PERFORM
PowER platFORM

H2020-NMBP-SPIRE-2018 CE-SPIRE-02-2018
"Processing of material feedstock using non-conventional energy sources (IA)"
PowerPlatform: Establishment of platform infrastructure for highly selective electrochemical conversions

D7.3: Exploitation Plan

Date: 31-12-2019

This document is the PERFORM's project Exploitation Plan (contract no. 820723) corresponding to D7.3 (M12) led by SUSTAINABLE INNOVATIONS EUROPE (SIE).

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Contact persons	Seda Çakir (Project coordinator TNO) seda.cakirbenthem@tno.nl		
Website	www.performproject.eu		

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Deliverable Contributors				
	Name	**Organisation**	**Role / Title**	**E-mail**
Deliverable leader	Mariana Fernandez	SIE	Communication Team Manager	marianafernandez@sustainableinnovations.eu
Reviewer(s)				
Final review and quality approval				

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EXECUTIVE SUMMARY

This deliverable **D7.3 Exploitation Plan** is customized for the PERFORM project, funded by the European Union under the Grant Agreement No. 820723. In this report, a total of ten Key Exploitable Results (listed below) are presented, among which five are newly identified during the first year of the project. Their tentative exploitation strategy has been considered as well.

1. Line 1: Two bio-based feedstocks
2. Line 2: Single bio-based feedstock
3. Electrochemical process intensification with flexible operation
4. Electrode upscaling
5. Integrated electrochemical process system (design)
6. Bio adipic acid of high quality
7. Valorisation of Dawn Technology™ product streams in the new market segment
8. Techno-economic analysis
9. Development of bio-based plastics
10. Bio-based and biodegradable polymers and materials incorporating dicarboxylic acids from electrochemical processes

It is highly important to keep the exploitation strategy consistent with the Market Assessment (D6.3, due M36) findings, the Business Plan (D7.7, due M48), and the Intellectual Property Management (D7.8, due M48). In addition, the exploitation strategy may vary depending on the actual product development result in the coming years. Lastly, there is no sufficient information to carry out the exploitation risk management at the current early stage in the project. Hence, a final Exploitation Plan will be updated in the last year of the project.

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Abbreviations and Acronyms

EIC	Exploitation and Innovation Committee
EU	European Union
GA	Grant Agreement
IP	Intellectual Property
KERs	Key Exploitable Results
NAFTA	North American Free Trade Agreement
SOE	State-Owned Enterprise
TRL	Technology Readiness Level

1. INTRODUCTION

The **D7.3 Exploitation Plan** is customized for the PERFORM project, funded by the European Union under the Grant Agreement (GA) No. 820723.

The partners in PERFORM project must, in accordance with the article 28.1 in GA, take necessary measures to ensure the exploitation of the project results up to four years after the end of the project. This report of Exploitation Plan intends to demonstrate the updated list of the key exploitable results (KERs) expected to achieve within the PERFORM project as well as to the tentative exploitation route how the involving partners plan to exploit the results after the project.

The exploitation strategy is highly interconnected with the following deliverables and may be adjusted accordingly in the later stage of the project if necessary:

- D6.3 Market Assessment (M36)
- D7.7 Business Plan (M48)
- D7.8 Intellectual Property (IP) Management (M48)

2. INNOVATION AMBITIONS OF PERFORM PROJECT

Using the **electrification** method, and **bio-based feedstocks** are the two major drivers transforming the European chemical industry, and they are also the ambitious innovation objective which the PERFORM consortium decides to target.

Despite the fact that the sales of the global chemical industry have tripled in the past two decades, the European Union (EU) countries' influence in the global market has gradually decreased. In 2018, six countries out of the top ten biggest chemical producers were located in Asia. Among which, China has

dominated the global market as the largest producer since 2008 with 18.2% of global sales and is still the leading country with 35.8% of global sales (as of 2018). Even though EU has kept its ranking at the second place; its sales have dropped in half to €565 million, and its market share has decreased from 26.5% in 2008 to only 16.9% in 2018; while the North American Free Trade Agreement (NAFTA) countries follow closely behind with only €35 million sales less in 2018 (see Figure 1 & 2) (CEFIC, 2019B).

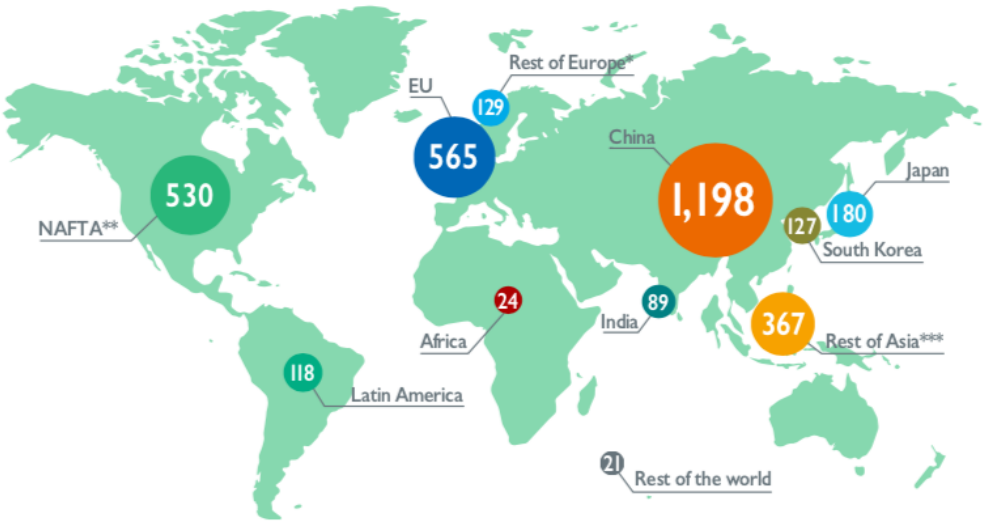

Figure 1 World chemical sales (2018, €3347 billion) (CEFIC, 2019b)

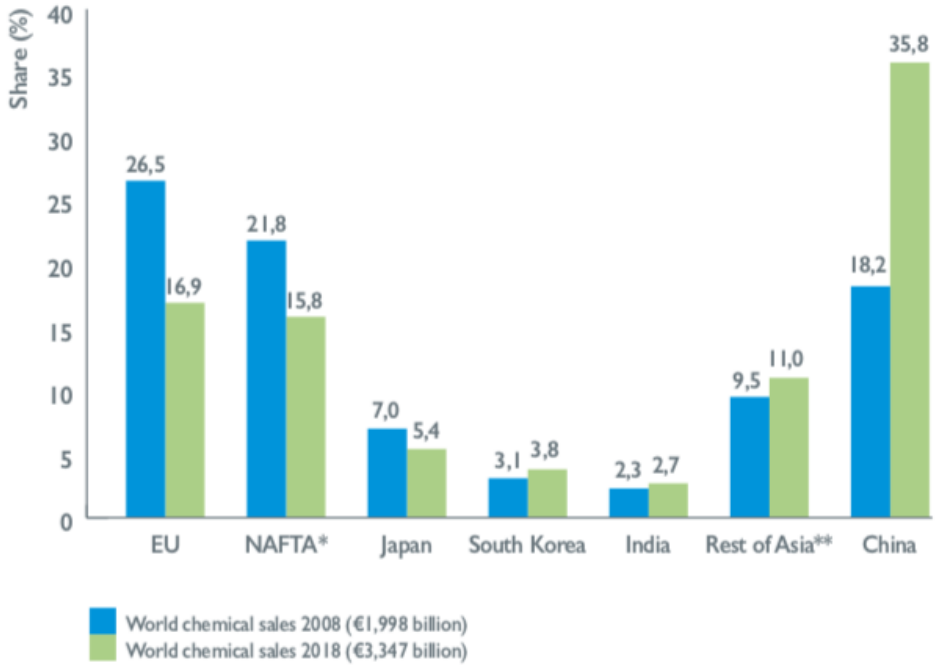

Figure 2 World chemical sales by region (CEFIC, 2019b)

The EU chemical market is expected to grow modestly in the following years if the current trends continue. Therefore, it is critical to understand what are the factors that may bring impacts to shape the market evolution. Below is a brief PESTEL Analysis (Investopedia, 2019) on the major parameters affecting the market from different aspects. A more comprehensive and complete analysis will be updated in the D6.3 Market Assessment (M36).

Political

The on-going Brexit dispute between United Kingdoms and EU may finally come to an end after more than three years of chaos. After the landslide victory of Mr. Johnson and his Conservative Party to form a new Parliament in mid-December 2019, UK Parliament is in confident to pass the Withdrawal Agreement Bill by the deadline of January 31th 2020 to formally leave the bloc. Yet, the agreement of the terms for UK to leave is not certain. If Britain leaves with "no deal", a new UK-EU trade agreement will be required, and the lengthy bureaucracy will for sure cast a shadow on the EU chemical industry as a whole as well as on the UK. (ICIS, 2019)

The trade war between US and China as well as the US sanctions have significantly increased the complexity of the daily operation, trade and investments of the EU chemical companies (CEFIC, 2019a) (Oxford Economics, 2019). A free and open trade can no longer be taken for granted. The worldwide trading system is gradually changing, and the new rules are yet unclear and await to be set up.

Another factor worth noticing is the rise of the state-owned enterprises (SOEs) (McKinsey, 2015) Their existence has once dropped during 1980 and 1990s. However, the trend has been turned over with the rise of China and other developing countries where the governments play a dominating role in the sector's development. SOEs are competing towards different objectives beyond the normal business rules in both financial and strategic perspectives.

Economic

The rise of middle class in the developing countries has greatly boosted the demand of various products of which chemistry is highly essential. However, the modest growth of GDP around the world as well as in EU may indicate possibly a conservative economic evolution and consumers' consumption power. The growth of worldwide GDP hasn't changed much since 2014 and is

expected to remain at the same level around 3,5% in the coming years; while EU's GDP has recovered from the lowest point at 2009, yet it still shows a weaker growth rate at 2,02% compared to the global performance (See Figure 3 & Figure 4). Over the next two years, the EU will see its real GDP growth rate remain even lower at 1,2% (Fortune, 2019).

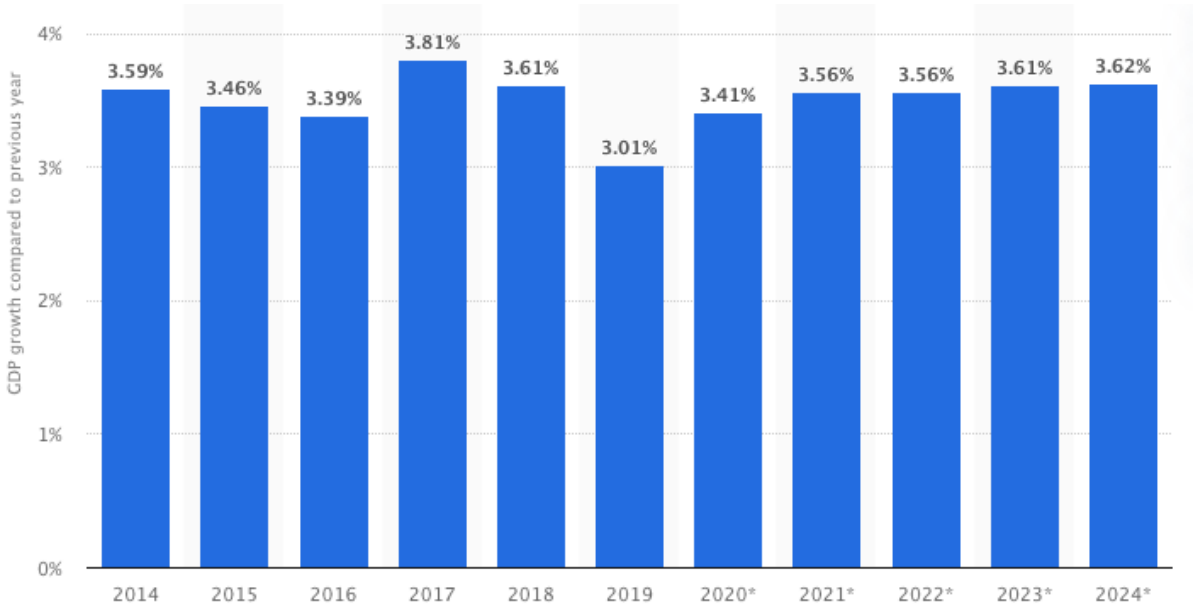

Figure 3 Growth of the global GDP from 2014 to 2024 (Statista, 2019)

Figure 4 European annual GDP growth from 2000 to 2018 (The World Bank, 2019)

The evolution of the end markets of chemical products will undoubtedly affect the demands and development direction of the chemical industry itself too. The growth of construction sector is expected to continue in 2020 thanks to the low interest rates and the high demand in the infrastructure investments. Also, the transformation trends of turning the buildings into more energy efficient and sustainable also give great impetus to the chemical industry. On the other hand, however, several end markets such as automotive and electrical appliances are witnessed the downturns (Process Worldwide, 2019)

The price and production volatility of oil always tends to be disruptive for chemical industry as the petrochemicals are highly dependent on it. The price of crude oil which has dropped notably in 2014 and 2015 seems stabilized in the past years (see Figure 5). At the meantime, the production becomes more difficult to forecast and may consequently disrupt the price. The diversity of the supply sources keeps increasing and so as the difficulties for those countries to be aligned for the total production. The US, Brazil, Iraq, Norway, the UAE, and Guyana have contributed the most to the supply growth (IEA, 2019). Lower oil price may discourage and constraint the R&D development of the bio-based alternatives from renewable biomass; in contrary, higher oil price can boost the investment in finding new sustainable solutions.

Figure 5 West Texas Intermediate crude oil prices from 2010 to 2019 (Macrotrends, 2019)

The impact brought by the oil doesn't stop here. As the demand of oil refinery in Europe has passed its peak because of multiple factors such as superior fuel efficiencies, climate concerns and switch towards electric vehicles, the capacity of the oil refineries as well as the feedstock availability for petrochemical has been declining. The flow of the investments has also gradually turned to more reliant on renewables and other low-carbon sources of raw materials (Industry Europe, 2018).

Social

As consumers' concern of single-use plastics as well as the popularity of circular economy concept grow, the demand for more sustainable alternative products is increasing. People are replacing their old linear consumption behavior of "take, make, and dispose". To achieve this goal, circulating molecules or high-performance and more durable materials will be needed.

Technological

The trend of digitalization has transformed many downstream customer sectors, yet the majority of the chemical companies seem to keep their wait-and-see position against this inevitable wave. According to Accenture's study (Accenture, 2018), only 40% of chemical companies have adopted digital technologies to ameliorate their operation efficiency while 32% are using it to boost growth. There is still huge potential for chemicle companies to benefit from the digital technologies to become more agile to customer sectors' needs, to differentiate themselves from the competitors, and to even involve more in customer sectors' production as collaborators.

Environmental

The climate change has hit the EU chemical industry unexpectedly from the logistic perspective as well (The Journal of Organic Chemistry, 2019). The waterway acts as important transportation channel of the raw materials for chemical manufacturers in the northwest Europe. Low water on the Rhine River in recent years has caused the increase of the logistic cost and problems for the production planning. Meanwhile, the issue of water resource scarcity also requires the chemical industry to re-design its production process to less water-demanded (Management Centre Europe, 2019).

Legal

The production of novel chemical products shall comply with REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) (ECHA, 2019), the Regulation (EC) No. 1907/2006 of the European Parliament and Council which aims to improve the protection of human health and the environment from the risks that can be posed by chemicals; at the meantime, it also expects to enhance the competitiveness of the EU chemical industry.

In the past years, the policy makers in developed countries have became more aware of the climate change issues and have passed several new regulations to push industries towards more green and sustainable development. One of the efforts is the new law approved in March 2019 by the EU Parliament to ban various single-use plastic products, including cutlery, plates, straws, bud sticks, food and drink containers. Ambitious targets for plastics bottle recycling (90% by 2029) and its recycled content (30% by 2030) have been set as well (European Parliament, 2019). To comply with these regulations, the manufacturers will have to turn to their upstream chemical suppliers to come up with new solutions.

PERFORM Objective

The European chemical industry is undoubtedly still a leading player in the global market, but the challenge is to remain competitive and to revive its position through providing higher added-value products and continuous innovation with more environmentally friendly mindset and circular economy concept.

Therefore, PERFORM aims to develop and construct a **highly versatile and modular electrochemical Power Platform** using biomass feedstocks to produce two chosen showcases and ideally for a wide range of chemical building blocks in the future.

- Showcase 1: Paired electrosynthesis of furfural to maleic acid and levulinic acid to valeric acid
- Showcase 2: Paired tandem electrosynthesis of glucose to glucaric acid and further glucaric acid to adipic acid

3. Key Exploitable Results

The list of the Key exploitable Results has been pre-identified during the proposal and Grant Agreement preparation stage, and it has been updated during the first year of the PERFORM project via an exploitation questionnaire (refer to

Annex I: Exploitation Questionnaire

designed and circulated by SIE to all consortium partners. This questionnaire is designed to collect primary information regarding the innovative products under development to allow SIE to form a fundamental understanding of the products for future analysis. Partners have also been asked to decide their tentative route(s) to exploit the products. The choice of the exploitation strategy will be a continuous discussion between partners and SIE throughout the project lifetime.

Currently, there are ten KERs in total that are expected to achieve at the end of the project as shown below in Table 1.

Table 1 Exploitable results

No.	Key Exploitable Results	Participating Partners	Technology Readiness Level (TRL)
1	Line 1: Two bio-based feedstocks	To be updated	
2	Line 2: single bio-based feedstock	VITO, TNO, INSTM, HST	
3	Electrochemical process intensification with flexible operation,	INSTEM, TNO, HST, AVT, VITO, PERS & GENS	
4	Electrode upscaling	VITO, AVT, INSTM	
5	Integrated electrochemical process	HST, TNO, VITO, AVT,	

	system (design)	INSTM, GENS, PERs	
6	Bio adipic acid of high quality	Radici & All partners	
7	Valorisation of Dawn Technology™ product streams in a new market segment	AVT, TNO, VITO, HYS, PERs	
8	Development of bio-based plastics	INSTM, AVT, TNO, VITO, GEN	
9	Bio-based and biodegradable polymers and materials incorporating dicarboxylic acids from electrochemical processes	Novamont	

In PERFORM project, an Exploitation and Innovation Committee (EIC) will be formed by one representative from each industrial partner and led by the Project Exploitation Manager from Sustainable Innovations Europe to update the initial Exploitation Plan periodically during the project lifetime. Other issues related to exploitation will be coordinated and discussed via the Committee through necessary methods including literature review, online or physical workshop, web and/or phone meeting, etc. The members of EIC will be confirmed in the upcoming months.

INFORMATION HAS BEEN REMOVED ON THE PUBLIC VERSION TO PREVENT IP ISSUES.

4. EXPLOITATION PLANNING

The success of product exploitation is highly dependent on a clear and well-structured strategy from the beginning and further revised throughout the project. This strategy should be aligned with the product development and the findings of other relevant analysis work mentioned previously as well. How to commercially exploit the project result and harvest the maximum potential economic benefits is no longer only relevant for R&D intensive companies but also important for public research institutes as well.

The methodology to develop the Exploitation Plan will follow the roadmap illustrated in Figure 6.

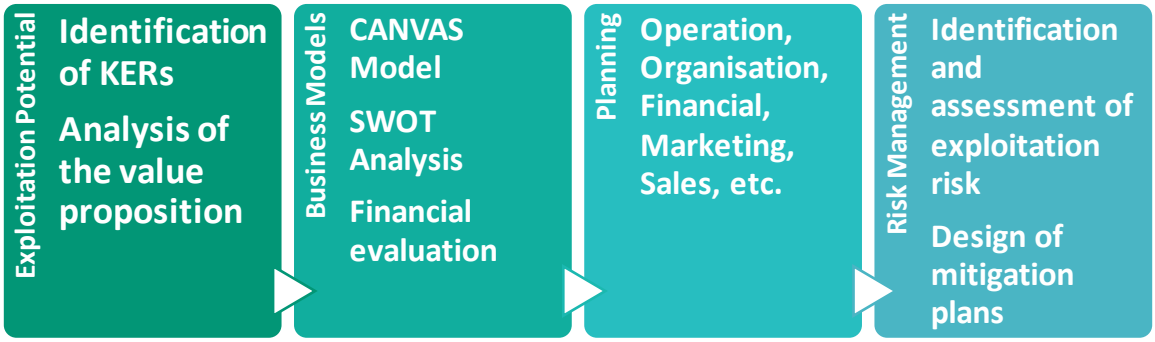

Figure 6 Exploitation Planning

The first step in the process is to identify the potential knowledge or results in all kinds of forms that have potential to be exploited. A KER will be identified by taking into account its value proposition (Osterwalder & Pigneur, 2010), differentiation from existing alternatives in the market, technology readiness level, possible forms of usage, variety of applications, etc. During the project lifetime, new KER may be discovered while identified KER may be dropped. A comprehensive market analysis of the target market(s) where the KERs aim to compete will be carried out in D6.3 Market Assessment (due at M36).

Secondly, the CANVAS business model (Osterwalder & Pigneur, 2010) will be applied to develop a customized business model and a commercial strategy to exploit the result. The financial aspects such as the revenue streams, cost structure, profitability, and cash flow will be examined as well. In addition, the SWOT analysis will be carried out to understand the strength and weakness of the product as well as the opportunities and threats in the market to facilitate the fine-tuning of the value proposition.

Thirdly, potential synergies between different project results and consortium partners and next steps for product commercialisation will be analysed.

Lastly, the potential exploitation risk will be identified and analysed along with the mitigation plan to ensure the success of product exploitation. The detailed methodology is presented in the following chapter.

5. Exploitation Risk

At this stage (M12), it is still too early to accurately identify and assess the potential risks that may influence the success of product exploitation.

In the later stage of the project, a questionnaire designed by SIE will be circulated to all consortium partners who have involved in the product development and exploitation in order to identify the possible factors from both internal within the consortium and external from the competitive landscape that may bring impact on the result exploitation.

In brief, the overall methodology will follow three steps outlined below and the result shall be summarized in Table 2 in the future version of the Exploitation Plan.

Table 2 Exploitation risk management

Risks Description	Type	Likelihood	Impact Intensity	Partner responsible	Mitigation Strategy

- Step 1: Identification of the potential exploitation risks which can be technical and/or non-technical factors.

- Step 2: Assessment of the possibility of occurrence and the potential impact of each risk identified in step 1. Then, those risks will be categorized into four groups according to the risk management matrix shown in Figure 7. Each type of risks requires a different level of attention and approach to deal with:
  - Critical or high risky: Should be carefully monitored and controlled throughout the whole project.
  - Medium: Keep under watch but no immediate action required.
  - Low: Require only regular check if its level changes.

- Step 3: Planning of the mitigation plan to avoid the potential risks from occurring and to control the impact if it does happen.

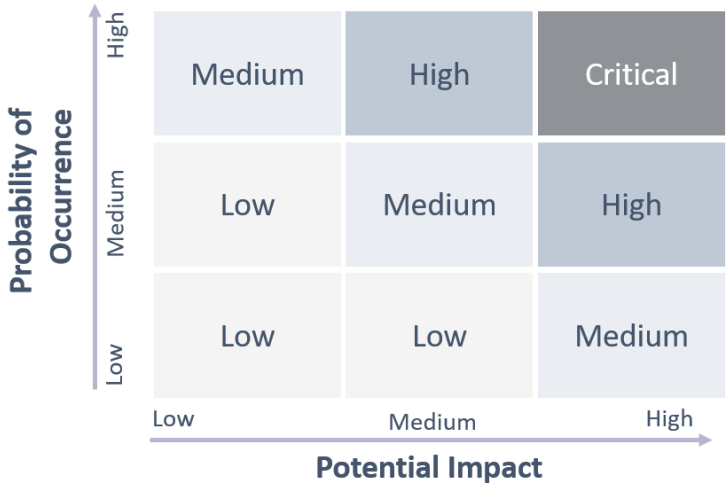

Figure 7 Risk management matrix

6. Conclusion

This report D7.3 Exploitation Plan presents the latest evolution of the key exploitation results identification and their initial exploitation strategy planning.

At this stage (M12), it is still too early to fully define the conclusive strategy in that it may vary depending on the actual product development afterwards. A clear view of the exploitation risk and the mitigation plan will not be possible to conduct at this point either. Thus, a final Exploitation Plan will be proposed in the last year of the project.

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8. Annex I: Exploitation Questionnaire

- **Section 1: Key Exploitable Results (KER)**

1. Please fill in following information

KER Name	
Lead partner	
Participating partners	

TRL	Initial: Current: Expected at the end:
Work Package	

TRL 0: Idea. Unproven concept, no testing has been performed.
TRL 1: Basic research. Principles postulated and observed but no experimental proof available.
TRL 2: Technology formulation. Concept and application have been formulated.
TRL 3: Applied research. First laboratory tests completed; proof of concept.
TRL 4: Small scale prototype built in a laboratory environment ("ugly" prototype).
TRL 5: Large scale prototype tested in intended environment.
TRL 6: Prototype system tested in intended environment close to expected performance.
TRL 7: Demonstration system operating in operational environment at pre-commercial scale.
TRL 8: First of a kind commercial system. Manufacturing issues solved.
TRL 9: Full commercial application, technology available for consumers.

2. KER description (Please include principal characteristics/functions/how it works, etc)

3. If this technology if developed by more than one partner, please indicate the contribution of each partner and how the ownership will be distributed among the partners.

Partner	Contribution (explain)

4. The new technology/product (KER) could be used in the form of?

☐ Software ☐ Products ☐ Research Roadmaps ☐ Policy recommendations
☐ Processes ☐ Services ☐ Pre-standards ☐ (Collaboration) platforms
☐ Data ☐ Reports ☐ Codes of conduct ☐ Educational material
☐ Prototypes ☐ Skills and knowledge

5. What makes this new technology/product (KER) attractive to the potential markets/users? Key benefits or problems solved by this new technology/product? What it does better than existing technologies/products?

6. What is current state of the art in the domain of this new technology/product (KER)?

7. What technology/product/company do you think will be the major competitors for this KER?

8. How do you plan on exploiting the project results after the end of the project?
   - ☐ Use for further research
   - ☐ Develop and sell the new product/service
   - ☐ Spin off activity
   - ☐ Cooperation agreement/Joint venture
   - ☐ Sell IP rights or IP-based business
   - ☐ License IP rights
   - ☐ Transfer ownership of IP rights to another partner from the consortium
   - ☐ Standardisation activities (new standards or support ongoing procedures)
   - ☐ Other methods. Please indicate:

9. Will this new technology/product (KER) be marketable? Yes ☐ No ☐
   If yes, what is the time to market after the end of the project (in years)?

- **Section 2: IPR Strategy and Protection**

1. **Foreground IP (Intellectual protection of the KER):**
   1. How do you plan to protect this new product/technology (KER)?
      - ☐ Trade secret
      - ☐ Copy right
      - ☐ Trade mark
      - ☐ Patent
      - ☐ Utility model
      - ☐ Industrial design
      - ☐ Other methods Please indicate:
      - ☐ No protection is foreseen Please explain why:

2. **Background IP (existing IP, previous to project start):**
   1. Does this new technology/product (KER) rely on any existing IP/background IP? What is it and which partner(s) own it? How is this background IP protected?

- ## Section 3: Market Analysis

1. What are the different applications for this new technology/product (KER)?

2. Who will be the target customers or users?

3. What is the value that you would like to get from this new technology/product (KER)? (e.g. for scientific, societal, or economic purposes, etc.) And how do you plan to get the value?

4. What is the strength/advantage and weakness/disadvantage of this new technology/product (KER) comparing to existing technologies/products?

Strength/Advantage (e.g. Uniqueness or innovativeness)	**Weakness/Disadvantage**