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SHORT COMMUNICATION

Creation of a participatory database of bioenergy projects

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Abstract. Bioenergy is part of the solution to decarbonize energy systems and the economy, and to decrease greenhouse gases emissions drastically. The main goal of this work is to present a participatory database of bioenergy projects, initially based on information available on the International Energy Agency website. This new database aims at being updated over time through data crowdsourcing and being easily exportable in a spreadsheet for further processing. It provides numerous information about bioenergy projects around the world like the types of technology, inputs, outputs, financial information and project status. A detailed overview of the current database is presented, as well as the modus operandi suggested to improve over time this resource through voluntary contributions. The growing quality of this database will serve future research projects and analysis, while being a relevant tool to contribute to the success of the bioenergy sector.

Keywords: participatory database; bioenergy; bioeconomy; data crowdsourcing; open data

1. Introduction

Biomass-based energy is a major focus due to the global challenges that the world is facing, especially energy resources depletion and global warming caused by the increase in greenhouse gases (GHG) emissions. Since 1990 until now, the world energy mix is still highly dominated by fossil resources (coal, oil and gas), as shown in Table 1 (International Energy Agency 2018a). Unfortunately, the share of fossil resources increased for the total primary energy supply and electricity generation. On the other hand, the share of heat generation using fossil fuels slightly decreases. Nevertheless, in absolute values, the energy consumption (including fossil) highly increased because of the growing world population. It is for example observable when examining the CO_2 emissions in the world (International Energy Agency 2018a): 20.5 billion tons (1990) and 32.3 billion tons (2015). Moreover, as fossil resources are finite, an increase in price should progressively be observable in the future. It would be the case for oil (Cunningham

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2018; Paraskova 2018a, b; U.S. Energy Information Administration 2018), but also for gas and coal (U.S. Energy Information Administration 2018).

Solving both issues (fossil resources depletion and GHG emissions) requires to change the energy mix and to give much more importance to renewables. Bioenergy has a major role to play as clean energy and fuels supplier. The bioenergy sector encompasses a large variety of inputs, technologies and outputs, as suggested by several reference books (Frank et al. 2006; Christopher 2013; Stuart and El-Halwagi 2013). Depending on the targeted kind of inputs and outputs, technologies should carefully be chosen (Villemont et al. 2017). A successful bioenergy project is not only based on technical aspects but also depends on economics and policy (Khanna et al. 2010; Lane 2018), and social considerations (Domac et al. 2005; Wegener and Kelly 2008). All these dimensions show how complex a bioenergy project can be and how difficult the definition of a successful pathway is to achieve this kind of project.

Table 1. World energy mix in 1990 and 2015 (International Energy Agency 2018a)

Percentage [%]	Total primary energy supply		Electricity generation		Heat generation	
	1990	2015	1990	2015	1990	2015
Fossil resources	81.12	81.46	63.28	66.18	98.08	92.68
Renewables	12.88	13.62	19.81	23.40	1.64	7.12
Nuclear	5.99	4.92	16.90	10.42	0.28	0.20

In this paper, the authors introduce a brand new participatory database on bioenergy projects based on data crowdsourcing. The initial information provided in the current version includes about 575 bioenergy projects collected and pretreated from the IEA-Bioenergy website (International Energy Agency 2018b). Crowdsourcing has been popularized for multiple applications such as encyclopedias like Wikipedia, data sharing like Wikidata (Vrandečić and Krötzsch 2014; Pellissier Tanon et al. 2016) or cartography like OpenStreetMap (Haklay and Weber 2008). In these applications, crowdsourcing has been highly efficient to gather the needed wide quantity of information, as stated by Hossain and Kauranen (2015). Hossain and Kauranen (2015) also highlight a major concern related to the accuracy and quality of information gathered through crowdsourcing. In the energy sector, Bazilian et al. (2012) reviewed several initiatives, mainly for data collection. The work presented in this communication is an attempt to leverage the potential of crowdsourcing in the bioenergy sector.

2. Problem statement and objectives

The bioenergy sector needs references so that the different stakeholders can take wise and proactive decisions on bioenergy projects. An up-to-date and centralized database gathering the information on a lot of these projects would then be valuable. The IEA already provides an insightful compilation of bioenergy projects. The authors' proposition is to increase the quantity of data through a participatory database which is updatable over time through data crowdsourcing and exportable as a spreadsheet file.

The next section presents an overview of the database, focusing on its content and general profile. The following section discusses how the database is operated, presenting how contributions can be provided to the project and how the updates are going to be implemented.

3. Overview of the participatory database

The first version of the database includes information about 575 bioenergy projects. The provided features include name of owner; name of project; location (country and city); startup date. It also provides the update date, date of last update achieved by the administrators of the database. Status of project such as failure, on hold, planned, commissioning, or operational are included in the database. The status of technology readiness level (TRL) is provided as well. Technology which includes algae-related processes, CHP (Combined Heat and Power), co-firing, fermentation, FCC (Fluid Catalytic Cracking), fuel synthesis, gasification, HTL (Hydrothermal Liquefaction), hydrotreatment and pyrolysis is included. Input (type and quantity): feedstock used in the project and output (type and quantity): target product as well as financial information (investment and/or funding) is informed in the database. The last but not least, contact information and additional information and/or potential references are also given in the database. When information is unavailable or unknown, "NaN" values are given. The following figures (Figure 1 to Figure 4) provide an overview of the database content.

Figure 1 presents the spatial distribution of the bioenergy projects in the world and their status. They are in 29 countries and most projects are implemented in Europe and North America. This figure also shows that these projects are mainly operational. In Europe, Scandinavian countries (Finland, Sweden and Denmark particularly) are leaders, closely followed by major countries like Germany, United Kingdom and Italy. Canada mostly relies on its woody resources to feed its bioenergy sector. USA is the country with the highest number of bioenergy project listed in the database. Emerging countries such as Brazil and China already have bioenergy projects and their share in the bioenergy sector is expected to increase in a near future. The database may not provide information on all bioenergy projects in the world. Consequently, a lot of significant projects may probably be missing. The interest of this database is to tackle these blind spots using crowdsourcing.

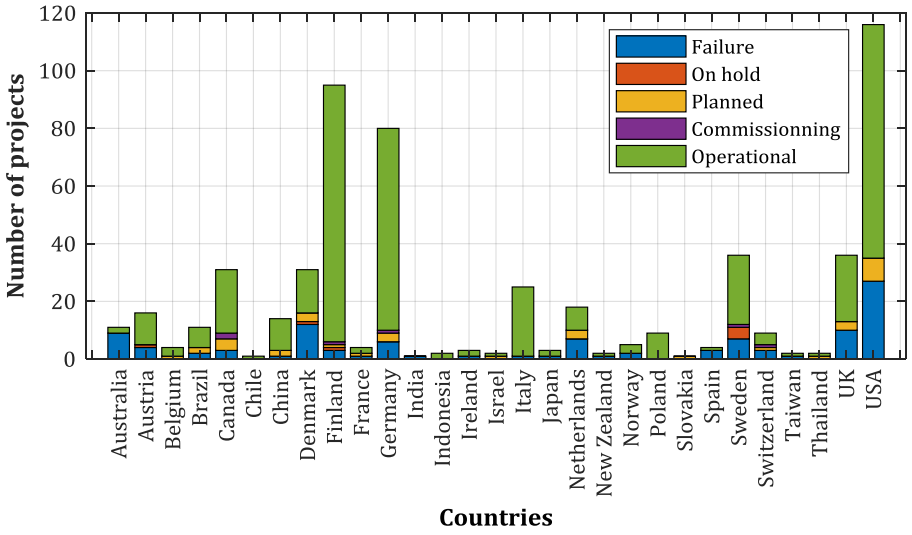

Figure 1. Number of bioenergy projects by country

An important criterion provided by the database is the Technology Readiness Level (TRL), which defines the technological maturity of a process or technology over a scale from 1 (the least mature) to 9 (the most mature) (Mankins 2009; Sanchez 2011). Figure 2 (a) shows that

more technologically mature projects have more likelihood to succeed. Another aspect must be noted: the most failure-prone phases are between the R&D (TRL < 5) and commercial (TRL = 9) levels, i.e. at the pilot and demonstration scales. This later phase is often called the "valley of death" in technology development (Ford and Dillard 2018). Results presented in Figure 2 (b) can be explained based on the previous TRL rationale. The most mature technologies (Combined Heat & Power [CHP] and co-firing) are the most numerous and successful while the least mature technologies (e.g. algae-related processes, fluid catalytic cracking [FCC] and hydrothermal liquefaction [HTL]) are the least numerous and the most failure-prone. These latter technologies can be represented as operational, but they are most of the time at the lab-scale, not demonstration or commercial.

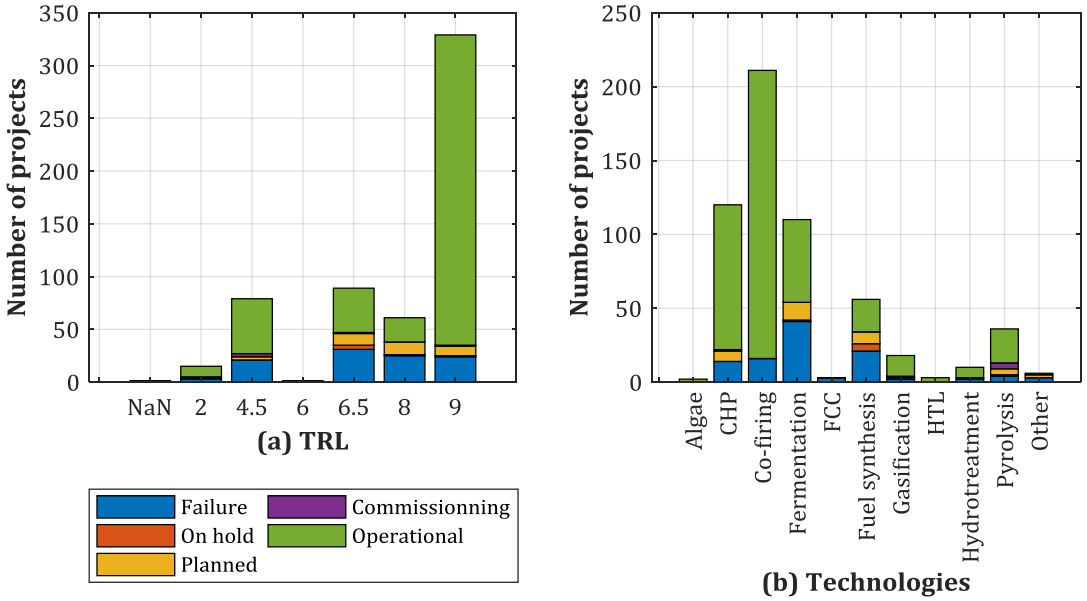

Figure 2. Number of projects by technology readiness level (TRL) (a) and technologies (b)

Figure 3 presents the number of projects depending on the type of inputs (a) and outputs (b). The use of energy crops (lignocellulosic) and a mix of coal and biomass represent most of inputs used in the bioenergy sector while the main targeted outputs are power and heat (as primary or secondary output). Liquid fuels and alcohols (mainly methanol and ethanol) also have a significant share that is expected to increase in the future to feed the growing biofuels industry.

Figure 4 indicates if financial (a) and contact (b) information are available in the database. Financial data are rarely given, probably due to the sensitive nature of this information. Besides, around half of the projects provides contact information.

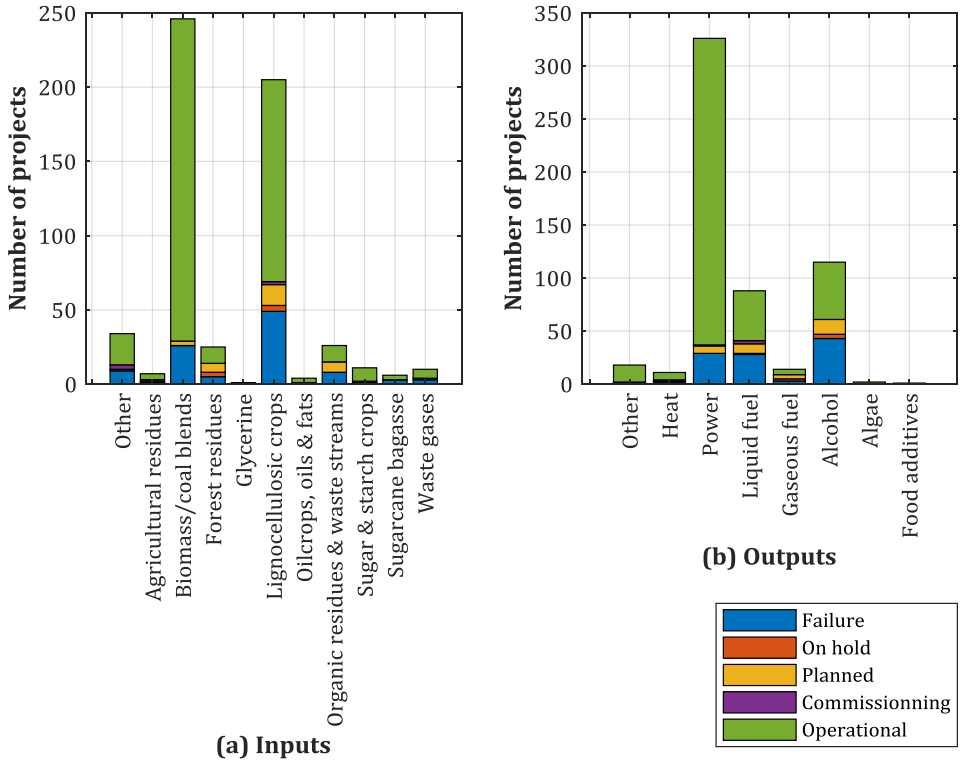

Figure 3. Number of projects by inputs (a) and outputs (b)

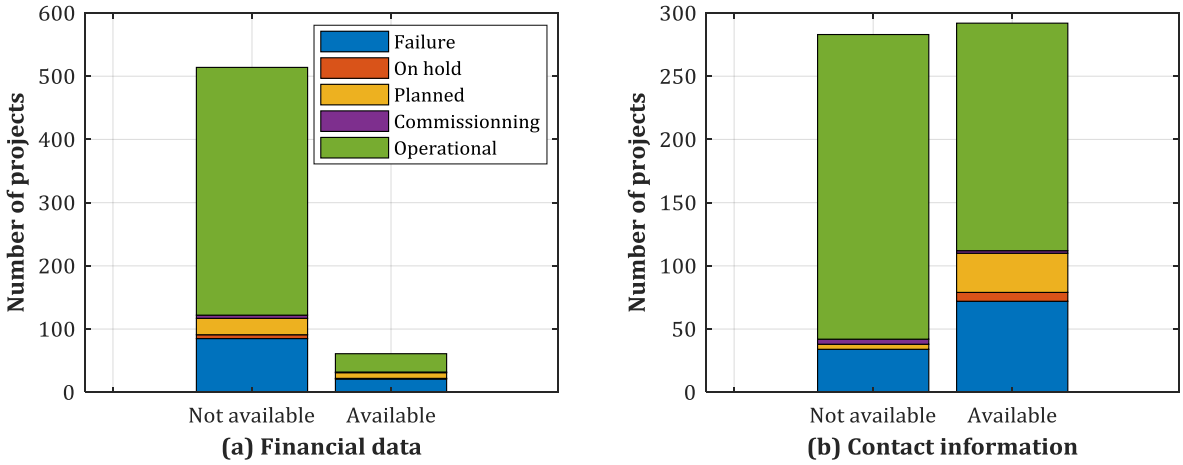

Figure 4. Number of projects with available financial data (a) and contact information (b)

4. Modus Operandi of the Participatory Database

The database is accessible in a read-only mode through the following reference (Delcroix et al. 2019a). The read-only mode is to prevent unregulated developments of the database. The spreadsheet is composed of two tabs, the first providing general information and the second showing the database.

Contributions to the database can be provided in another editable spreadsheet provided in the following reference (Delcroix et al. 2019b). This spreadsheet also consists of two tabs, the first presenting general information and the second being a template that can be completed by anyone wanting to provide insightful information about one or several bioenergy projects. The contributions should include information as presented in the beginning of section 3. Periodically, these contributions will be evaluated, validated and included in the database by the administrators. Experts, researchers, etc. wanting to become administrators can contact the current administrators. Based on their experiences and expertise, they could become administrators.

5. Conclusion

This paper presents the creation of a participatory database providing insightful information about bioenergy projects. This new database allows voluntary contributions and is easily downloadable as a spreadsheet file for further data processing and analysis. Its content is initially based on information available in the IEA website and is composed of data about bioenergy projects, including the types of technology, inputs, outputs, financial information and projects' status. It consists of two parts: first, an online spreadsheet file in read-only mode providing the current version of the database; second, another online editable spreadsheet file allowing to propose new contributions to enhance the content of the database. After evaluation and validation, the new content will be periodically added to the database by the administrators. This crowdsourcing approach has the potential to gather information rapidly and to increase the quality of the database. In brief, the long-term objective of this database is to serve future research projects and analysis and to contribute to the success of the bioenergy sector.

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