Data template to build model for Life Cycle Assessment (LCA) and Techno-Economic Assessment (TEA)

Release Status: Final

Author: P. COLLET

Date: 16 December 2020

Filename and version: D.4.1_Data_LCA_TEA

Project ID NUMBER 837754

STRATEGY CCUS (H2020-LC-SC3-2018-2019-2020/H2020-LC-SC3-2018-NZE-CC)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 837754

Document History

Location

This document is stored in the following location:

Filename	D.4.1_Data_LCA_TEA
Location	https://strategyccus.eu/project-outputs/economics-outputs

Revision History

This document has been through the following revisions:

Version No.	Revision Date	Filename/Location stored:	Brief Summary of Changes
Final		https://brgm365.sharepoint.com/:f:/r/sites/H2020STRATEGYCCUS/Documents%20partages/Deliverables/WP4?csf=1&web=1&e=S94Gs2	

Authorisation

This document requires the following approvals:

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Distribution

This document has been distributed to:

Name	Title	Version Issued	Date of Issue
		PUBLIC	03/01/2021

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Executive summary

This report presents the needed data to build models for Life Cycle Assessment and Techno Economic Assessment. The following main categories of processes are considered: CO_2 emissions sources, CO_2 transport, CO_2 capture technologies, CO_2 use and CO_2 storage. For each studied promising region (France - Rhone valley-, Spain –Ebro basin- and Portugal - Lusitanian basin -), a list of potential technologies is proposed for the different listed categories. The construction of the list of inputs and emissions has been done with WP2 "Mapping the technical potential of promising start-up regions" and WP5 "Establishing realistic detailed plans for CCUS at different geographical and timescales".

For all the selected technologies, data sheets have been developed. These sheets consist in the collection of the names (not the numbers) of the technical and environmental flows involved in the processes implementation. Each consumption of goods, materials, utilities, etc. are reported in these data sheets, as well as their respective units. For the selected regions, considered technologies are:

- CO2 emission from: refinery, power plant, cement industry, hydrogen production, steel production.
- Capture: pre / post combustion capture (MEA, membrane) and oxy-fuel combustion.
- Transport: pipelines.
- Use: biofuel from microalgae, methanation, methanol production, mineralization, e-fuel production, fertilizers production, photo / electroreduction of CO2 and use of CO2 in greenhouses.
- Storage: aquifer storage.

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List of needed data for LCA and TEA modelling

1 Introduction

The objective of the task 4.1 “Generic LCA and TEA modelling and data collection” of the WP4 “Methodological developments for mapping environmental and economic drivers” is to collect the list of data that will be needed to properly perform the Life Cycle Assessments (LCA) and Techno Economic Assessments (TEA).

For the selected regions, considered technologies are:

- CO2 emission from: refinery, power plant, cement industry, hydrogen production, steel production.
- Capture: pre / post combustion capture (MEA, membrane) and oxy-fuel combustion.
- Transport: pipelines.
- Use: biofuel from microalgae, methanation, methanol production, mineralization, e-fuel production, fertilizers production, photo / electroreduction of CO2 and use of CO2 in greenhouses.
- Storage: aquifer storage.

It is important to notice that these templates do not aim to present the values that will be used in the modelling of LCA and TEA. The aim of these data templates is to prepare data collection among the different stakeholders by proposing a list of parameters, economic and environmental flows that will need to be collected.

The choice of the technologies that are described in the three selected regions relies on the WP2 deliverable D 2.2 : “Key data for characterising sources, transport options, storage and uses in the promising regions”, and on frequent exchanges with WP2 and WP5 leaders.. This D2.2 has been elaborated with the local teams of the different regions to produce a preliminary overview of the technical potential to develop ICCUS clusters ad networks.

2 Structure of the data template

This paragraph presents the general structure of the data templates that will be used for data collection for all processes involved in the STRATEGYCCUS project. Data are divided in three sections: general parameters, technical parameters and economic parameters.

It has to be noticed that for all the described processes, only the technical parameters are modified. Both the general and the economic parameters are kept unchanged for all the selected technologies. Therefore, in all the processes that will be described in this report, only the technical parameter will be specified.

Most of the data template have been build based on the Life Cycle inventory database Ecoinvent, version 3.6 (https://www.ecoinvent.org/). In some cases, when data are incomplete or even missing in the Ecoinvent database, scientific publications have also been used.

In majority of the described processes, infrastructures needed to support the technology implementation have a climate change weight that is almost negligible. Therefore, in a first approximation, those infrastructures will be only described as a certain amount of stainless steel.

For processes where infrastructure can play an important role (pipelines or greenhouses for instance), a specific attention will be paid to have a precise description of the infrastructure's composition.

2.1 General parameters

Those common general parameters are the same for all the described technologies. Location is needed if some data are spatially specific (for instance the country electricity mix). Annual operating hours is needed for the calculation of operational expenditures.

Table 2-1 General parameters needed for data template

Parameters	Values	Units
Location (GPS)	D2.4[1] of WP2 (tbf)	Degree
Annual operating hour	(tbf)	Hour

2.2 Economic parameters

The list of the economic parameters that have to be filled in the tables has been built in close interaction with WP5 "Establishing realistic detailed plans for CCUS at different geographical and timescales".

Table 2-2 Economic parameters needed for data template

Parameters	Values	Units
General (defined in relation with WP5)		
Base year	To be filled with WP5 (tbf)	year
Construction time	(tbf)	year
Operation time	(tbf)	year
Residual value	(tbf)	€
Inflation	(tbf)	%
Cost of debt	(tbf)	€

[1] Deliverable D2.4 : Dataset of STRATEGY CCUS promising regions (confidential)

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% Debt	(tbf)	%
% Equity	(tbf)	%
Depreciation	(tbf)	year
% subvention	(tbf)	%
Tax rate	(tbf)	%
Discount rate	(tbf)	%
Currency	(tbf)	€
Investments costs		
Inside Battery Limit (ISBL) cost	(tbf)	€
Outside Battery Limit (OSBL) cost	(tbf)	€
Utilities cost		
Steam	(tbf)	€
Electricity	(tbf)	€
Water	(tbf)	€
OPEX costs		
Labour costs	(tbf)	€ or % ISBL
Maintenance	(tbf)	€ or % ISBL
Insurance	(tbf)	€ or % ISBL
Overheads	(tbf)	€ or % ISBL

2.3 Technical parameters

Technical parameters are specific to each technology that will be assessed. These technologies are categorized as CO2 emitters, capture technologies, CO2 transport technologies, use technologies and storage technologies.

3 CO_2 emissions sources

Different emissions sources of CO2 are considered: refinery, power plant, cement industry, hydrogen production, steel production. These emitters have been chosen based on the emitters mapping provided by WP2 and on the quantities of CO2 emitted. Indeed, in a first approach, deployment of CCUS in the three selected regions will be prioritized for big emitters. Therefore, it is necessary to notice that this list is not exhaustive and that new emitters could be added during the project if needed.

3.1 CO2 from refinery

The data list is build based on the Life Cycle Inventory database Ecoinvent v3.6 and data collection in WP2.

Table 3-1 Technical parameters needed for refinery data collection

Parameters	Values	Units
Flue gas out		
Total CO2 production	D2.4 of WP2 and WP5	tons / year
Temperature	(tbf)	°C
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Output composition (should include if possible CO2, SO2, N2, NH3, O2, H2O, CO, CH4, NOx, SOx, H2S, PM10, PM2.5).	(tbf)	% mol or %wt
Utilities		
Crude oil	(tbf)	tons / year
Heat (Indicate the type of resource used)	(tbf)	MJ / year
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	MWh / year
Water	(tbf)	m3 / year
Materials		
Stainless steel	(tbf)	ton
Product(s) out: refinery production		
Average capacity factor	(tbf)	%
Gasoline	(tbf)	tons / year
Diesel	(tbf)	tons / year

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Jet fuel	(tbf)	tons / year
Naphta	(tbf)	tons / year
Heavy fuel	(tbf)	tons / year
Heating oil	(tbf)	tons / year
Petroleum coke	(tbf)	tons / year

3.2 CO2 from power plant

The data list is build based on the Life Cycle Inventory database Ecoinvent v3.6 and data collection in WP2.

Table 3-2 Technical parameters needed for power plant data collection

Parameters	Values	Units
Flue gas out		
Total CO2 production	D2.4 of WP2 and WP5	tons / year
Temperature	(tbf)	°C
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Output composition (should include if possible CO2, SO2, N2, NH3, O2, H2O, CO, CH4, NOx, SOx, H2S, PM10, PM2.5).	(tbf)	% mol or %wt
Utilities for coal power plant		
Coal	(tbf)	tons / year
Chlorine	(tbf)	kg / year
Water	(tbf)	m3 / year
Utilities for natural gas power plant		
Natural gas	(tbf)	Nm3 / year
Water	(tbf)	m3 / year
Utilities for fuel power plant		
Fuel oil	(tbf)	tons / year
Ammonia	(tbf)	kg / year

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Limestone	(tbf)	kg / year
Water	(tbf)	m3 / year
Materials		
Stainless steel	(tbf)	ton
Product(s) out: energy production		
Capacity	(tbf)	MW
Electricity output	(tbf)	MWh / year

3.3 CO2 from cement production plant

The data list is build based on the Life Cycle Inventory database Ecoinvent v3.6 and data collection in WP2.

Table 3-3 Technical parameters needed for concrete production plant data collection

Parameters	Values	Units
Flue gas out		
Total CO2 production	D2.4 of WP2 and WP5	Tons / year
Temperature	(tbf)	°C
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Output composition (should include if possible CO2, SO2, N2, NH3, O2, H2O, CO, CH4, NOx, SOx, H2S, PM10, PM2.5).	(tbf)	% mol or %wt
Utilities		
Heat (Indicate the type of resource used)	(tbf)	MJ / year
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	MWh / year
Clay	(tbf)	tons / year
Calcareous marl	(tbf)	tons / year
Lime	(tbf)	tons / year
Materials		
Stainless steel	(tbf)	tons

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Product(s) out: energy production		
Average capacity factor	(tbf)	%
Cement net production	(tbf)	tons / year

3.4 CO2 from hydrogen production plant

The data list corresponds to the production of H2 by steam methane reforming (SMR). It is build based on the Life Cycle Inventory database Ecoinvent v3.6 and data collection in WP2.

Table 3-4 Technical parameters needed for hydrogen production plant data collection

Parameters	Values	Units
Flue gas out		
Total CO2 production	D2.4 of WP2 and WP5	tons / year
Temperature	(tbf)	°C
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Output composition (should include if possible CO2, SO2, N2, NH3, O2, H2O, CO, CH4, NOx, SOx, H2S, PM10, PM2.5).	(tbf)	% mol or %wt
Utilities		
Natural gas	(tbf)	Nm3 / year
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	MWh / year
Water	(tbf)	m3 / year
Materials		
Stainless steel	(tbf)	ton
Product(s) out: energy production		
Average capacity factor	(tbf)	%
H2 net production	(tbf)	Nm3 / year
CO net production	(tbf)	Nm3 / year

3.5 CO2 from steel production

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The data list is build based on the Life Cycle Inventory database Ecoinvent v3.6 and data collection in WP2.

Table 3-5 Technical parameters needed for steel production data collection

Parameters	Values	Units
Flue gas out		
Total CO2 production	D2.4 of WP2 and WP5	tons / year
Temperature	(tbf)	°C
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Output composition (should include if possible CO2, SO2, N2, NH3, O2, H2O, CO, CH4, NOx, SOx, H2S, PM10, PM2.5).	(tbf)	% mol or %wt
Utilities for coal power plant		
Coke	(tbf)	tons / year
Iron	(tbf)	tons / year
Heat (Indicate the type of resource used)	(tbf)	MJ / year
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	MWh / year
Oxygen		Nm3 / year
Materials		
Stainless steel	(tbf)	ton
Product(s) out: energy production		
Average capacity factor	(tbf)	%
Steel net production	(tbf)	tons / year

4 CO_2 capture technologies

4.1 Post combustion technologies

Post combustion carbon capture technologies absorb the produced CO2 after carbon combustion (of fossil and / or commodities). One of the main challenges is the separation of CO2 (in relatively low concentration) from other gas like dinitrogen (N2). Different kind of technologies are available for

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post combustion CO_2 capture. In the STRATEGY CCUS project, solvent-based (monoethanolamine, MEA) and membrane-based technologies will be assessed.

4.1.1 Amine-based technology

Solvent-based CO_2 capture involves the absorption of CO_2 from the emitted gas into a liquid carrier, the solvent. Then the solvent is regenerated to break the absorbent-CO_2 bond and reuse the solvent. The most commonly used solvent is the MEA. The data list is build based on the following references: Ecoinvent v3.6 and (Giordano, Roizard et Favre 2018)

Table 4-1 Technical parameters needed for amine-based CO_2 post combustion capture data collection

Parameters	Values	Units
Flue gas in		
Temperature	D2.4 of WP2 and WP5	°C
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Input composition. Could be identical to output composition of the emissions process	(tbf)	% mol or %wt
Captured CO2 flow		
Temperature	(tbf)	°C
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Capture ratio	(tbf)	%
Composition	(tbf)	% mol or %wt
Flue gas out		
Temperature	D2.4 of WP2 and WP5	°C
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Output composition (should include if possible CO2, SO2, N2, NH3, O2, H2O, CO, CH4, NOx, SOx, H2S, PM10, PM2.5).	(tbf)	% mol or %wt

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Utilities		
Heat (Indicate the type of resource used)	(tbf)	MJ / year
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	MWh / year
Water	(tbf)	m3 / year
MEA	(tbf)	kg / year
NaOH	(tbf)	kg / year
Activated carbon	(tbf)	kg / year
Materials		
Stainless steel	(tbf)	ton

4.1.2 Membrane-based technology

CO2 separation by membranes is based on the selective transport and separation of the CO2 in the flue gas. It is particularly well adapted for emitters where the carbon dioxide partial pressure is high, like natural gas processing (Wilberforce et al. 2019). The data list is build based on the following references: Ecoinvent v3.6 and (Giordano, Roizard et Favre 2018)

Table 4-2 Technical parameters needed for membrane-based CO2 post combustion capture data collection

Parameters	Values	Units
Flue gas in		
Temperature	D2.4 of WP2 and WP5	°C
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Input composition. Could be identical to output composition of the emissions process	(tbf)	% mol or %wt
Captured CO2 flow		
Temperature	(tbf)	°C
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour

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Capture ratio	(tbf)	%
Composition	(tbf)	% mol or %wt
Flue gas out		
Temperature	be filled with WP2 and WP5	°C
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Output composition (should include if possible CO2, SO2, N2, NH3, O2, H2O, CO, CH4, NOx, SOx, H2S, PM10, PM2.5).	(tbf)	% mol or %wt
Utilities		
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	kWh / year
Materials		
Stainless steel	(tbf)	ton

4.2 Pre-combustion technologies

In pre-combustion technologies, CO2 from gasification is removed from the syngas, before the use of the syngas directly as a fuel in steam turbine. This is the case in integrated gasification combined cycle (IGCC) power plant. Syngas can also be used indirectly as a precursor for second generation biofuels, and CO2 pre-combustion could also arise in such systems. In a fist approach, the same technologies will be used for both post and pre-combustion carbon capture systems.

4.3 Oxy-fuel combustion technology

In oxy-fuel combustion, the combustion of the fuel occurs in oxygen instead of the air. This technology uses air separation unit to produce clean oxygen (95% to 99% purity), that significantly affects the energy balance of the system. The exhaust gas is an almost a pure carbon dioxide stream, that doesn't need any supplementary purification step before transportation and sequestration. This technology is still under development. Nevertheless, it is included in the list of potential future capture technologies, as the StrategyCCUS aims at defining long term prospective scenarios for CCUS deployment in Europe. The data list is build based on the following references: Ecoinvent v3.6 and (Cau et al. 2018)

Table 4-3 Technical parameters needed for oxy-combustion capture data collection

Parameters	Values	Units
Flue gas in		

Temperature	D2.4 of WP2 and WP5	°C
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Input composition. Could be identical to output composition of the emissions process	(tbf)	% mol or %wt
Captured CO2 flow		
Temperature	(tbf)	°C
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Capture ratio	(tbf)	%
Composition	(tbf)	% mol or %wt
Flue gas out		
Temperature	be filled with WP2 and WP5	°C
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Output composition (should include if possible CO2, SO2, N2, NH3, O2, H2O, CO, CH4, NOx, SOx, H2S, PM10, PM2.5).	(tbf)	% mol or %wt
Utilities		
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	MWh / year
Materials		
Stainless steel	(tbf)	ton

5 CO_2 transport by pipelines

CO2 transportation would be most likely done by pipelines. Most of the existing CCUS projects, applied for Enhance Oil Recovery, transport CO2 by pipelines so this is the selected technology. The data list is build based on the following reference: Ecoinvent v3.6 and (Chisalita et al. 2019).

Table 5-1 Technical parameters needed for pipelines CO2 transport data collection

Parameters	Values	Units
CO2 flow in		
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Input composition	(tbf)	% mol or %wt
Utilities		
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	MWh / year
Materials		
Stainless steel	(tbf)	ton
Product(s) out: energy production		
CO2 transported	(tbf)	tons / year

6 CO_2 use

The list presented in Table 6-1 is based on data provided by WP2 for the three selected regions: France (Rhone valley, FR), Spain (Ebro basin, ES) and Portugal (Lusitanian basin, PT). This first attempt correspond to a panel of three to five technologies that will be potentially implemented in short term in the selected regions. The list of CCU technologies for long term will be based on both these data and on regional prospective scenarios / roadmaps for each regions. Therefore new CCU technologies could be added to this first list of short term CCU technologies. For each technology, expected output as well as the potential related functional unit are given. The functional unit corresponds to a reference value that is appropriate for the function served by the product being assessed, and to which all the flows and results (environmental impacts) are related

Table 6-1 List of technologies for carbon use in the three selected regions

Technology	country	Output	Functional unit
Microalgae	FR	Biofuels	1 MJ biofuel
Methanation	FR, PT	biomethane	1 MJ bioCH4
Methanol	FR, ES	Methanol	1 MJ biomethanol
Mineralization	FR, PT, ES	Concrete aggregates	1 m3 of concrete aggregates

E-fuels	PT, ES	E-fuels	1 MJ e-fuel
Fertilizers	ES	urea	1 kg urea
Photo / Electro-reduction	ES	Mono / polymer	1 kg Mono / polymer (tbd)
Greenhouses	PT, FR	Vegetables	1 kg vegetables

6.1 Methanation

Methanation consists in the conversion of carbon monoxide (CO) and carbon dioxide (CO2) to methane (CH4) through hydrogenation. In a context of climate change mitigation, needed H2 for hydrogenation is considered to be produced by electrolysis. H2 production by SMR with CCS could also be an option, although this is not presented in the table below. The data list presented in Table 6-2 is build based on the following references: Ecoinvent v3.6 and (Collet et al. 2017)

Table 6-2 Technical parameters needed for methanation data collection

Parameters	Values	Units
CO2 flow in		
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Input composition	(tbf)	% mol or %wt
Utilities for electrolysis		
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	MWh / year
Deionised water	(tbf)	kg / year
Utilities for methanation		
H2 from electrolysis	(tbf)	Nm3 / year
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	kWh / year
Catalyst	(tbf)	kg / year
Materials		
Stainless steel	(tbf)	ton
Product(s) out: energy production		
Methane	(tbf)	Nm3 / year

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O2	(tbf)	Nm3 / year
Heat	(tbf)	MJ / year

6.2 Mineralization

Mineralization of carbon dioxide (CO_2) corresponds to the reaction of CO_2 with materials containing alkaline-earth oxides, leading to CO_2 storage into thermodynamically stable solid. The data list presented in Table 6-3 is build based on the following references : Ecoinvent v3.6 and (Ostovari, Sternberg et Bardow 2020). In the case described below, CO_2 reacts with Serpentinite in order to obtain $MgCO_3$. Other carbonates can be produced depending on the substrate.

Table 6-3 Technical parameters needed for mineralization data collection

Parameters	Values	Units
CO2 flow in		
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Input composition	(tbf)	% mol or %wt
Utilities		
Heat (Indicate the type of resource used)	(tbf)	MJ / year
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	MWh / year
Serpentinite (case specific)	(tbf)	kg / year
NaCl	(tbf)	kg / year
NaHCO3	(tbf)	kg / year
Ammonium sulphate	(tbf)	kg / year
Cooling water	(tbf)	m3 / year
Materials		
Stainless steel	(tbf)	ton
Product(s) out		
Magnesium carbonate	(tbf)	kg / year
Magnetite	(tbf)	kg / year

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6.3 Methanol

Carbon dioxide hydrogenation can lead to the production of methanol. Due to its relatively low production costs, methanol production appears as a good opportunity for CCU. The data list is build based on the following references : Ecoinvent v3.6 and (Matzen et Demirel 2016)

Table 6-4 Technical parameters needed for methanol production data collection

Parameters	Values	Units
CO2 flow in		
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Input composition	(tbf)	% mol or %wt
Utilities for electrolysis		
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	MWh / year
Deionised water	(tbf)	kg / year
Utilities for methanol production		
Heat (Indicate the type of resource used)	(tbf)	MJ / year
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	kWh / year
Catalyst	(tbf)	kg / year
Water	(tbf)	m3 / year
H2 from electrolysis	(tbf)	Nm3 / year
Materials		
Stainless steel	(tbf)	ton
Product(s) out: energy production		
Methanol	(tbf)	tons / year

6.4 Microalgae

Different products from microalgae can be produced by different conversion pathways. In the StrategyCCUS project, a focus will be put on biofuels production from microalgae, because of the relatively higher maturity of this conversion route compared to other conversion pathways. Among these biofuels, liquid hydrocarbons that can be substituted for or blended with gasoline or diesel

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fuel are particularly attractive. In a first step, the conversion pathway towards biodiesel will be considered. The data list presented in Table 6-5 is build based on the following references : Ecoinvent v3.6 and (Valente, Iribarren et Dufour 2019; Collet et al. 2014).

Table 6-5 Technical parameters needed for biodiesel from microalgae data collection

Parameters	Values	Units
CO2 flow in		
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Input composition	(tbf)	% mol or %wt
Utilities		
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	MWh / year
Heat (Indicate the type of resource used)	(tbf)	MJ / year
Water	(tbf)	m3 / year
Ammonium nitrate	(tbf)	kg / year
Diammonium Phosphate	(tbf)	kg / year
Hexane	(tbf)	kg / year
Methanol	(tbf)	kg / year
Materials		
Stainless steel	(tbf)	ton
Product(s) out: energy production		
Biodiesel	(tbf)	tons / year
Glycerin	(tbf)	tons / year
Oil cakes	(tbf)	tons / year

6.5 E-fuels

In the StrategyCCUS project, a focus will be put on e-fuels that could be used as substituted to actual liquid hydrocarbons fuels. Among the different e-fuels that are possible, the conversion pathway towards OMEs (OxyMethylene Ethers) will be considered. The data list is build based on the following references : Ecoinvent v3.6 and (Deutz et al. 2018)

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Table 6-6 Technical parameters needed for OME production data collection

Parameters	Values	Units
CO2 flow in		
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Input composition	(tbf)	% mol or %wt
Utilities for electrolysis		
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	MWh / year
Deionised water		kg / year
Utilities for OME production		
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	MWh / year
Heat (Indicate the type of resource used)	(tbf)	MJ / year
Water	(tbf)	m3 / year
H2 from electrolysis	(tbf)	Nm3 / year
Materials		
Stainless steel	(tbf)	ton
Product(s) out: energy production		
Methanol	(tbf)	tons / year

6.6 Fertilisers

In the Spain region, CO2 is planned to be converted into fertilizers. In the example given below two fertilizers are jointly produced: Ammonium nitrate + calcium carbonate. The data list is build based on the following references : Ecoinvent v3.6 and (Lake et al. 2019)

Table 6-7 Technical parameters needed for fertilizers production data collection

Parameters	Values	Units
CO2 flow in		
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year

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Flow rate	(tbf)	Nm3/hour
Input composition	(tbf)	% mol or %wt
Utilities		
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	kWh / year
Cellulose based waste material	(tbf)	kg / year
Aqueous ammonia	(tbf)	kg / year
Aqueous calcium nitrate	(tbf)	kg / year
Hexane	(tbf)	kg / year
Methanol	(tbf)	kg / year
Materials		
Stainless steel	(tbf)	ton
Product(s) out: energy production		
Fertilisers (Ammonium nitrate + calcium carbonate)	(tbf)	tons / year

6.7 Photo / electroreduction

6.7.1 Electroreduction

In a first approach, the acid formic production will be chosen as an example of possible pathway for electroreduction development process. The data list is build based on the following references : Ecoinvent v3.6 and (Thonemann et Schulte 2019; Aldaco et al. 2019). If needed in the project, other molecules production such as ethylene (Khoo, Halim et Handoko 2020) could be investigated.

Table 6-8 Technical parameters needed for acid formic production data collection

Parameters	Values	Units
CO2 flow in		
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Input composition	(tbf)	% mol or %wt
Utilities		
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	MWh / year

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Heat (Indicate the type of resource used)	(tbf)	MJ / year
Copper (cathode)	(tbf)	kg / year
Methanol	(tbf)	kg / year
Tetrabutylammonium tetrafluoroborate (TBABF4)	(tbf)	kg / year
Cooling water	(tbf)	m3 / year
Deionised water	(tbf)	m3 / year
Materials		
Stainless steel	(tbf)	ton
Product(s) out: energy production		
Acid formic	(tbf)	kg / year

6.7.2 Photoreduction

Unfortunately, no data are available yet on LCA of CO2 photoreduction process. However, implication of IFPEN in the H2020 Sun2Chem project will help defining the list of potential inputs that would be needed to perform LCA and TEA.

6.8 Greenhouses

In Portugal, CO2 is expected to be used as input into greenhouses for vegetables production. Indeed, CO2 enrichment in greenhouses has proved to enhance the production of a different of crops. The example is related to the production of tomatoes, cucumbers and strawberries in Italy, and will serve as a basis for the development of such technology in Portugal.

The data list is build based on the following references : Ecoinvent v3.6 and (Marchi, Zanoni et Pasetti 2018)

Table 6-9 Technical parameters needed for greenhouses data collection

Parameters	Values	Units
CO2 flow in		
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Input composition	(tbf)	% mol or %wt

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Utilities		
Heat (Indicate the type of resource used)	(tbf)	MJ / year
Water	(tbf)	m3 / year
Ammonium nitrate	(tbf)	kg / year
Diammonium Phosphate	(tbf)	kg / year
Materials		
Stainless steel	(tbf)	ton
Product(s) out: energy production		
Vegetables / fruits / Flowers	(tbf)	kg / year

7 CO_2 storage

In the three selected regions, CO2 sequestration is expected to be mainly done in saline aquifers. The data list is build based on the following reference: Ecoinvent v3.6 and (Chisalita et al. 2019).

Table 7-1 Technical parameters needed for CO2 storage data collection

Parameters	Values	Units
CO2 flow in		
Pressure	(tbf)	bar
Volume	(tbf)	Nm3 / year
Flow rate	(tbf)	Nm3/hour
Input composition	(tbf)	% mol or %wt
Utilities		
Electricity (Indicate the type of electricity (from grid, other…)	(tbf)	MWh / year
Materials		
Stainless steel	(tbf)	ton
Product(s) out		
CO2 stored	(tbf)	tons / year
Leakage	(tbf)	%

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8 Conclusion

The report presents a first list of CO2 emitters and use and / or storage technologies that will be mobilized in the deployment of CCUS scenarios in the three selected regions (France, Portugal and Spain). Main objectives are shortly described each technology, as well as to list all potential parameters and variables that would be required to perform TEA and LCA.

The technologies that are presented here do not constitute a final set of process, but rather a starting point to help building prospective scenarios of CCUS deployment in Europe. Close interactions with WP2 and WP5 have been needed to build this first attempt and are expected to continue to keep on improving the lust of the potential involved processes.

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 837754