Proposal title:

"Advanced direct biogas fuel processor for robust and cost-effective decentralized hydrogen production" BioRobur^{Plus}

Topic: FCH-02-2-2016. Development of compact reformers for distributed bio-hydrogen production

Funding scheme: Collaborative project

Start date of project: 1st January 2017

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Deliverable: Final PUEF including potential future penetration of the BioRoburplus technology in spin-off fields, including a disclosable version.

Organization name of lead contractor for this deliverable:

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Dissemination level: **Public**

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Versions and Changes

Version	Date	Changes	Author
1	02/11/2021	Deliverable Version 1	Freddy Liendo
2	07/01/2022	Deliverable Version 2	Freddy Liendo
4.	21/03/2022	Deliverable Final Version	Freddy Liendo

Contents

1. Executive Summary

This document reports the final version of the Plan for Use and Exploitation of the Foreground (PUEF) generated during the project (where "Foreground" means the results, including information, materials and knowledge, generated in the project). This is one of the deliverables (D6.8) foreseen in the BioRobur^{Plus} Project proposal, corresponding to Task 6.3. The Task involves the organization and implementation of an Exploitation Road map to facilitate the development of the project's Plan for Use and Exploitation of Foreground.

The PUEF contains a thorough description of the identified exploitable results of the project, their characterization in terms of commercial viability for the near future, identification of Intellectual Property Rights for all project partners and their exploitation claims and interests, together with a risk assessment of these exploitable results and mitigation actions for the identified risks. This deliverable also includes the results generated in the project with Potential Commercial or Industrial Applications and Intellectual Property Rights.

The PUEF is one of the mandatory reports that h2020 projects are required to submit to the EC. The PUEF summarises the consortium's strategy and concrete actions to disseminate, exploit and protect the foreground generated by the project. It is a guideline to the Consortium for the Dissemination and Exploitation activities to be carried out in the context of the BioRobur^{plus} project. This report is the first PUEF release. It gives an introduction of renewable hydrogen production technologies and respective comparison with BioRobur^{plus} technology. It also provides the exploitable results and the potential routes for their exploitation that project partners have envisioned at the beginning of the project and which are being redefined as the project technically is progressing.

2. Introduction

The aim of BioRobur^{plus} project is the development of a robust and efficient hydrogen production processor from biogas with no preliminary CO_2 separation. The TRL6 demo-plant will deliver at least 50 Nm^3/h (107 kg/day) of H_2 at 99.9% purity and 1.5 bar with an energy efficiency conversion of 81% on a HHV basis. The ways to reach this objective are:

I. high thermal integration,
II. PSA (pressure swing adsorption) offgas exploitation for reformer feed preheating,
III. power consumption minimization through CO_2 removal prior to the PSA.

The application envisaged by BioRobur^{plus} project are related with the industries with decentralized hydrogen production uses. The use of the BioRobur^{plus} system as renewable hydrogen production units connected to small local biogas distribution networks hosting small biogas production sites and various users including industries utilizing biogas in their production purposes all over the year and hydrogen production and distribution facilities employing the BioRobur^{plus} technology. As a consequence, the exploitation will focus on these activities, which will be the recipient of know-how produced y BioRobur^{plus}. Speaking in terms of technology segments, BioRobur^{plus} tackles mainly sectors transportation, industrial energy and industry feedstock. Additionally, other potential applications related with the knowledge produced by BioRobur^{plus} project during its lifetime, i.e. at component level, will also be investigated and analyzed, including spin-off activities, innovative products and future research.

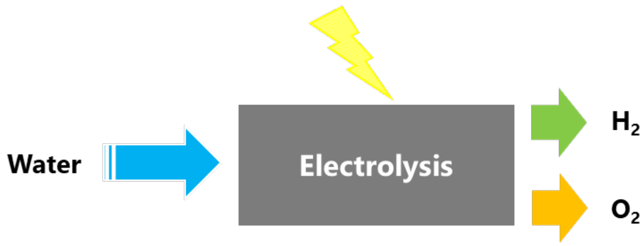
This document starts with a briefly description of the BioRobur^{plus} process with competitive technologies and systems for renewable hydrogen. Furthermore, a preliminary identification of the project impact is given and finally the exploitable results that so far has been identified are described.

The Exploitation Plan (EP) is being designed in order to multiply the impact of the proposed solutions and ensure the exploitation beyond the project itself. The exploitation strategy aims to reflect and will be built-up as a result of a complete analysis of the market trends, potential users, and financial sustainability. The target users will be identified and analyzed in terms of specific needs and objectives.

3. Technologies and systems for renewable hydrogen production

Hydrogen is a flexible energy carrier that can be produced from any regionally-prevalent primary energy source. Moreover, it can be effectively transformed into any form of energy for diverse end-use applications. However, its production plays a critical role to determine how properly it fulfils the sustainable and environmentally friendly fuel criteria. Currently, the largest use of hydrogen is in industry and refining as a by-product from industrial plants and as a product from reforming of natural gas, liquefied petroleum gas and coal gasification.
Renewable hydrogen can be produces from reforming, electrolysis and fermentation processes. A technology benchmarking will be performed between the following process:

- **The electrolysis process** consists of using an electrical current to split the molecules of water into its main building blocks, i.e. hydrogen and oxygen. The process is currently regarded as the ideal technology for producing sustainable hydrogen. This is provided that sustainable electricity is used. However, the current electricity mix, which is for a large part still coal-based, means the production of hydrogen via electrolysis is even more carbon intensive than production from natural gas using SMR.



- Hydrogen production from **fermentation process**. Dark anaerobic fermentation is one of the most promising processes for the bio-hydrogen production. It's possible to use a wide variety of inexpensive feedstocks as the organic fraction of municipal wastes, fruit and vegetables-based market wastes. This process is carried out by anaerobic bacteria belonging to Clostridia species, highly concentrated in anaerobic digested sludge.

- **BioRobur^{plus} technology** is based on the hydrogen production from biogas via oxidative steam reforming (OSR) reaction. The peculiar feature of OSR approach lies in the fact that heat is directly provided within the reactor, through partial oxidation of the biogas supported by heat recovery on the feed gas streams This eliminates the need of indirect heating within the reformer, and increases the flexibility of the plant, otherwise characterized by several temperature interval constraints and heat transfer limitations in thermally-coupled equipment.

  BioRobur^{plus} Project will demonstrate the capacity of bio-hydrogen production from biogas in a cost competitive and sustainable manner thereby replacing traditional industrial routes with a novel approach by exploiting all possible energy integration means, as well as innovative structured catalysts and control means to achieve not only cost-competitiveness but also durability and environmental viability.

A technical-economic-environmental comparison of BioRobur^Plus technology with competitive technologies and systems for renewable hydrogen production (direct bio hydrogen production from fermentation and electrolysis concepts) will be performed in the next months when more experimental data of BioRobur^plus technology will be available.

4. Preliminary Market Analysis

As mentioned before, BioRobur^plus project targets on the development of a complete fuel processor for the direct conversion of biogas into hydrogen. Thus, the current and projected biogas production has been analyzed in order to estimate properly the dimension of the related impact of the BioRobur^plus project.

4.1. Biogas production in Europe: current status, future perspectives

The number of biogas plants in Europe has greatly increased. Between 2009 and 2016, the total number of biogas plants rose from 6,227 to 17,662 installations [1]. According to the EBA (European Biogas Association), there were at least 17.439 biogas plants in Europe at the end of 2015, which is a 3 % year-on-year increase (16,834) and 17,662 unit at the end of 2016 (Figure 1). Every EU country has a biogas energy recovery, but about 75 % of the output is concentrated in three countries, Germany (8 Mtoe), the UK (2.4 Mtoe) and Italy (2 Mtoe), as is possible to see in the Figure 2. They are followed by the Czech Republic and France running neck and neck with about 0.6 Mtoe each. Germany is the undisputed No. 1 biogas producer country with 10,846 biogas plants [2]. Furthermore, it is estimated that 16,093.6 ktoe of biogas primary energy was produced in 2016 in the European Union. The landfill biogas (17.2 % in 2016) and wastewater treatment plant shares (8.7 % in 2016) have been falling steadily.

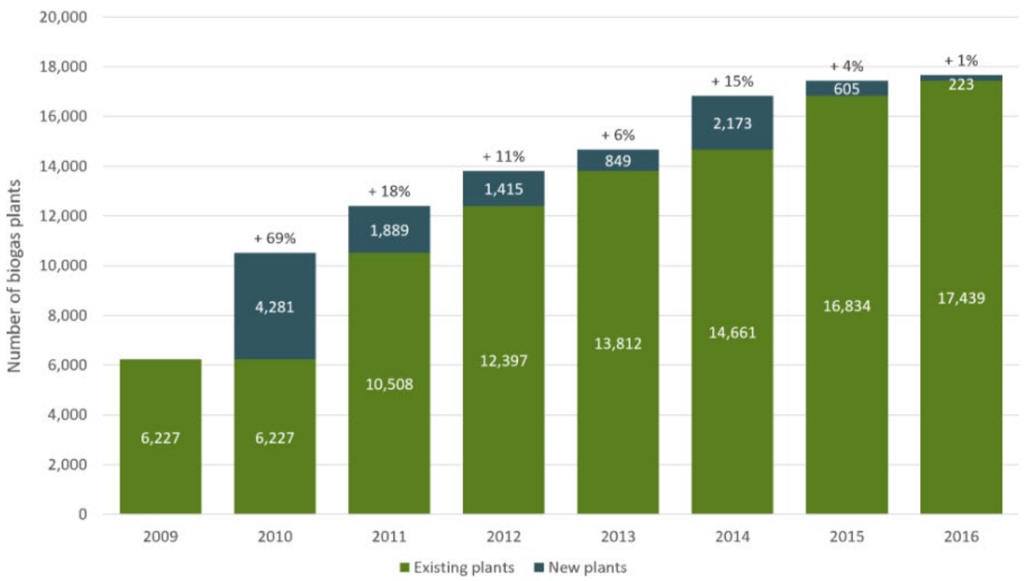
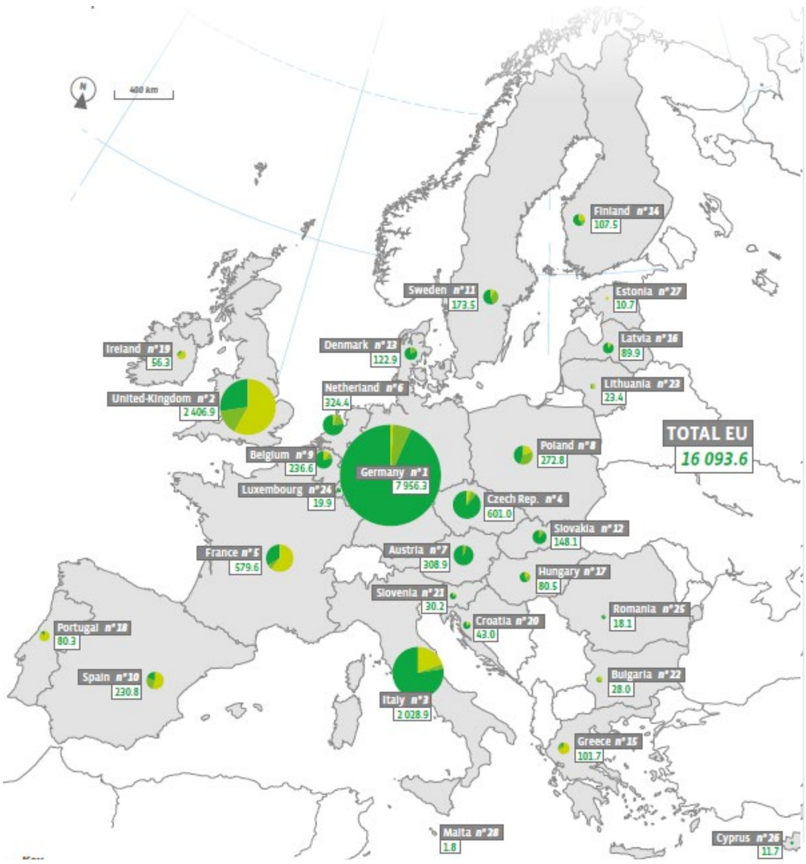


Figure 1. Evolution of the number of biogas plants in Europe (adopted from [1]).

Figure 2 shows how this scenario is declined at a national level, with Germany and Italy (heavily represented in the BioRobur^plus partnership) holding the most important production of biogas from decentralized sites and organic waste valorization. A more sustainable policy of (local) waste valorization plays in favour of a significant growth of this type of biogas production facilities as opposed to landfills. The BioRobur^plus technology for the cost-effective production of hydrogen from biogas aims at gaining significant market penetration in this perspective, starting from Countries like Germany, the UK or Italy, but with great application opportunities all over Europe owing to the flexibility of its components which are expected to fit several different biogas sources.



Legend:

- Landfill gas.

- Urban sewage and industrial effluent sludge gas.

- Other biogas.Decentralised agricultural plant, municipal waste methanisation plant, centralised co-digestion plant.

Figure 2. Map of installed biogas plants in Europe 2017 (Source: EurObserv'ER 2017) [2].

The potential biogas production for the EU28 in 2030 is calculated to be 28.8 and 40.2 Mtoe in the growth and accelerated growth scenarios respectively [3]. This is about 1.9 and 2.7 times larger than the biogas production in 2014 (Eurostat data). Clearly, these results show that there is a considerable growth potential of biogas from digestion of waste streams, if the right policies and regulations are put in place.

In Europe, the highest percentage of the total production of biogas comes from the many small-scale digesters producing small quantities of biogas (50-200 Nm^3/h) which exactly matches the BioRobur^plus concept and gives an immediate idea of its huge potential penetration in the hydrogen economy perspective. In this context, the BioRobur^plus technology, capable of processing at high efficiency just-desulphurized biogas for pure hydrogen generation purposes is expected to provide a significant impulse to the growth of the decentralized biogas generation, well beyond the already interesting level achieved in Countries like Germany or Italy, also on the grounds of specific incentives.

Another application opportunity which should provide impact to the BioRobur^{plus} systems is the use as renewable hydrogen production units connected to small local biogas distribution networks hosting small biogas production sites and various users including industries utilizing biogas in their production purposes all over the year and hydrogen production and distribution facilities employing the BioRobur^{plus} technology.

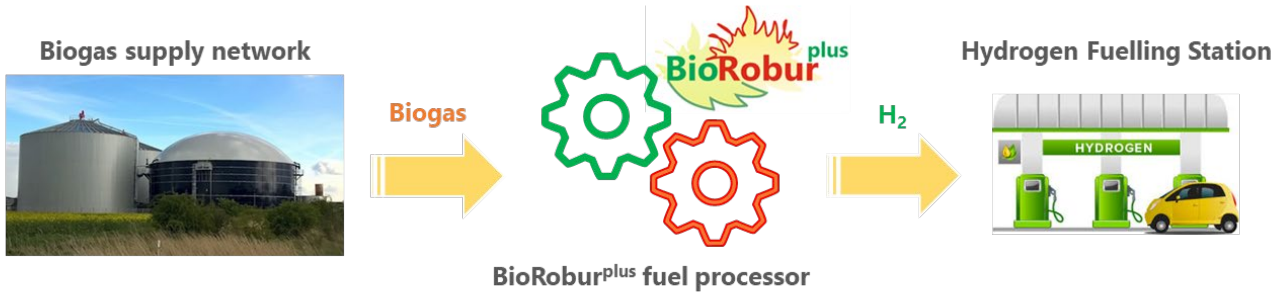


Figure 3. Possible scenario: Networking using BioRobur^{plus} technology in the distributed energy market.

4.2. Hydrogen Market Opportunities

Currently, the largest use of hydrogen is in industry and refining as a by-product from industrial plants and as a product from reforming of national gas, liquefied petroleum gas and coal gasification
Hydrogen can link different energy sectors and energy transmission and distribution networks, and thus increase the operational flexibility of future low-carbon energy systems. Hydrogen is a flexible energy carrier that can be produced from any regionally-prevalent primary energy source. Moreover, it can be effectively transformed into any form of energy for diverse end-use applications (Figure 4).

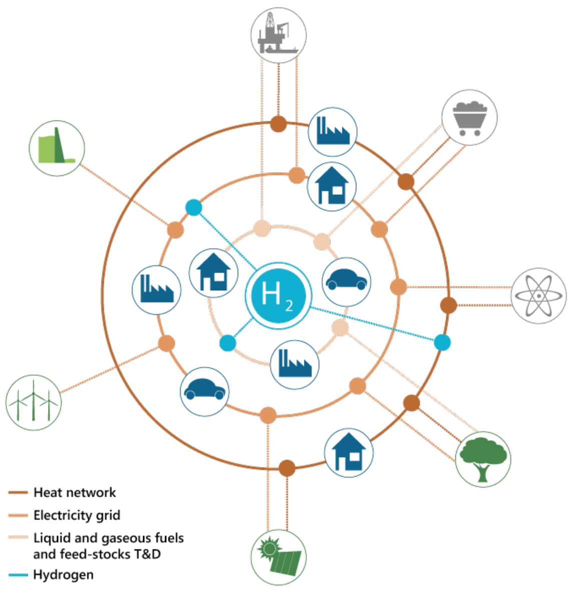


Figure 4. H_2 has a portfolio end-use (taken from [4])

Hydrogen has been identified as a central pillar of the required energy transition, in the last study performed by Hydrogen Council [5]. The hydrogen scaling up study outlines a comprehensive and qualified long-term potential of hydrogen and a roadmap for deployment, which shows seven major roles that hydrogen can play in this transformation (Figure 5).

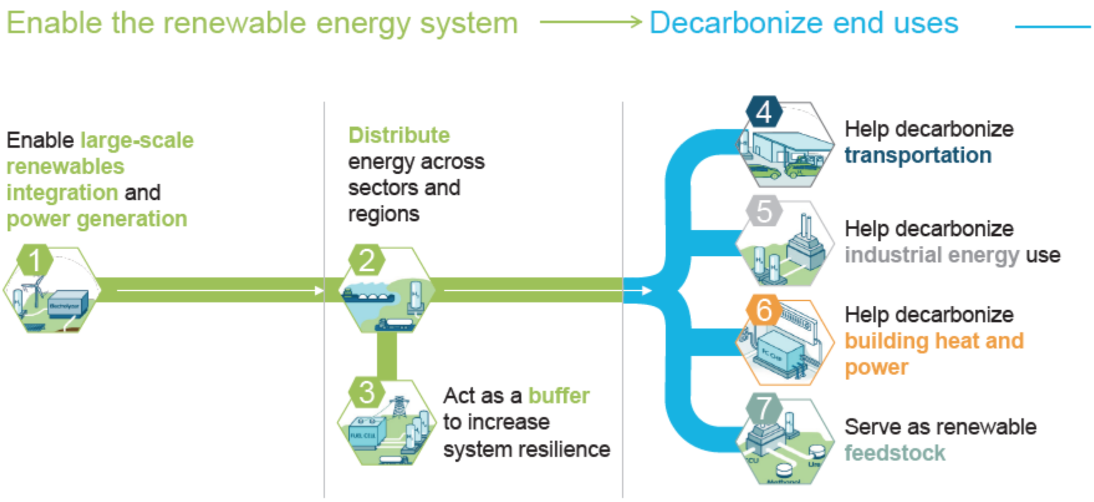


Figure 5. Roles of the hydrogen in the energy transition (Source: Hydrogen Council [5]).

Across all seven roles, hydrogen could account for 18% of total final energy consumed by 2050.

Figure 6. Hydrogen vision for 2050 (Source: Hydrogen Council [5]).

This would reduce annual CO_2 emissions by roughly 6 Gt compared to today's technologies and contribute roughly 20% of the additional abatement required to limit global warming to two degrees Celsius. Its deployment potential would avoid the consumption of more than 20 million barrels of oil per day compared to today's energy composition. It would radically decrease the need and energy required to transport fossil fuels across the world and increase self-reliance and energy security. Alongside its environmental benefits, the hydrogen economy could create opportunities for sustainable economic growth. The study envisions a market for hydrogen and hydrogen technologies with revenues of more than $2.5 trillion per year and creating more than 30 million jobs by 2050 [5,6].

As a result, it is obvious that there is a positive trend for the hydrogen application in the energy transformation required to limit global warming to two degrees Celsius. Hence, the timing for the demonstration of BioRobur^plus technology is very good.

The most bankable business cases so far identified for BioRobur^plu s technology, in the short- and medium-term could involve mobility and industry feedstock as primary applications.

Transportation sector

Deployment of hydrogen mobility is currently strongly politically driven. Many EU Member States have published ambitious national roadmaps on hydrogen mobility. Most roadmaps estimate an exponential growth of hydrogen mobility after 2020 [7]. The most ambitious roadmaps are Germany, France, Scandinavia, Italy and UK.

EU-wide	2017	2020	2025
# FCEV	600	4 000	800 000
# Buses	85	575	1 800
# HRS	85	740	1 500
H_2 demand (t/yr) *	550	3 650	120 500
Equiv. Electrolyser (MW baseload/yr)	3	21	690

*Assuming FCEV 0.5 kg/d and buses 20 kg/d @ 270 days

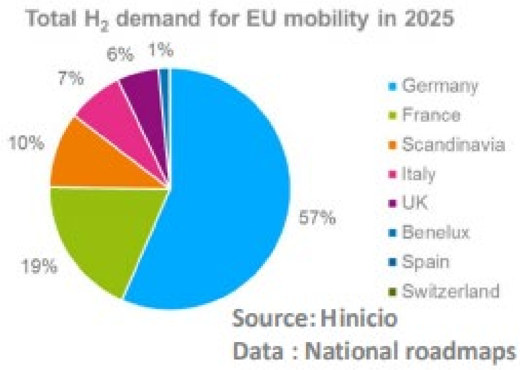


Figure 7. EU Hydrogen mobility deployment projection in 2017-2020-2025 [7].

On the demand side, the Hydrogen Council sees the potential for hydrogen to power about 10 to 15 million cars and 500,000 trucks by 2030. Current global announcements for investment in more than 5,000 hydrogen refuelling stations have be done in California, North-eastern US, Germany, Denmark, France, Netherlands, Norway, Spain, Sweden, UK; Dubai; China, Japan, South Korea

Industry Feedstock

Chemical and petrochemical industries use about 25 EJ worth of fossil fuels as feedstock each year and about 8 EJ of hydrogen; most of which is produced from natural gas, oil, or coal. Hydrogen is used as renewable feedstock in 30% of methanol and about 10% of steel production. Almost all the hydrogen is used in refineries and in the production of fertilizers and other chemicals (Figure 8).

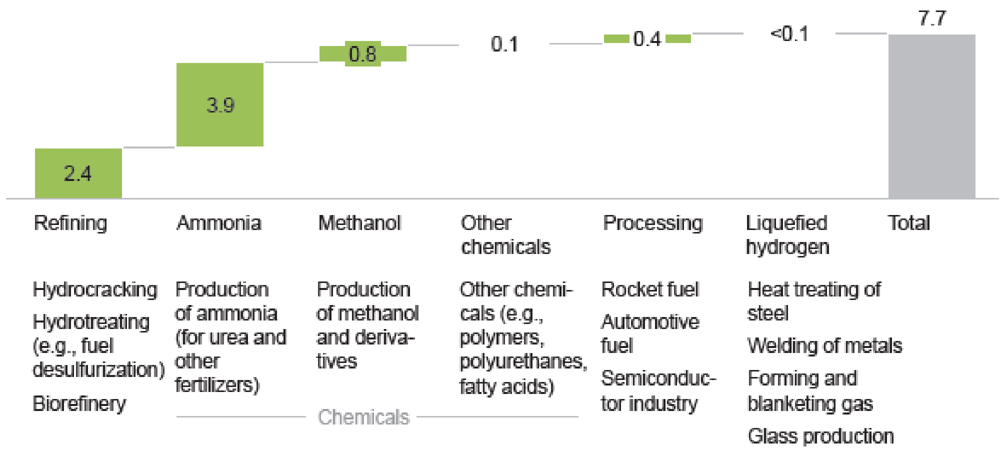


Figure 8. Total hydrogen use, 2015 estimate, EJ (Source: hydrogen council [5]).

This briefly economic analysis of the hydrogen market indicates that increased hydrogen demand is expected in the near future.

Overall, the study predicts that the annual demand for hydrogen could increase tenfold by 2050 to almost 80 EJ in 2050 meeting 18% of total final energy demand in the 2050 two-degree scenario.

5. Exploitable Results and its use

In this section, we specify the exploitable foreground and provide the plans for exploitation.

- **Results with Potential Commercial or Industrial Applications**
- **Intellectual Property Rights – Applied for or Registered**

5.1. Exploitation Plan

The Exploitation Plan (EP), included in the PUEF, will be designed to multiply the impact of the proposed solutions and prepare the transition towards industrial and commercial uptake to fully achieve the expected impact. The EP will describe the activities to be undertaken (how and by whom) to ensure the exploitation beyond the project itself. The exploitation strategy will reflect and will be built-up as a result of a complete analysis of the market trends, potential users, and financial sustainability. The target users will be identified and analyzed in terms of specific needs and objectives.

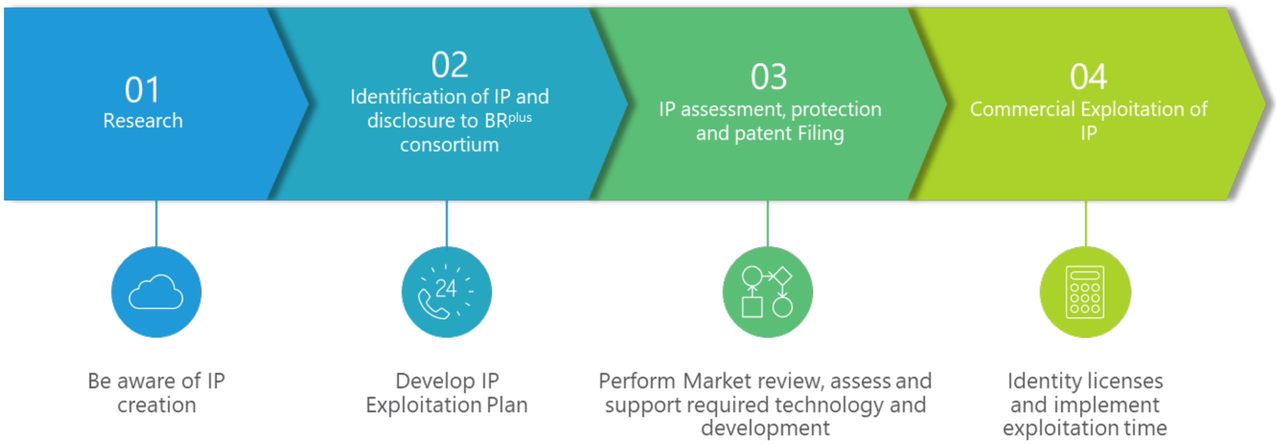


Figure 9. Identification and exploitation of the project results.

All the identified exploitable results during the project are described here, including the characterization in terms of commercial viability for the near future, identification of Intellectual Property Rights, together with a risk assessment of these exploitable results and mitigation actions for the identified risks will be described here.

So far, some exploitable results have been identified by some of the partners, and those are described as follows.

- **Exploitable Results**

Table 1. List of all exploitable results

No.	Exploitable Result	Partner and involved Partners	Work Package (WP)	Is IP Protected? How?	Plan/Strategy for exploitation
1	Ceramic media with continuous porosity gradient	EngiCer, KIT, SUPSI	WP4	No	This innovation could be implemented in gas-fired IR burners and catalyst supports. Sales of the ceramic materials could be generated in the medium/long-term.
2	Reforming catalyst stable under biogas reforming conditions	JM	WP2	Patent on catalyst formulation (background IP).	IP protection under biogas reforming conditions being considered. Catalyst development samples will be made available to customers.
3	Cost-effective and efficient PSA technology for hydrogen purification (multi-bed configuration).	HST, POLITO	WP3	No	This innovation can be implemented in the transportation and industry feedstock sectors for Hydrogen purification applications.
4	BioRobur^{plus} technology feasibility for H_2 production	HST	WP5-6	No	This ER foresees the entire process for Hydrogen production through the BioRobur^{plus} technology.

Characterization of each Exploitable Result.

Table 2. Exploitable Result Review

Exploitable result no. from table 1	N° 1. Ceramic media with continuous porosity gradient
Its purpose	A continuous gradient in porosity inside a cellular ceramic structure can be an interesting feature for gas-fired IR burners (so-called porous burners) and catalyst supports. The new feature could increase performance of the burner or catalyst reactor. Currently, porous ceramics applied in these fields are limited by single porosity.
State of the art / Current status of development (give references)	The innovation is in the design phase. No prototypes have been realized so far and the potential advantages are theoretical, not experimentally verified.

How the foreground might be exploited, when and by whom (Who will be the customer? What benefit will it bring to the customers?).	The innovation could be implemented and adapted for ceramic structures currently used in catalysis and infrared burners. Sales of materials could be generated in the medium/long-term.
IPR exploitable measures taken or intended	None.
When is the expected date of achievement in the project?	Differentiation into the two named fields will take place after the project end, if there will be evidence of the advantages.
When is the time to market (year)?	Medium to long-term (3-5 years) after project end.
Estimated costs for product development	Not possible to estimate at the present time.
What agreements, if any, have been signed regarding the exploitation between Consortium Partners and/or external organizations?	None more than the GA and CA.
Estimated cost/target price of the product/result	Not possible to define at present; it strongly depends on the final application.
Estimated market size?	Not possible to estimate at present. Future project results may give a better picture of where it would make sense to apply the innovation, thus making it possible to quantify the market.
Further research necessary, if any	The innovation would need to be adapted to the specific application. Certainly, a further development will be needed.
Potential/expected impact (quantify where possible)	New sales. Not quantifiable at the moment.
Exploitable result no. from table 1	**N° 2. Reforming catalyst stable under biogas reforming conditions**
Its purpose	The exploitable foreground is a reforming catalyst that is stable to deactivation from coke formation under biogas reforming conditions.
State of the art / Current status of development (give references)	Current SoA is a reforming catalyst used under steam reforming and autothermal reforming conditions for natural gas.
How the foreground might be exploited, when and by whom (Who will be the customer? What benefit will it bring to the customers?).	Development samples of the catalyst will be made available to customers for evaluation. The benefit will be for them to reform biogas rather than natural gas.
IPR exploitable measures taken or intended	Background IP covers the catalyst formulation. JM are considering additional IP protection for applications in biogas reforming.
When is the expected date of achievement in the project?	Already achieved.
When is the time to market (year)?	5 years
Estimated costs for product development	<£100,000.

What agreements, if any, have been signed regarding the exploitation, between Consortium Partners and/or external organizations?	None
Estimated cost/target price of the product/result	Not yet identified, price is highly dependent on PGM price at the time of supply to the customer.
Estimated market size?	Dependent on the market size for biogas reformers.
Further research necessary, if any	None
Potential/expected impact (quantify where possible)	New sales. Not quantifiable at the moment.
Exploitable result no. from table 1	**N° 3. Cost-effective and efficient PSA technology for hydrogen purification**
Its purpose	Improved efficiency gas-purification systems, allowing better thermal integration in gas production systems and lower investment and operating costs.
State of the art / Current status of development (give references)	Expensive technologies.
How the foreground might be exploited, when and by whom (Who will be the customer? What benefit will it bring to the customers?).	Iron, steel processes, reforming gas. Larger application opportunities are though related the biogas-to-biomethane that can also take advantage of the concepts.
IPR exploitable measures taken or intended	None
When is the expected date of achievement in the project?	By the project end
When is the time to market (year)?	5 -15 years
Estimated costs for product development	
What agreements, if any, have been signed regarding the exploitation, between Consortium Partners and/or external organizations?	None
Estimated cost/target price of the product/result	-
Estimated market size?	Dependent on the market size for biogas reformers. It is expected to have a growth of 6% during the period 2019-2023.
Further research necessary, if any	None
Potential/expected impact (quantify where possible)	New sales. Not quantifiable at the moment.
Exploitable result no. from table 1	**N° 4. BioRoburplus technology feasibility for H_2 production**
Its purpose	Develop a technology capable to produce H_2 with high potential to entry into the EU market of H_2.

State of the art / Current status of development (give references)	Green hydrogen is the most expensive for of hydrogen to produce. The EU target is 5.7 €/kg, and the cost of green H_2 production is around 6 €/kg.
How the foreground might be exploited, when and by whom (Who will be the customer? What benefit will it bring to the customers?).	Industrial feedstock (NH_3 in the fertilizer industry, Petrochemical industry), fuel cell vehicles and energy storage. As benefits for customers, there are the potential for additional system flexibility and storage, which support further deployment of variable renewable energy (VRE); contribution to energy security; reduced air pollution; and other socio-economic benefits such as economic growth and job creation, and industrial competitiveness.
IPR exploitable measures taken or intended	None
When is the expected date of achievement in the project?	By the project end
When is the time to market (year)?	2023
Estimated costs for product development	6.16 €/kg H_2 (for 50 Nm^3/h H_2) 4.85 €/kg H_2 (for 800 Nm^3/h H_2) For detailed information, see D6.7.
What agreements, if any, have been signed regarding the exploitation between Consortium Partners and/or external organizations?	None
Estimated cost/target price of the product/result	1.1 (for 50 Nm^3/h H_2) 0.86 (for 800 Nm^3/h H_2)
Estimated market size?	H_2 demand is expected to reach 10 Mton by 2025. The global hydrogen generation market is projected to reach USD 201 billion by 2025 from an estimated USD 130 billion in 2020, at a CAGR of 9.2% during the forecast period. Increasing fuel cell power generation application is driving the growth of the market.
Further research necessary, if any	None
Potential/expected impact (quantify where possible)	New sales. Cost production of H_2 meets EU targets considering larger production scales and longer operating times for the plant. Considering 800 Nm^3 H_2/h (0.6 kton/y) of productivity and a selling price equal to EU target (5.6 €/kg), the annual revenues of the process would be 656 k€/y.

6. Risk assessment and Action Plan

The risks associated with the exploitable results are identified in this section, including their management and mitigation strategies. The risks identified during the project are summarized below.

- Technology risks (i.e. successful exploitation depends on development of new technology by partners outside the consortium).
- Legal risks (i.e. potential to infringe 3rd parties' IPR).
- Partnership risks (i.e. Potential for conflicts of interest within the consortium if two parties wish to exploit the same IP, or disputes over IP ownership).
- Environmental, health or safety risks (i.e. any potential risks identified that could be created by the new products/results).
- Other, which?

Table 4. Risk Analysis Table

Exploitation Result from Table 1	Type of risk	Description of risk. Severity?	Mitigation strategy	Who is responsible	Outcome: Risk contained? Yes/No
1	Performance not improved compared to state of the art porous ceramics	Medium	Re-design	SUPSI	Yes
2	Catalyst is too expensive	Medium	Additional catalyst development to reduce PGM loading if necessary	JM	Yes
2	Catalyst does not meet customer requirements	Low	Additional catalyst development based on customer requirements	JM	Yes
2	No (biogas reforming) market for catalyst	Medium	Look for alternative markets for catalyst	JM	Yes
3	Performance not improved compared to the state of the art	Medium	Evaluation of further adsorbent materials and/or better design of heat integration.	HST POLITO	Yes
4	Non-competitive production costs within the EU market of H_2.	Medium	Evaluation of varying the process parameters according to the sensitivity analysis of costs.	HST	Yes

7. BioRoburplus technology penetration in Spin-off fields

This section of this deliverable aims to determine the BioRoburplus potential to penetrate in Spin-off field, where several factors must be considered. Profit, capacity, customers, marketing, process, quality, and so on are among the most important factors determining the potential penetration. This analysis will allow the transferability of the technology from the research to the business community.

Considering the promising results from the LCA and TEA studies, the technology offers sustainability from the environmental and economic points of view at a higher scale. Despite the technical issues faced during the experimental campaign, the good performance of the catalysts was proven. Thus, addressing the technical issues in a scaled-up plant, the process quality and capacity would be high and would also allow reaching the economic profits reported in D6.7. The potential customers are many, as the H_2 market is very wide and continuously grows, according to the marketing perspectives.

The owners of the technology could be all the partners of the consortium. Thus, also considering the participation of researchers and their compensation and remuneration. The participation of researchers allows the technology growth and worth increase. The technical benefits of spin-off penetration could also be high because the know-how could increase, and the process could be improved continuously. Continuous improvement could guarantee the increase of the value of the technology.

The protection (patenting) is needed to guarantee the right to stop others from copying, manufacturing, selling or importing your invention without permission. The technology patent can be European as an initial stage to gain field in the European market (as in the marketability study) and then apply for a patent in other countries to expand protected marketability of the technology.

The success of the spin-off will be guaranteed by a well-developed business plan and a complete, balanced and cohesive management team. Insiders and outsiders could enhance the team. The insiders bring a detailed understanding of the company's assets, capabilities, customers, competitors, and stakeholders. The outsiders provide new blood in support functions such as finance, legal, or administration. The financial structure is an important aspect to consider. The divested business should have the financial resources needed to bridge the transition period to full independence from its former parent and implement a different strategy from "business as usual."

8. Conclusion

A PUEF has been presented in this deliverable. Brief descriptions of renewable hydrogen production technologies, market analysis for the BioRobur^{plus} implementation plan, currently possible exploitable results and identification of the main barriers for their exploitation of project results (technical and non-technical) were presented.

Three main exploitable results, Ceramic media with continuous porosity gradient, Reforming catalyst stable under biogas reforming conditions and Cost-effective and efficient technology for hydrogen purification, were discussed in this deliverable, including intellectual property rights actions linked to the reforming catalysts.

This deliverable includes benchmarking the BioRoburplus technology based on techno-economic evaluation (D6.7), marketing analysis, and exploitation plan. The main risks and mitigation strategies were also summarized in this deliverable. And the potential penetration of the BioRobur^{plus} technology was also assessed, concluding the possibility to transfer the research technology to business.

9. References

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