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KEROGREEN

"Production of Sustainable aircraft grade Kerosene from water and air powered by Renewable Electricity, through the splitting of CO_2, syngas formation and Fischer-Tropsch synthesis"

Project No: 763909

Deliverable D6.6

Conceptual paper on acceptability of KEROGREEN (Task 6.5)

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1 Purpose

The purpose of deliverable 6.6 conceptual paper on acceptability of KEROGREEN is to present the approach that is used to assess the theoretical acceptability of KEROGREEN in comparison to competing technologies. The resulting impact assessment matrix will be presented in KEROGREEN deliverable D6.7.

2 Methodology

2.1 General Approach

Unlike the environmental Life Cycle Assessment (LCA) and Life Cycle Costing (LCC), methods for the assessment of risks and opportunities regarding society are not as developed. However, the inclusion of the social sustainability aspects is necessary for a holistic assessment and eventually for a sustainable implementation of a new technology. The implementation of social impact assessment has already been discussed and highlighted as fundamental in 1993 during a workshop of the Society of Environmental Toxicology and Chemistry (SETAC) [1]. Hence, a Social LCA (S-LCA) is implemented and connected to the methods of LCA and LCC in this project.

The presented approach gives an overview on the potential impacts of KEROGREEN on environmental and social sustainability issues and fuel production costs in comparison to bio- and fossil-based fuel production. It should be clear that social welfare of people - regardless whether the fuel is produced and used domestically or exported to another country - should not suffer from the transition to another kind of fuel. This social welfare can be influenced at different levels, which is why a high amount of different indicator results is generated from the methods of S-LCA, LCA and LCC. The quantitative results are presented in an impact assessment matrix without weighing factors as a tool for acceptability assessment. As the actual acceptance of a technology depends on subjective values, the weighing of the indicators can be done individually with the impact assessment matrix.

Four different technical concepts of KEROGREEN are assessed which have been developed within the project. Eventually, those four concepts are compared to the results of fossil- and bio-based fuels (based on literature and the ecoinvent database) as competing technologies.

The available full load hours (flh) and social circumstances differ across the globe and have a strong influence on the results of all three assessment methods. Various KEROGREEN locations are modelled according to the different narratives and connected countries of possible Power-to-X producers presented in the Frontier Economics publication International Aspects of a Power-to-X Roadmap [2].

2.2 Life Cycle Assessment

According to the International Standard ISO 14040, the LCA method enables the identification of opportunities for an improved environmental performance of a product along the entire life cycle (from resource extraction and processing over manufacturing and the use-phase up to the point of disposal). Additionally, it can be used to inform stakeholders from industry, government or NGOs, to select relevant indicators for further monitoring and for marketing purposes. In this case, it is especially used to identify risks at an early stage of technological development in order to enhance the environmental performance and to give the possibility to evaluate the acceptability of KEROGREEN. [2]

Ecoinvent 3.71 is used as background database for the LCA of KEROGREEN. In combination with the Life Cycle Impact Assessment (LCIA) method ReCiPe 2016 it delivers the potential environmental impacts of all inputs and outputs from and to the biosphere with the according connections between the processes in the foreground and the background system of the LCA model. The foreground system consists of the KEROGREEN process, including feedstock provision, construction and operation of the plants with 1 kg of fuel as functional unit. The material and energy flows of the foreground system of KEROGREEN are based on simulations and calculations from the project. The construction of the plant (divided into several process steps) is modelled on the basis of related technologies in the ecoinvent database and similar models from the literature. Due to the early development stage of the process, the model is limited by a high level of uncertainty. Especially the construction of the plant is upscaled from lab- / pilot-plant-scale to an industrial plant with the capacity equal to an electrolyser with 1 MWe capacity. Nevertheless, first conclusions can be drawn regarding hot spots and potentials. The results (e.g. kg CO_2 equivalents) are expressed as potential environmental impacts per kg of fuel produced.

The models of the bio-based reference processes are based on KEROGREEN deliverable D6.4. The model of the fossil kerosene production is based on the ecoinvent process *market for kerosene – Europe without Switzerland* which considers international supply chains as input.

2.3 Life Cycle Costing

Life Cycle Costing is generally used to assess different investment possibilities considering the life cycle of a product. The results are divided into operational expenditures (OPEX) and capital expenditures (CAPEX) with the functional unit of 1 kg of fuel. The costs are determined from the fuel producer´s perspective here. The costs that are connected to the provision and usage of the fuel afterwards are assumed to be equal for all assessed technologies and therefore excluded from the assessment.

The cost flows for KEROGREEN are based on cost estimates from the project partners in combination with additional cost factors and respective values from literature sources. The cost factors account for CAPEX beyond the purchasing price of the plant and for OPEX. As a more specific part of OPEX, the labor costs for operating the plant are calculated with the formula from Peters et al. (2004) [4] in combination with country-specific salaries from [5], [6], and [7].

The fuel production costs for the fossil- and bio-based reference processes are based on KEROGREEN deliverable D6.4.

2.4 Social Life Cycle Assessment

Social Life Cycle Assessment (S-LCA) is a method for the social risk assessment of products and services along the entire life cycle. Considering the three pillars of sustainability, the connection of S-LCA with LCA and LCC results in a life cycle sustainability assessment [8].

The PSILCA v.3 database is used for the life cycle-based social risk assessment for KEROGREEN. Risks and opportunities for different stakeholder groups can be identified along the life cycle with 69 qualitative and quantitative indicators. The results are expressed in medium risk hours, which represent the average share of each worker hour along the life cycle that bear a medium risk of the according social impact. The quantitative value for a medium risk varies across the different impact categories.

PSILCA is based on a multi-regional input/output database, which is called Eora. All processes in the PSILCA database are related to industry sectors within 189 included countries or regions. The functional unit of each process is measured in US Dollar Output (USD). Other outputs than the functional unit are the risks of the assessed process itself. The inputs are the materials and services from other industry sectors within the country / region or from other countries / regions, measured in USD. Each one of the inputs bears risks on their own and contributes to the risk of the assessed process with the corresponding risk hours of their output.

The scope of the S-LCA is limited to the main feedstock in this work, which is electricity for KEROGREEN, biomass for bio-based fuels and crude petroleum for fossil kerosene. The construction of the plants is excluded due to a lack of specific data.

2.5 Choice of Indicators

The indicators are chosen with a focus on various sustainability issues that can be connected to the provision of biomass, petroleum or to the general energy sector and provision of fuel, especially with regard to different locations around the world. The information about the indicators is sourced from the ReCiPe 2016 v1.1 report and the PSILCA v.3 database documentation [9], [10].

Impact category	Unit	Indicator information	Potential impact
Fine particulate matter formation	kg PM2.5 eq	LCA indicator for assessing the air pollution by matter with a diameter less than 2.5 µm along the life cycle.	Damage to human health
Global Warming Potential	kg CO_2 equivalents	LCA indicator for assessing the additional radiative forcing integrated over 100 years along the life cycle.	Damage to human health, damage to the terrestrial and aquatic ecosystem
Land Use	m2a crop eq	LCA indicator for assessing the area and time integrated for land use along the life cycle.	Damage to the ecosystem
Marine Eutrophication	kg N to marine water	LCA indicator for assessing the dissolved inorganic nitrogen increase in marine water	Damage to the marine ecosystem
Fuel production costs	€ / kg	CAPEX and OPEX are levelized to the output of 1 kg of fuel.	Higher fuel prices

Active involvement in corruption and bribery	Medium risk hours	S-LCA indicator for assessing the risk of companies along the life cycle being actively involved in corruption and bribery.	“Corruption translates into human suffering, with poor families being extorted for bribes to see doctors or to get access to clean drinking water. It leads to failure in the delivery of basic services like education or healthcare. It derails the building of essential infrastructure, as corrupt leaders skim funds” [11]
Child labor	Medium risk hours	S-LCA indicator for assessing the risk of child labor occurring along the life cycle.	“Child labour can result in extreme bodily and mental harm, and even death. It can lead to slavery and sexual or economic exploitation. And in nearly every case, it cuts children off from schooling and health care, restricting their fundamental rights and threatening their futures.“ [12]
Indigenous rights	Medium risk hours	S-LCA indicator for assessing the Indigenous People Rights Protection Index along the life cycle.	“eviction from their ancestral lands, being denied the opportunity to express their culture, physical attacks and treatment as second-class citizens.” [13]

2.6 Impact Assessment Matrix

With result indicators from all three sustainability dimensions, opportunities and challenges of implementing KEROGREEN as fuel providing technology can be identified. A single technology generally cannot lead to positive outcomes in every aspect. The Impact Assessment Matrix can be used to assess the potential trade-offs and co-benefits.

Impact / Risk Category	All scenarios achieve lower impact than bio and fossil	Best case scenario could achieve lower impact than bio and fossil	All scenarios could achieve lower impact than bio or fossil	Best case scenario could achieve lower impact than bio or fossil	Median with lower impact	No improvement	Weighting
Potential GWP							
Potential Fine Particulate Matter Formation							
Potential Land Use							
Potential Marine Eutrophication							
Potential Fuel Production Costs							
Risk of Corruption and Bribery							
Risk of Child Labor							
Risk of Human Rights Issues faced by Indigenous peoples							

Whether certain improvements are considered as important or not depends on the perceived impacts and personal preferences. Therefore, this matrix can be used with the provided information as a personal acceptance assessment tool.

3 Limitations

All results are influenced by the chosen locations and not all possible locations are assessed within this project. Hence, different locations could still lead to other impacts, especially regarding the social risks.

The KEROGREEN models are based on early-stage simulations and assumptions, as the process is not yet fully developed. The efficiency and thereby especially energy demand and production costs could still change with further development.

The scope of the S-LCA is reduced in comparison to the other applied methods. Furthermore, the implemented data of the PSILCA database is based on the entire industry sectors and their precursors, which means that social risks of electricity provision are not limited to renewable sources, unlike it is the case for the LCA and LCC models. However, the risks cannot be further distinguished from the available data.

4 Conclusions

With the transition to an innovative technology for a lower impact on climate change, other potential environmental impacts and socio-economic risks must not be neglected. A general interest in less CO_2 emissions can be assumed as valid; any other potential trade-offs and co-benefits are subject to personal preferences and level of personal impact. Due to the high amount of assessed impact categories, this decision on weighing should be left to the public audience.

It is important to highlight that the quantitative assessment of social risks itself is connected to a high level of uncertainty and is not meant to evaluate countries. A high social indicator result in a certain country does not necessarily mean that the risk in the country itself is high, but the high risk can also be based on many different contributions along the value chain that ends with the initially assessed country. Furthermore, the results should not be used to exclude certain countries, but rather to identify hot spots and to implement measures that could lower the risks.

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