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Bioenergy Retrofits for Europe's Industry

The BIOFIT Project – Retrofitting of the bioethanol industry

VIRTUAL SEMINAR ON LIGNOCELLULOSIC ETHANOL RETROFITS

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GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

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- **Public Research Body under the Ministry of Science and Innovation**
- **RD&I in the fields of Energy, Environment and Technology, including sociotechnical aspects, and in specific areas of Basic Research**

Human resources ≈ 1250 people

Budget ≈ 88 M€

Income generated by R&D activities (2019) ≈ 29 M€

CIEMAT SITES

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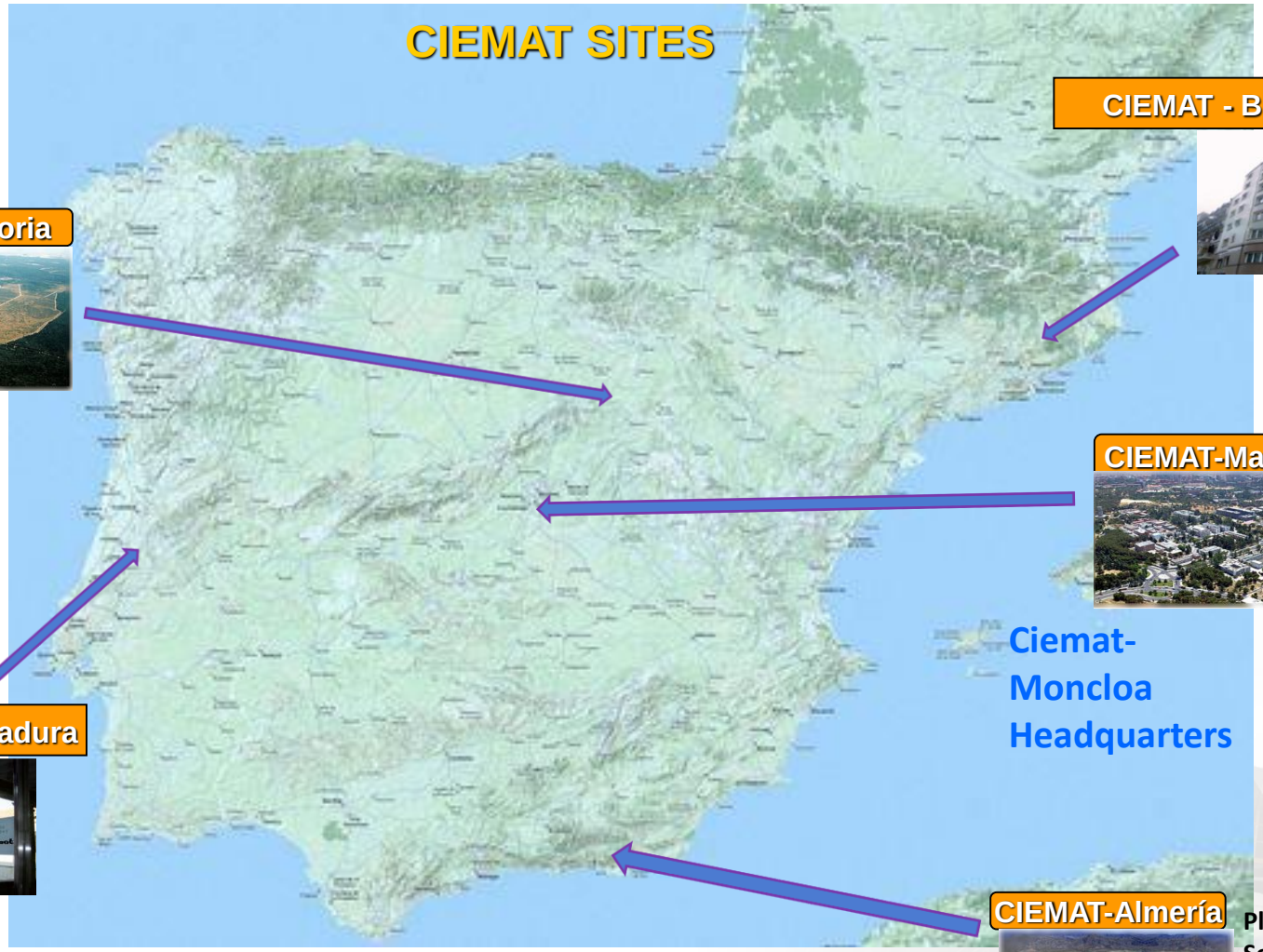

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Research Lines

- Development of different biological processes for the conversion of lignocellulosic biomass into liquid biofuels and bioproducts.
  - Hydrothermal and thermomechanical technologies for biomass pretreatment
  - Hydrolysis of carbohydrates by biological catalysts
  - Fermentation of resulting sugars by microorganisms
  - Techno-economic analysis of energy systems based on lignocellulosic biomass, especially those focused on obtaining biofuels and bioproducts

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What is RETROFITTING?

- **Retrofitting** – which means replacing a part of a factory or installation with state-of-the-art equipment – is a good alternative to new plants for replacing fossil fuels, upgrade outdated technology, or producing additional output from biomass.
- Bioenergy retrofitting could provide significant benefits compared to building new plants, notably lower capital expenditure, shorter lead times, faster implementation, and less production time loss.

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BIOENERGY RETROFITTING IN EUROPE'S INDUSTRY

✓ The BIOFIT project **aims to facilitate** the market uptake of **bioenergy retrofitting** concepts in several specific industrial sectors in Europe:

- **First generation biofuels** → **1G Bioethanol industry**
- **Pulp and paper**
- **Fossil refienries**
- **Fossil firing power plant**
- **Combined Heat and Power plants**

✓ A **core activity** of BIOFIT is to develop 10 concrete **case studies** together with industrial partners.

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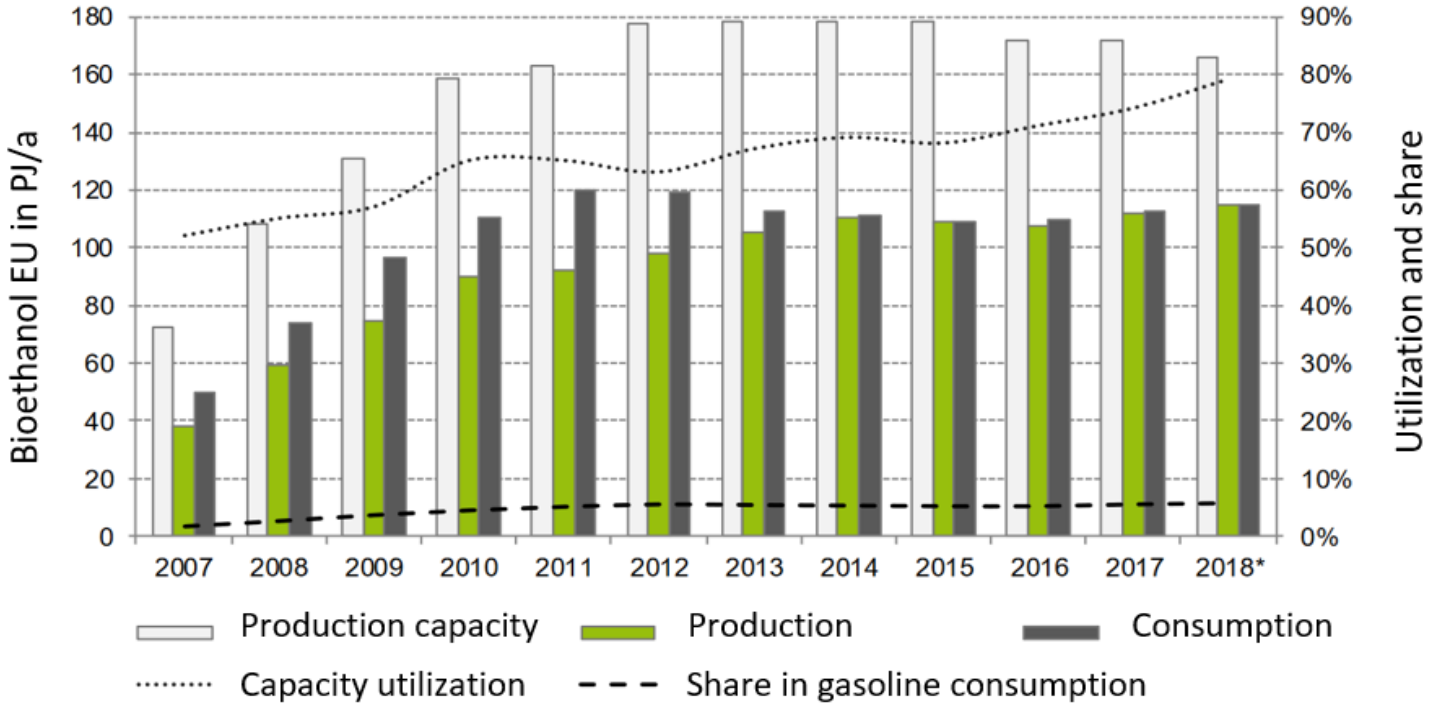
BIOETHANOL MARKET OVERVIEW IN EU



Datenbasis: EC, Eurostat, Global Trade Atlas, ePURE, EU FAS Posts, * Prognose
Kapazität und Auslastung inklusive non-fuel Ethanol

During the last years:

- ✓ Share of bioethanol in petrol≃ 5%
- ✓ Bioethanol production and consumption increase slightly.
- ✓ Between 2018 and 2019, bioethanol consumption dedicated to transport increased by 6.4%.

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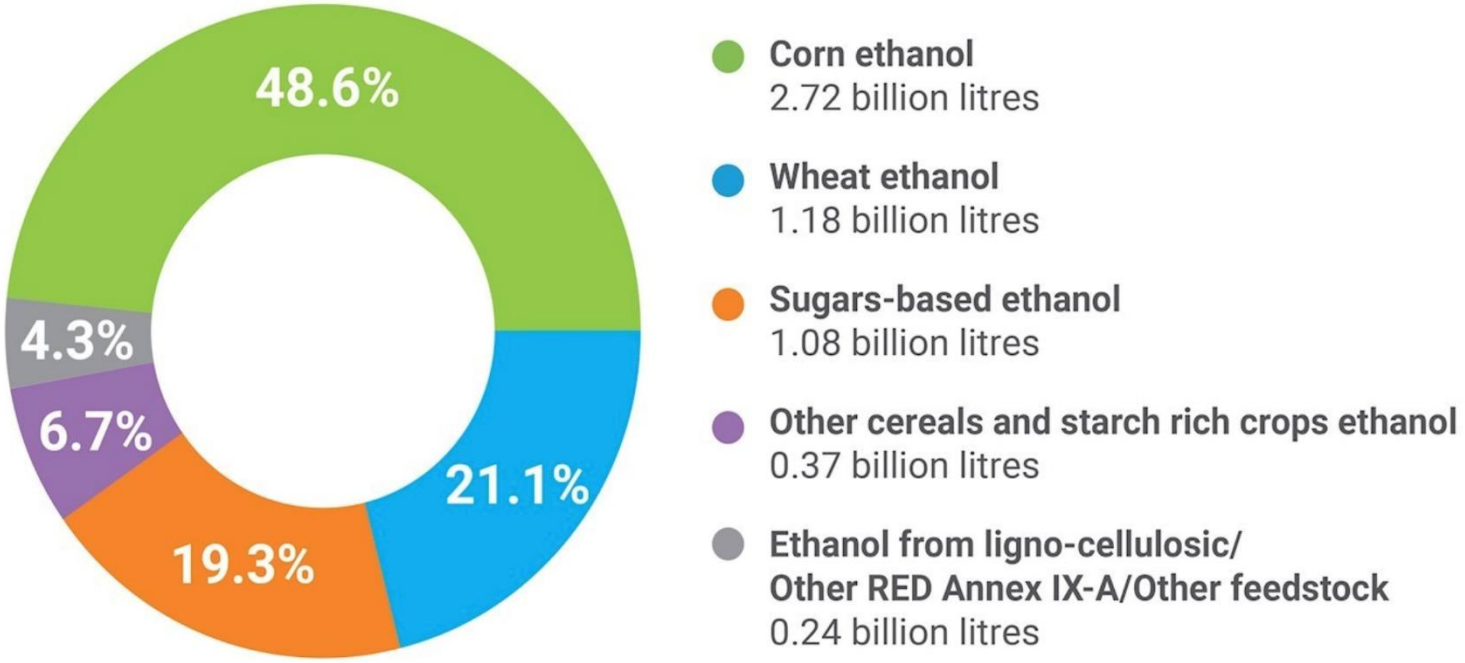
BIOETHANOL MARKET OVERVIEW



Source: Aggregated and audited data of ePURE members (pure alcohol)

- In 2019, 48.6 % of bioethanol was produced from corn, followed by wheat and sugar -->**1G BIOETHANOL**
- **Concerns** over the long-term **sustainability of 1G bioethanol:**
  - ✓ Competition for food and feed production
  - ✓ Impacts on land use
  - ✓ Water resource

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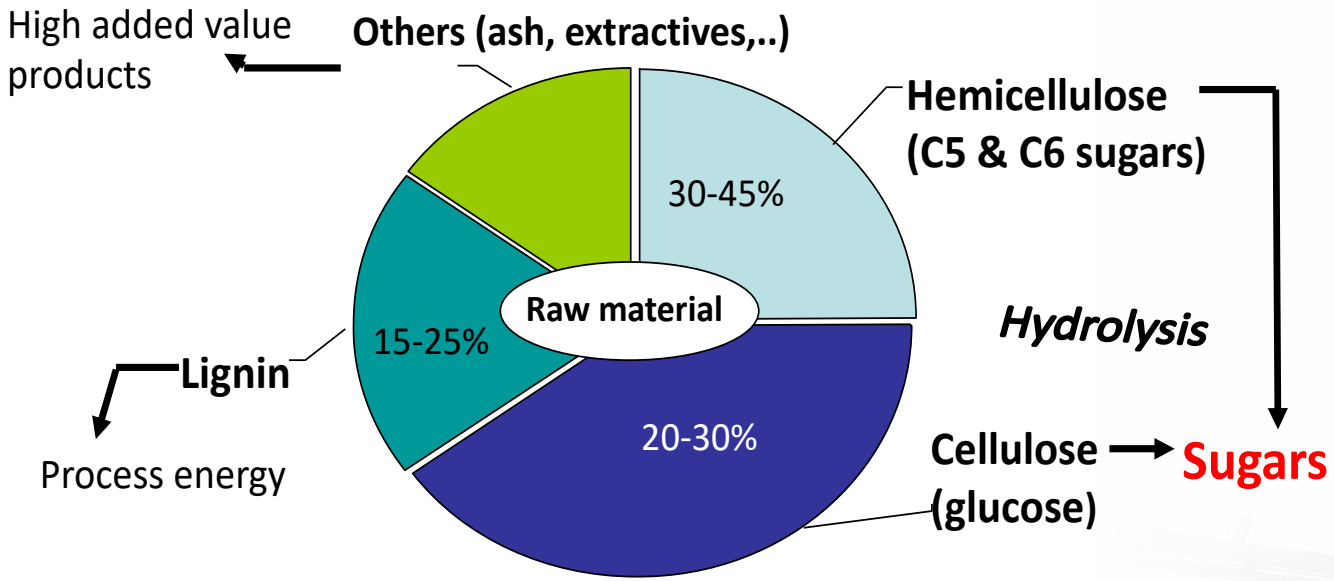
ADVANCED BIOETHANOL

WHY BIOETHANOL FROM LIGNOCELLULOSIC BIOMASS?



- Lignocellulosic biomass is one of the most abundant renewable sources
- **Feedstocks not linked to the food market**, many of them residues (agricultural and forest residues, residues from agroindustries (pulp and paper, food…), organic fraction of municipal solid wastes (MSW), or energy crops
- Lower lifecycle CO_2 emissions →sustainability criteria
- Possibility to obtain high-added value products

RENEWABLE ENERGY DIRECTIVE II (RED II)

- **Promote the transition** from **crop/food-based** biofuels to biofuels from **non-food feedstock:**
  - Within **14% renewable energy target** in **transport sector**, minimum shares **for advanced biofuels** has been stablished: 0.2% (2022), 1% (2025) and 3.5% (**2030).**
  - **Limitation for food-based biofuel** up to a maximum of 7%.

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OPPORTUNITIES FOR RETROFITTING

- ✓ **Policies** are the **main driver** to promote the transition from 1G to adavanced biofuels.
- ✓ **Advanced bioethanol** prouction still presents **uncertainities** regarding its **economic viability**.
- ✓ The **integration of 2G technology into an existing 1G facility** could be an excellent strategy to ease the transition from 1G generation to advanced biofuels.
- ✓ Integration of 1G and 2G technologies could result in **synergies and cost saving**:
    - Taking adavantage of the existing product distribution and feedstock supply and storage systems.
    - Using the lignocellulosic parts of the sugar and starch crops.
    - Sharing the purification areas.
    - Adapting the sugar content of the fermentation by mixing the mash.
    - Sharing the general infraestructure.
    - Using the lignin as a renewable fuel or for high-added value compounds production.

BIOETHANOL CASE STUDY - METHODOLOGY

Main objectives

- To develop a concrete case study for the **retrofitting of a 1G bioethanol facility** together with an industrial partner → VERTEX BIOENERGY

- To **compare the retrofitting case** to:
  - A **reference case**: current situation of the 1G facility
  - An **alternative case**: stand-alone 2G facility

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BIOETHANOL CASE STUDY - METHODOLOGY

PROJECT DESCRIPTION

- Current situation
- Retrofit case
- Alternative case

MARKET ASSESSMENT

TECHNO-ECONOMIC ASSESSMENT

SUSTAINABILITY ASSESSMENT

RISKS ANALYSIS

BIOETHANOL CASE STUDY - METHODOLOGY

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- **PROJECT DESCRIPTION**
  - Current situation
  - Retrofit case
  - Alternative case
- **MARKET ASSESSMENT**
- **TECHNO-ECONOMIC ASSESSMENT**
- **SUSTAINABILITY ASSESSMENT**
- **RISKS ANALYSIS**

Data acquisition:

- ✓ **1G bioethanol production:** real data from **Vertex Bioenergy.**
- ✓ **Advanced bioethanol production**: modelling of the retrofitting case through process simulation tools →**Aspen Plus V11** (Aspen Technology, Inc,USA):
  - ✓ Generation the mass and energy balance for calculating the raw materials, consumables, utilities and energy requirements.

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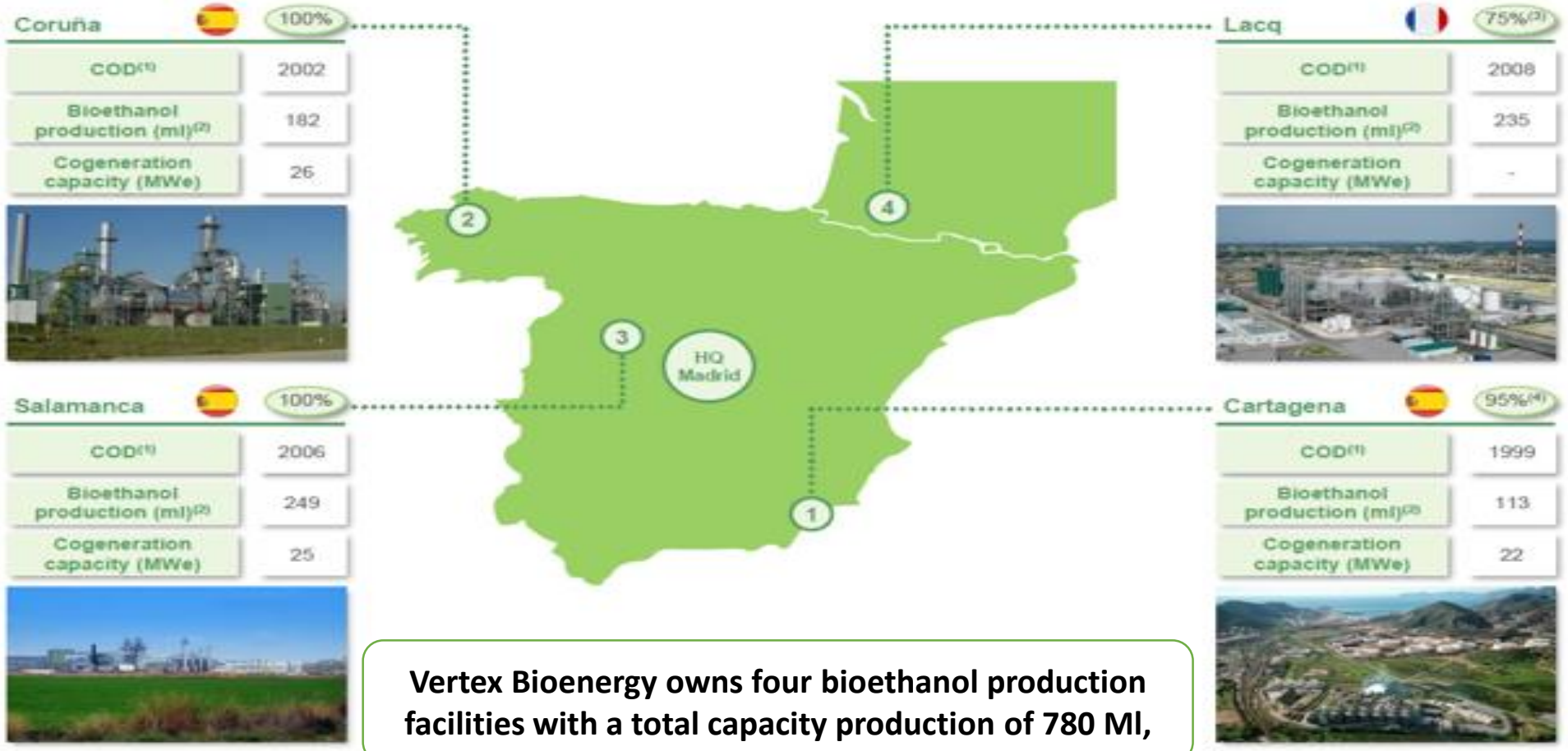
INDUSTRIAL PARTNER- VERTEX BIOENERGY



Vertex Bioenergy owns four bioethanol production facilities with a total capacity production of 780 Ml,

Source: Company information.
(1) Commercial operation date.

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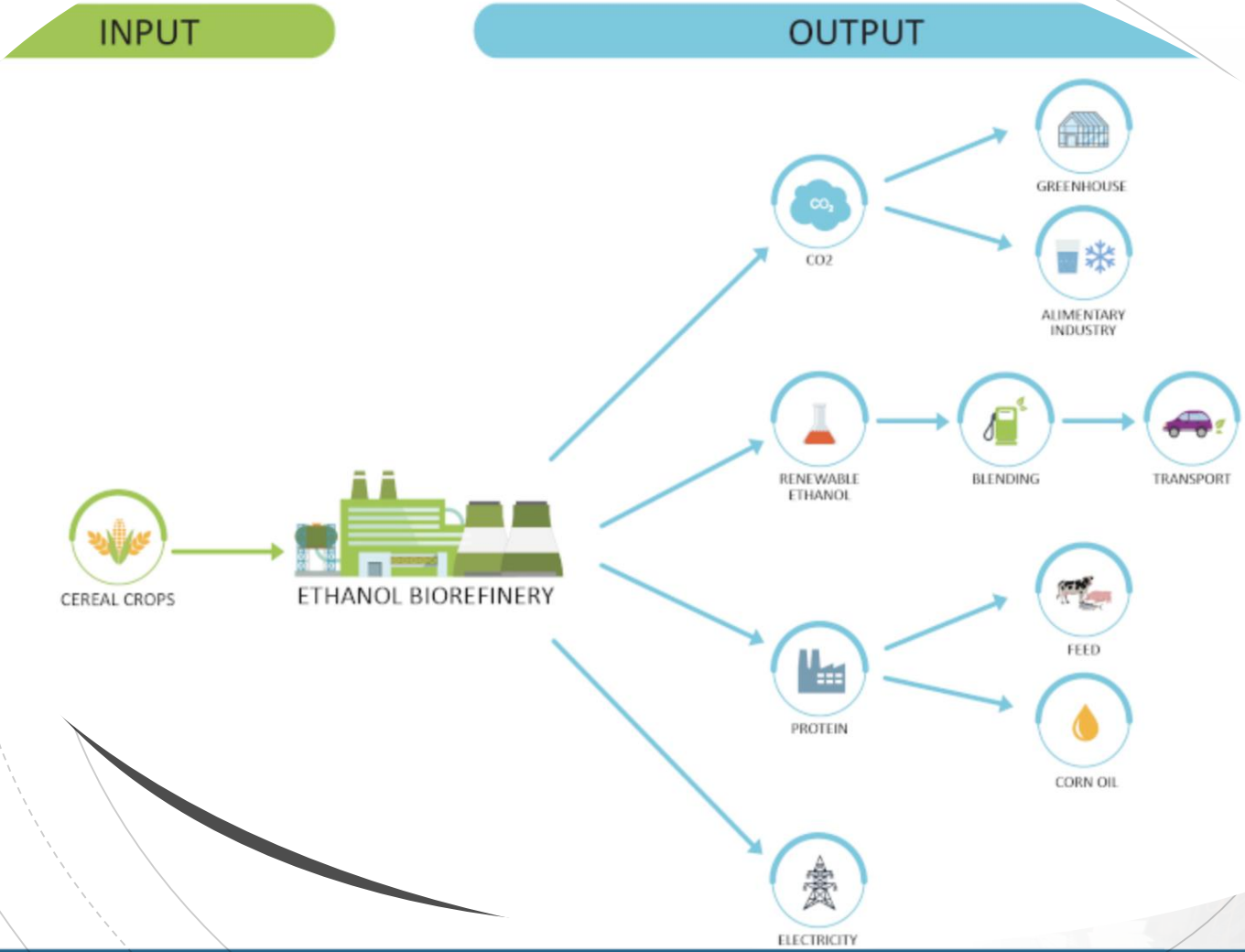
INDUSTRIAL PARTNER- VERTEX BIOENERGY



VERTEX BIOENERGY HAS ALSO A PRODUCTION CAPACITY OF **ANIMAL FEED** OF 505.000 TONNE PER YEAR AND 575.000 MWH OF **ELECTRICITY.**

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CASE STUDY

Biocarburantes de Castilla Y Leon (BCyL) facility, Salamanca (Spain)

CURRENT STATE

Feedstock:

- Corn grain: 562,800 t /year

Products:

- **Ethanol : 241,670 m^3/year**
- DDGS : 142,800 t/year
- Electricity : 207,900 MWh
- CO_2 : 40,000 t/year

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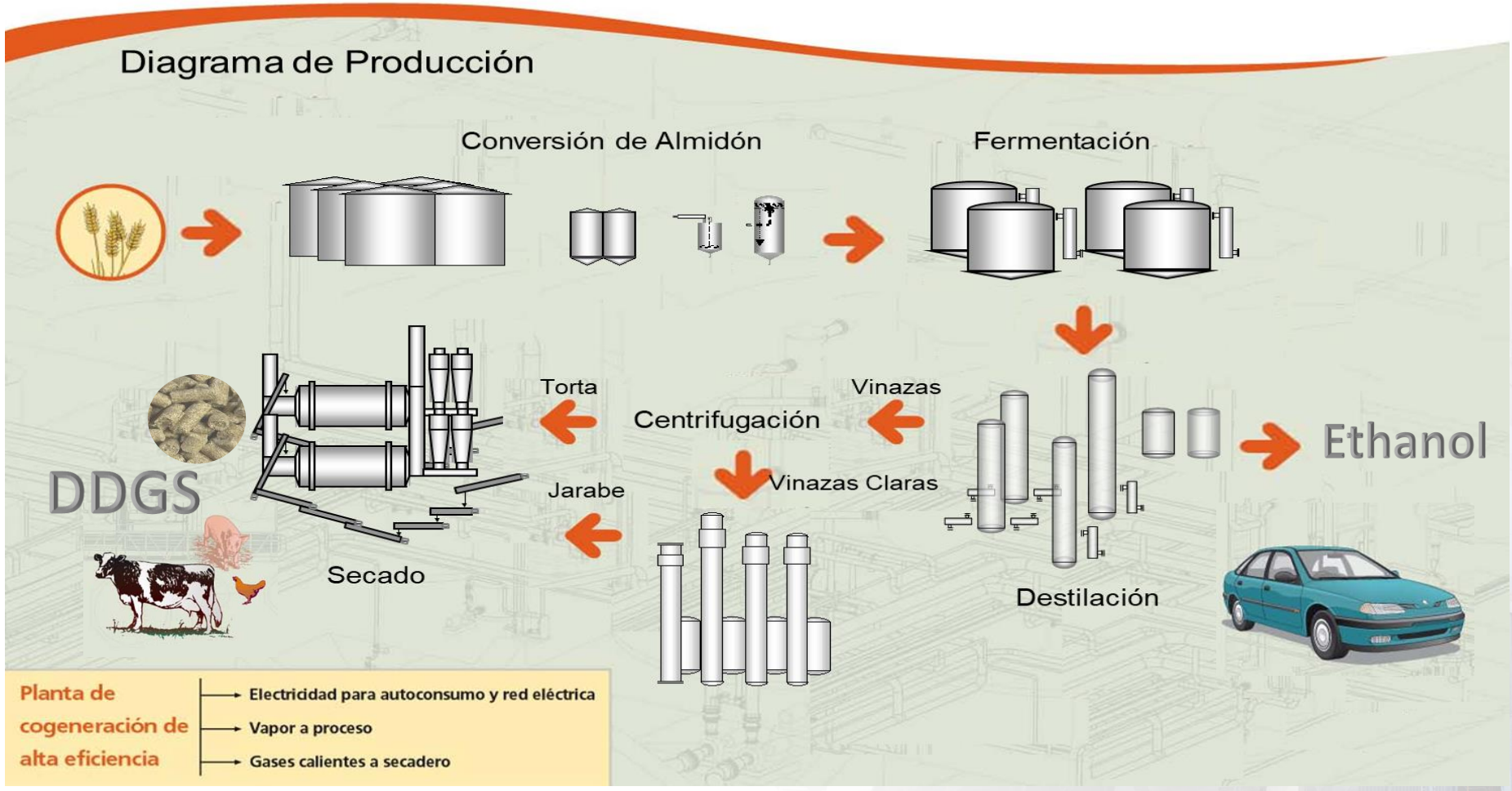
BCyL FACILITY



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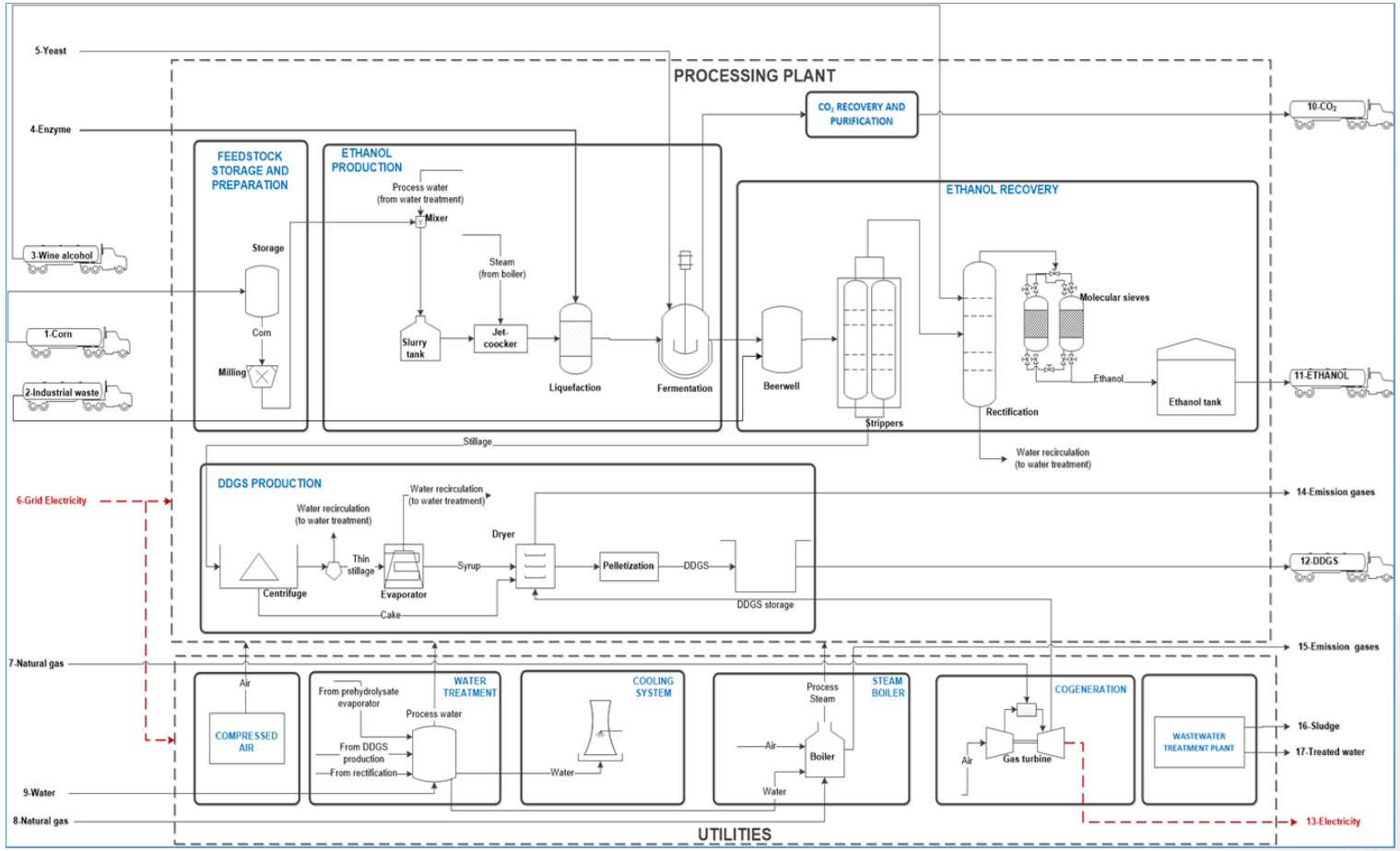
RETROFIT: CASE 1



- **Production** of **11,000 m3/year** of advanced bioethanol sustainable using **industrial residues** listed in RED II
- **Feedstock:**
  - Industrial waste from yeast production plant (10 % vol Ethanol): **20,000 m3/year**
  - Wine alcohol (93% vol Ethanol): **9,700 m3/year**

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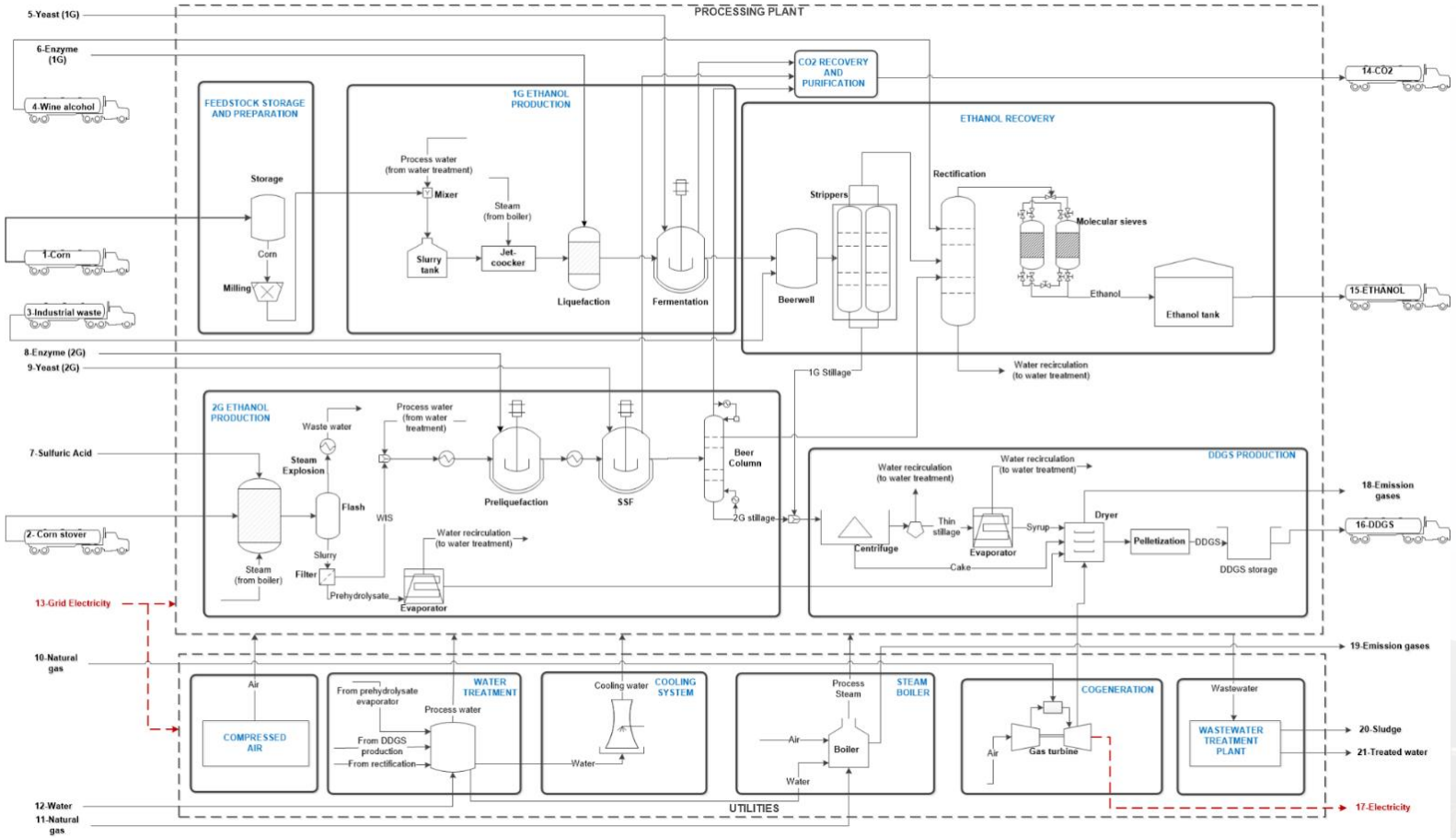
RETROFIT: CASE 2



- **Production** of 11,000 m3/year of advanced bioethanol from industrial residues and **19,000 m3/year** of advanced ethanol from **corn stover.**
- **Feedstock:**
  - ✓ Corn stover: 129,000 t/year
  - ✓ Industrial waste (10 % vol Ethanol): 20,000 m3/year
  - ✓ Wine alcohol (93% vol Ethanol): 9,700 m3/year

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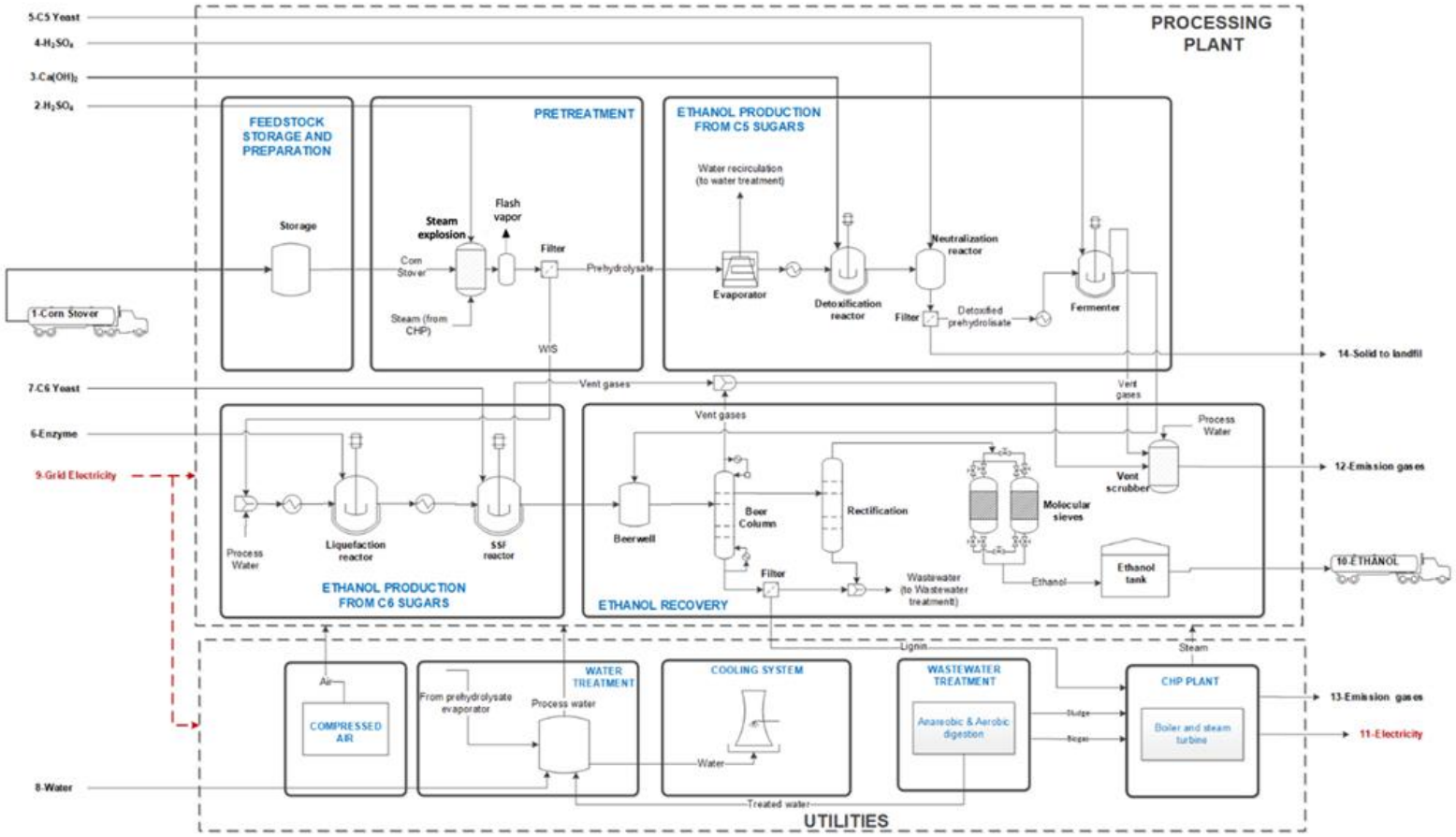
ALTERNATIVE SCENARIOS



- **Production** of **30,000 m3/year** of advanced ethanol from corn stover in a **Second-Generation facility.**

- **Feedstock:**
  - ✓ Corn stover: 114,000 t/year

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OUTCOMES FROM THE STUDY SO FAR…

Key Performance Indicators (KPIs)	
Technical	Increase in biomass converted per year Increase in bioenergy or biofuel generated per year
Economic	Internal rate of return CAPEX reduction compared to alternative
Environmental	Carbon dioxide equivalent emission reduction Increased efficiency of resources consumption

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OUTCOMES FROM THE STUDY SO FAR…

Key Performance Indicators (KPIs)

Technical

Economic

Environmental

Feedstock	Current situation	Case 1	Case 2
Corn (t/y)	562,800	537,184	492,937
Industrial waste (m^3/y)	-	20,000	20,000
Wine alcohol (m^3/y)	-	9,680	9,680
Corn stover (t/y)	-	-	128,680

Increased efficiency of resources consumption

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OUTCOMES FROM THE STUDY SO FAR…

Key Performance Indicators (KPIs)

Technical

- Increase in biomass converted per year
- Increase in bioenergy or biofuel generated per year

Economic

- Assessment in progress
- Preliminary results: better results obtained for **Case 2** than for **Case 1**, mainly due to the lower production of DDGS in Case 1

Environmental

- Carbon dioxide equivalent emission reduction
- Increased efficiency of resources consumption

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OUTCOMES FROM THE STUDY SO FAR…

Key Performance Indicators (KPIs)	
Technical	Increase in biomass converted per year Increase in bioenergy or biofuel generated per year
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Environmental	• Assessment in progress

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MARKET BENEFITS

- Reduction of food-materials for energy purposes.
- Promoting advanced bioethanol in the short-medium term
- Increasing the value chains of residual feedstocks.
- Diversification of feedstock

POLICY RECOMMENDATIONS

- The European **biofuel installations are fairly new** → Costly investments in retrofitting measures may seem early from a plant operator's view.
- **Biofuel sector is heavily influenced by regulations** → The high risk of change of regulation hinders investments in the biofuel sector.
- **Dedicated biofuel products** at the pump → It allows customer to choose sustainable fuels.
- The **CO_2 emissions** of the different fuels **should be visible to the customer** at the pump.

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Thank you!

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