Inventory database for biogenic gases production and Carbon Capture, Utilization and Storage (CCUS) technologies applied in the biofuel sector in Europe

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Introduction

The biofuels market in Europe is growing rapidly due to the need to reduce greenhouse gas emissions, enhance energy security, and promote sustainable alternatives to traditional fossil fuels (Malico, 2019). Although biogenic gases are greenhouse gases (GHG), they do not contribute to the accumulation of CO_2 in the atmosphere as they are part of the fast domain of the carbon cycle (Ciais et al., 2014). However, to obtain a circular economy in Europe, it is of crucial importance that the biofuel sector becomes circular and to achieve this, it is pivotal to know the current status of the biogenic emissions. Thus, it is essential to create an inventory database for biogenic gases production and Carbon Capture, Utilization and Storage (CCUS) technologies applied in the biofuel sector for, emissions tracking, resource planning (Malico, 2019), regulatory compliance, policy support, market transparency, research and development, international cooperation, and participation in carbon trading initiatives. This inventory database aims to identify and map biogenic CO_2 production from the biofuel sector and their CUS applications (Mac Dowell, 2017) by geographical distribution in terms of available quantities, targeting a comprehensive monitoring of the current situation of biofuels in the EU27. It focuses on the operational biofuel plants in the EU, and mainly on biogas, biomethane, bio-syngas, bio-ethanol, biomass thermoconversion (pyrolysis, gasification and combustion), and biochar production.

Methodology

The first step was to identify the plants by collecting general information such as name, address, company, country, website, and end-users as well as plant production details such as end-product, annual production, production process, feedstock, and annual feedstock. The second step was to find if the emissions are reported and to record the annual GHG emissions, annual biogenic GHG emissions or other biogenic gases. In addition, other emissions management information was collected, such as annual captured emissions, capture technology process, or emissions management technology, if used.

The final database includes as much of the following information (Table 1) as possible for each identified plant. Where biogenic CO_2 emissions were not reported, an estimate of these emissions was made based on the capacity of the plant, the production process and the feedstock used.

Table 1: Inventory database information fields for biogenic gases production and their CCUS applications in the biofuel sector in Europe

1.Facility name	2.Plant Address	3.Company Name	4.Country	5.Website	6.End product	7.Capacity (MW)	8.Heat Capacity (MWth)	9.Electricity Capacity (MWe)
10.Total Production (TWh/y)	11.Production (tn/y)	12.Price (€/MWh)	13.Clients/end-users (households, municipalities)	14.Feedstock Type	15.Annual feedstock consumption (tn/y)	16.Production technology	17.Are the emissions reported? (Yes/No)	18.CO_2 emissions (tn/y)
19.Biogenic CO_2 emissions (tn/y)	20.Other biogenic gases	21.Other biogenic gases (tn/y)	22.Capture process applied? (Yes/No)	23.Captured CO_2 (tn/y)	24.Capture process technology	25.Impurities in biogenic gases	26.Current management of biogenic gases in the plant	

The investigation performed for the database creation encompasses five distinct biofuel sectors:

i) Biomass gasification for syngas production

The mass of CO_2 produced from burning syngas comes from the average composition of syngas and the full conversion of the carbon produced to CO_2. The volume of syngas, if unknown, was calculated depending on its calorific value and the energy generated.

ii) Biomass combustion for renewable electricity and heat generation

Since the main source of biomass energy in most cases is various types of woody biomass, the carbon content of woody biomass was assumed equal to 50% (w/w) so the amount of CO_2 (kg) produced is based on the carbon produced for full biomass combustion with 10% of moisture. If the annual feedstock consumption was unknown, but the energy production (kWh) was recorded, then the CO_2 emissions were calculated based on the biomass net calorific value (NCV).

iii) Biomass fermentation for bioethanol production

To calculate biogenic CO_2 emissions during bioethanol production, a basic calculation for glucose fermentation was used. According to the fermentation reaction, for every litre of bioethanol, 0.75 kg CO_2 is produced.

iv) Anaerobic digestion for biogas and/or biomethane production

The estimation of biogenic CO_2 emissions from biogas plants involves two main steps. The first step is to determine the production of relevant end-products, such as biogas, biomethane, or electricity, and convert it into appropriate units (Nm^3/year, m^3/year, GWh/year for biogas and biomethane, and GWhel/year for electricity). The second step is to estimate the biogenic CO_2 emissions for each end-product. Converting biogas volume to CO_2 mass involves using an average biogas composition based on the feedstock. For converting biogas production (GWh) to biogas volume, one needs to divide the energy output by the higher heating value (HHV) of methane. To convert electrical output (GWhel) to biogas volume, it should be divided by the lower heating value (LHV) and the efficiency (η) of the cogeneration unit, which ranges from 0.25 to 0.40.

v) Biomass pyrolysis for biochar production.

The mass of biogenic CO_2 produced is calculated based on the mass of biomass pyrolyzed and its carbon content (approximately 50% for woody raw material) and the carbon yield contained in the biogenic gas (approximately 75%).

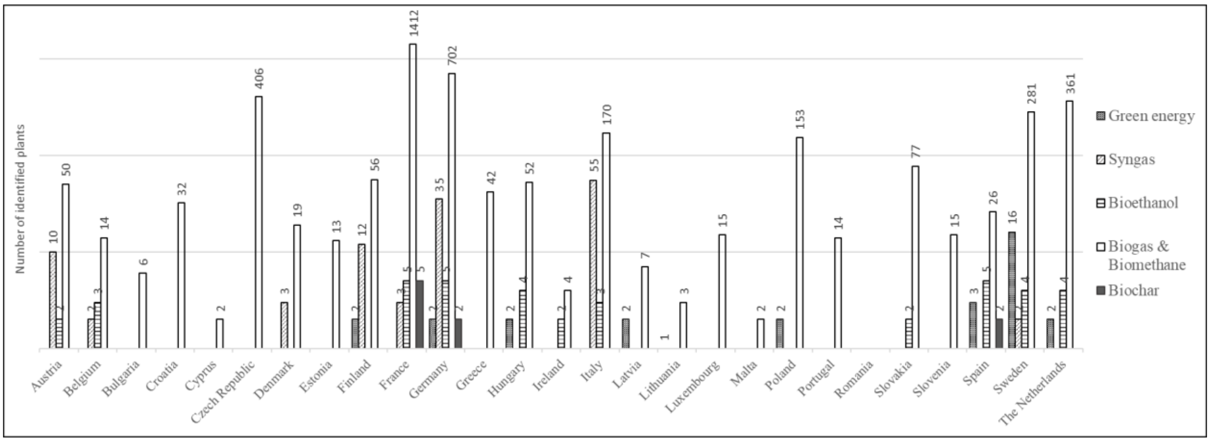

Figure 1: Number of identified plants per biofuel sector and per country

Results

The operational biofuel plants identified include 3,933 production plants of biogas & biomethane, 123 of bio-syngas, 45 of bio-ethanol 34 large operational production plants of green energy and 12 production plants of biochar. The following figure (Figure 1) illustrates the geographical distribution of the plants per sector.

Conclusions

The database created identified more than 4,000 biofuel production plants and it contains a large amount of information (spanning up to 26 different fields). However, in many of the plants, the information available is scarce or incomplete, being difficult to complete all the information fields. Among those plants, only 26 implement CCUS technologies, with 23 emphasizing on the capture and utilization of carbon dioxide, while three biomass combustion plants apply carbon capture and storage.

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