month of XY. • The business / industrial strategy is officially adopted. If not, this strategy can be validated for the month of X. • Financial projections for the full-scale deployment of the solution are made based on the adopted business strategy. If not, these projections can be defined for the month of X.
Project budget :	
Project Schedule:	• Start-up of project: TX 20XY • Project completion: TX 20XY • Launching on the market / integration on the plant: TX 20XY
For an SME, would the project be financeable by a loan or fundraising?	Yes, no, why
Financial Projections:	**Estimated size of target market:** **Sales project forecast to 2025 :**
For Accelerators: What are the financial projections in terms of production, sales and valuation until 5 years after the end of the project?	*Accelerator targets the financing of future unicorns and centaurs. Centaurs" have a valuation of more than €100M and "unicorns" have a valuation of more than €1 billion.*
Partners / partners profile for your project:	Search for partners
Level of innovation (disruptive / incremental / usage):	
IP (patents, trademarks, designs):	
HR identified for the project	*Project team already constituted, by whom ...*
Identified needs related to the project	*Tech-eco study or market study to be done, setting up of financial projections, business plan...*

V – Action plan

- Axelera will propose the most appropriate call(s) for the project on XY/05/2023 with its recommendations.
- The engagement will be launched on XY/06/2023.…

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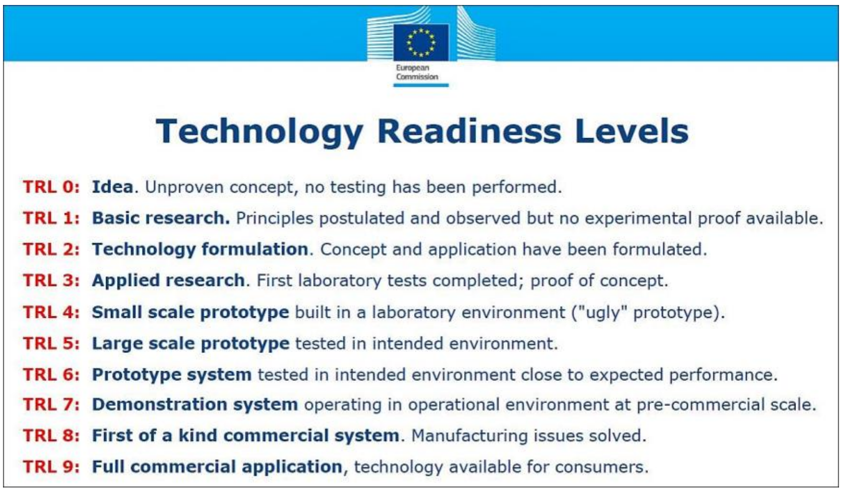
VI – Conclusions et recommendations

This part is to be completed by Axelera

Project strengths:	
Project Improvement Points:	
Axelera's service offer under discussion ?	Yes / No
Which service(s)?	• Identify the call for proposals for 1 project idea • Recommendations for project support • Partner search • Proposal review • EU project opportunity input • Identify several call for proposals for a project portfolio - In-house workshop • In-depth review • Administrative submission support • Writing support • Assistance to the setting up of a European project - global service
Recommendation for next steps	
Action plan validation	• Axelera will propose the most appropriate call(s) for the project on XY/05/2020 with its recommendations. • - The engagement will be initiated on XY/06/2020.



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Annex 03 - Questionnaire for the industrial's interviews

TABLE OF CONTENTS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037009.

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Annex 04 - Seminar CCU (agenda)

En collaboration avec le

Journée dédiée au déploiement des technologies CCU à l'échelle du territoire - 8 Septembre 2022

Bel Air Camp (Air B) au 44 avenue Paul Kruger - 69100 Villeurbanne

PROGRAMME

8h30 – 9h55	**Session 1 : CCU – Introduction**	
8h30 – 9h00	Accueil café	
9h – 09h10	Mission décarbonation	*Laure HUGONET , Marcos VERSIANI AXELERA*
9h10 – 9h25	Etat des lieux des projets CCU en France	*Bruno LANGLOIS, Club CO2*
9h25 – 9h40	Groupe de travail CCUS comité stratégique de la filière – NSE	*Sylvain NIZOU , CEA*
9h40 – 9h55	Valorisation du CO2 – L'avis de L'ADEME	*Alix BOUXIN, ADEME*
9h55 – 11h15	**Session 2 : CCU – Cadre réglementaire et opportunité de financement**	
9h55 – 10h10	Cadre réglementaire européen pour les projets CCU	*Tudy BERNIER, CO2 Value Europe*
10h10 – 10h25	Cadre réglementaire Français – CCU dans la Stratégie Nationale Bas-Carbone	*David PIGOT, DREAL*
10h25 – 10h45	**Coffee break**	
10h45 – 11h00	Opportunités de financement public au niveau européen	*Jennifer SHAW-TABERLET, AXELERA*
11h00 – 11h15	Opportunités de financement public au niveau français	*Alix BOUXIN, ADEME*
11h15 – 12h20	**Session 3 : Demandes de produits fabriqués à partir du CO2 industriel et networking**	
11h15 – 11h35	Pitch : Entreprises intéressées par les produits fabriqués à partir du CO2 industriel	*Julien SCHMIT, GRT Gaz Marc- Olivier VICTORIN, Elkem Jean-François BASSET, Firmenich*
11h40 – 12h20	**Networking**	*Tous*
12h20 – 14h	**Pause Déjeuner**	
14h – 16h40	**Session 4 : Présentation des technologies de captage et de valorisation du CO2 et présentation du projet européen PYROCO2**	
14h – 14h15	Présentation du Projet European PYROCO2 – 'Demonstrating sustainable value creation from industrial CO2 by its thermophilic microbial conversion into acetone' *(Présentation en anglais)*	*Alexander WENTZEL Sintef*
14h15 - 14h30	Technologies Axens de captage et de transformation du CO2	*Nadège GUERNALEC et Marion GUILLEVIC, Axens*
14h30 - 14h45	Transformation du CO2 (Plasma-catalytic Technology)– ENERGO	*Vincent SIMONNEAU, Energo*
14h45 – 15h	Technologies de captage et transformation du CO2 – Technip Energies	*Gauthier PERDU, Technip Energies*
15h – 15h15	Technologies de captage et transformation du CO2 – AIR LIQUIDE	*Fabrice DELCORSO, Air Liquide*
15h15 – 15h35	**Coffee break**	
15h35 – 15h50	La récupération, purification et mise en œuvre du CO2 et la production et distribution de l'hydrogène– AIR PRODUCTS	*Alexandre LEMEE, Air Products*
15h50 – 16h05	Le recyclage du CO2 et celui de déchets en gaz durables (méthane de synthèse, hydrogène) – ENOSIS	*Stephane PALMADE, Enosis*

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En collaboration avec le

16h05 – 16h20	Valorisation du CO2 et de la chaleur fatale d'origine industrielle pour produire des microalgues	*Christophe LOMBARD, AlgoSource*
16h20 – 16h35	De la capture de CO2 aux matières premières biosourcées via les microalgues	*Guillaume CHARPY, CarbonWorks*
16h35 – 16h40	Conclusions	*Marcos VERSIANI , AXELERA*
16h40	**Fin de l'évènement / Echanges libres**	

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