# EXPLOITATION PLAN

**GREENH2ATLANTIC PROJECT**

**Deliverable:** D10.2

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The project GreenH2Atlantic has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n° 101036908.

| Project acronym | GreenH2Atlantic |
|---|---|
| **Project full title** | A 100MW flexible Green hydrogen production process sourcing hybrid renewable energy and supplying green hydrogen to multiple end-uses |
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| **2020 AWP topic addressed** | |
| **Coordinator's contact details** | PEDRO VALVERDE<br>pedro.valverde@edp.com |

## DELIVERABLES DETAILS

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## DOCUMENT HISTORY

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| V0 | Tommaso Orlandini, Karan Narayan | 16/05/2022 | |
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[1] PU = Public
CO = Confidential, only for members of the consortium (including Commission Services)



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## Executive Summary

The present document constitutes the first version of GREENH2ATLANTIC Exploitation Plan (D10.2), developed within the framework of *Task 10.2 – Exploitation Plan and IPR management* led by EDP, as part of *Work Package 10 – Replication, Exploitation and EU-wide Industrialization* under the responsibility of ENGIE. The overarching objective is to detail a plan, for each project partner, to outline the various exploitation opportunities and business options of the GREENH2ATLANTIC project, to maximize the opportunities for market adoption and replication of the GREENH2ATLANTIC results.

GREENH2ATLANTIC Exploitation Plan encompasses a framework to continuously identify and characterize project's Key Exploitable Results and how connected Intellectual Property Rights (IPR) will be managed to facilitate replication and early identify and resolve potential IP conflicts.

This first version of GREENH2ATLANTIC Exploitation plan presents an initial analysis of GREENH2ATLANTIC value proposition and its expected advancements beyond the state-of-the-art. Furthermore, it includes IPR management procedures and an overview of the currently identified Background and Foreground IPs.
This deliverable will be updated every 18 months with a final version to be produced under Deliverable 10.3 at the end of the project (M72).



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## Abbreviations

*AHyMS: AI-enhanced Advanced Hydrogen Management System*
*ALK: Alkaline (electrolyser)*
*BFMULO: Background-foreground-making-using-licensing-other*
*BoP: Balance of Plant*
*CA: Consortium agreement*
*CFPP: Coal Fired Power Plant*
*DMP: Data Management Plan*
*EC: European Commission*
*EMS: Energy Management System*
*FCR: Frequency Containment Reserve*
*FGHPP: Flexible Green H2 Production Process*
*FRR: Frequency Restoration Reserve*
*GA: Grant Agreement*
*GDPR: General Data Protection Regulation*
*IP: Intellectual Property*
*IPR: Intellectual Property Rights*
*KER: Key Exploitable Results*
*LCOH: Levelized Cost of Hydrogen*
*PR: Project Results*
*RE: Renewable Energy*
*RES: Renewable Energy Source*
*SOTA: State-of-the-art*
*TRL: Technological Readiness Level*



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# Introduction

## 1.1. Purpose of the document

The present document defines the Exploitation Plan of the GREENH2ATLANTIC project deriving from the activities carried out in Task 10.2, within *Work Package 10 – Replication, Exploitation and EU-wide Industrialization*. The Exploitation Plan aims to provide a plan to outline the different exploitation opportunities and business options considering the outcomes of the GREENH2ATLANTIC project.

The planned activities will encompass the following five pillars:

1. It will identify the GREENH2ATLANTIC Key Exploitable Results (KERs) and their market potential;
2. It will support the validation of innovative business models connected with the innovative KERs;
3. It will provide an extended assessment of the exploitation risks;
4. It will accompany, in collaboration with other GREENH2ATLANTIC tasks, the exploitation roadmap and investment planning across Europe;
5. It will provide IPR strategies recommendation and identify synergies within the project's partners.

The present document will follow the European Commission guidelines and definition of Exploitation. **Error! Reference source not found.** provides an overview of what is meant by Exploitation and its main target to maximize the impact of the KER generated in GREENH2ATLANTIC.


*Figure 1 – What is meant by Exploitation [1]*

Finally, the Exploitation Plan aims to reach the following two main objectives:



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- Reach a common vision and agreement on the project results and its interest to each of the partners towards commercial approach;
- Assess the effective exploitability of the results, eventually proposing new ones and removing the ones not to be exploited (not expected to generate income to partners).

The exploitation plan will accompany the progress of the project and it will be updated every 18 months with a final version to be expected at the very end of GREENH2ATLANTIC (M72).

## 1.2. Relation to other Work Packages and Deliverables

The Exploitation Plan has a transversal role through GREENH2ATLANTIC and is interlinked with numerous other activities that will be carried out throughout the project. Firstly, it is closely intertwined with the Dissemination strategy, part of *WP11 – Stakeholder Engagement through Communication, Dissemination and Outreach*. Exploitation and Dissemination, depend on each other advancements and have the common strategy to maximize the impact of the KERs generated from the technical and business developments of GREENH2ATLANTIC. Moreover, the Exploitation plan, will encompass the results from the Business Case evaluation and the techno-economic roadmap of Tasks 9.1 and 9.2, respectively, as well as the outcomes of T10.1 and T10.5, where the technical steps for the overall project and electrolyser production scale-up plans will be outlined.

The foreseen relations with other GREENH2ATLANTIC activities and timeline, are summarized in Figure 2.

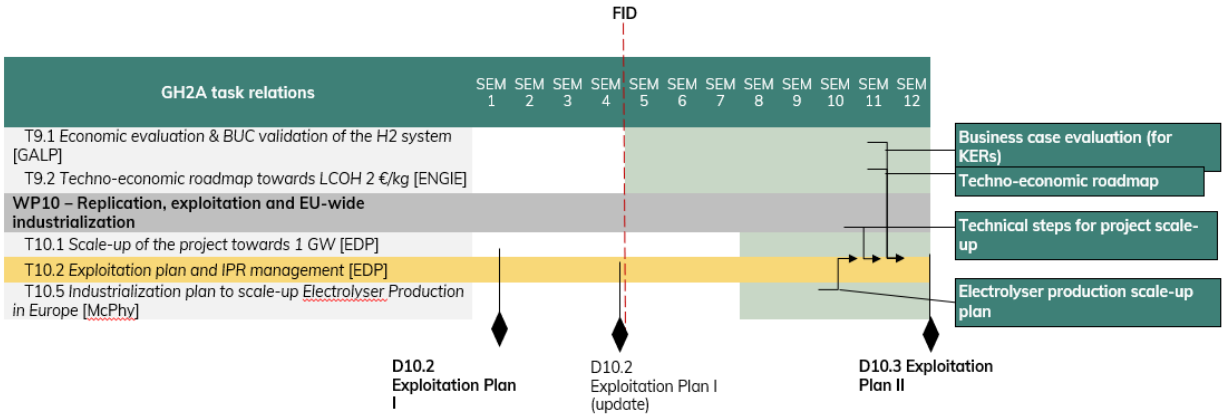


*Figure 2 – Exploitation Plan related activities*

## 1.3. Deliverable structure

GREENH2ATLANTIC Exploitation Plan is structured into the following sections:

**Chapter 1** presents a high-level introduction of this document, its purpose and the relation with other Work Packages and Tasks to ensure that the exploitation of the Project Results (PR) is maximized.



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**Chapter 2** comprises GREENH2ATLANTIC value proposition, starting from a brief overview of the Project and its main expected outcomes, defined as PRs which are translated into the project's KERs. For each identified KER a brief state-of-the-art (SOTA) overview is presented together with the expected advancements beyond SOTA that will be achieved throughout the project. Finally, KER characterization methodology is introduced, which will be applied and detailed in the following planned versions of the present deliverable.

**Chapter 3** outlines the exploitation framework, using, as a starting point, what was agreed in the Grant and Consortium Agreements, as well as the implemented strategy for IPR management together with a preliminary list of identified Background and Foreground IPs.

Once the project's value proposition and expected KERs are defined, **Chapter 4, and Chapter 5** include a comprehensive description of all the partner's individual and common (Consortium level) exploitation plans and how these results will affect their business plans.

Finally, **Chapter 6** draws the conclusions highlighting the main outcomes of this deliverable and the next steps to be included in the updated versions of this deliverable.



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# 2. GREENH2ATLANTIC value proposition

As initial step towards the identification of relevant exploitation opportunities, an overview of the project activities, PRs and their alignment within the European overall targets was done. Once the PRs are identified, an analysis was conducted with the GREENH2TLANTIC project partners to assess the exploitation potential of each result, hence translating them into KERs. Within this process, ownership of the KERs was assigned to a specific partner, or in some cases to several partners, according to their scope of work within GREENH2ATLANTIC and their exploitation interest of a specific PR. The results of the mentioned steps are presented in Section 2.1.

Section 2.2 provides an overview, for each identified KER, of the expected developments and innovation beyond the current SOTA that will be achieved within the end of the GREENH2ATLANTIC project as well as an estimation, where relevant, of the TRL development to be achieved.

Finally, Section 2.3 introduces the selected KER characterization methodology that will be applied to all identified KER throughout the GREENH2ATLANTIC project and the outcomes will be presented in the future versions of the present deliverable.

Overall, the final goal of the KER characterization process is to ensure smooth and successful exploitation of the identified results, by outlining relevant strategies for market penetration.

## 2.1. GREENH2ATLANTIC project and main outcomes

### GREENH2ATLANTIC project

Hydrogen is a key element for the future of the energy sector and to achieve climate neutrality. It is expected to be used mainly in the areas where electrification is not an option (hard to abate sectors), including the current energy-intensive industry and certain heavy-duty transport sectors. The goal of promoting renewable and low-carbon gases, which have a minor contribution to the current EU energy mix, is to decarbonise these sectors, increase the flexibility of the electricity system, strengthen security of supply by reducing dependence on natural gas imports and allow to store (and produce) electricity.

It is foreseen that renewable and low carbon gases (including low carbon hydrogen) will represent roughly 2/3 of the gaseous fuels in the 2050 energy mix, with the remaining 1/3 being covered by fossil gas combined with carbon capture. In line with the EU hydrogen strategy, the production of renewable hydrogen in the EU is expected to reach 1 million tonnes by 2024 and up to 10 million by 2030. In addition to this, recent events on rising energy prices have reminded us that the resilience of the European energy system is increasingly



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important as the EU energy system integrates more decentralised renewable energy and fossil fuels are gradually phased out.

The GREENH2ATLANTIC project will allow consortium partners to position themselves in a relevant role in the hydrogen value chain by delivering and engineering, new products and services in the hydrogen sector. On top of the EU and Portuguese decarbonization strategies and several ongoing initiatives that are setting the framework conditions for the worldwide diffusion of the hydrogen market, considerable effort is being committed within the GREENH2ATLANTIC activities to contribute to the REDII and Green Deal targets and simultaneously respect a Just and Sustainable transition of the region of Sines, historically reliant on coal.

In order to achieve the project's main objectives, a four-phases approach will be carried composed by i) Research & Development, ii) Engineering, Manufacturing & Construction of a first of a kind large scale 100 MW hydrogen Production Plant; iii) Operation and, finally, iv) its Scale-up & Replication, ensuring the supply of Sines' refinery and paving the way to decarbonize the national natural gas grid.

GREENH2ATLANTIC project aims to develop a novel, more compact 16 MW Alkaline (ALK) electrolyser module with fast-cyclability (20-100% in seconds) allowing to efficiently follow intermittent RES power supply. By modularizing the 100 MW platform a 40% footprint reduction is expected to be achieved. The AI-enhanced Hydrogen Management System (AHyMS) will optimally dispatch the hybrid RES power production using novel forecasting algorithms, as well as provide the efficient monitoring and proposed control trajectory of the output hydrogen flows. The 100 MW system will be demonstrated and operated dynamically at TRL8 harvesting the maximum hybrid RE power to reliably supply multiple local off-takers with 100% green hydrogen.

The technological improvements and focus on system optimization that are expected to be achieved within the scope of the GREENH2ATLANTIC have the potential to guide the hydrogen economy towards a significant reduction of green hydrogen production cost and, consequently, wider deployment of large-scale hydrogen plants.
Finally, the GREENH2ATLANTIC project is part of higher scale initiative formed by EDP, ENGIE, GALP, MARTIFER, BONDALTI and VESTAS (below identified as Equity Partners), which aims to scale up GREENH2ATLANTIC project with the final goal to reach electrolyser capacity of, at least, 1GW by 2030.



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## Project expected exploitable results

The first step towards the identification of exploitation opportunities requires the identification of the Project Results (PR). PRs are defined by the European Commission as follows: "*A **Project Result** is defined as any tangible or intangible output of the action, such as data, knowledge and information whatever their form or nature, whether or not they can be protected*".

Preliminary project results, according to the planned work to be performed throughout the GREENH2ATLANTIC project, can be summarized as follows:

- Novel, pressurized large scale 16 MW ALK electrolyser modules;
- Development of scalable 100 MW ALK electrolyser platform, composed of 6 modules;
- Develop a flexible green $H_2$ production process, directly coupling renewables with the electrolyser, supplying the produced hydrogen to multiple end-users (Sines refinery and Natural Gas grid);
- AI-enhanced Hydrogen Management System (AHyMS) development and integration at TRL8;
- Target and overall LCOH < 3 EUR/kg and Demonstrate CAPEX reduction, improvement in increase, Balance of Plant (BoP), lifetime, current density and flexibility.

Following the PR description, a KER can be defined as a PR emerged throughout the project, selected for its high potential to be exploited by project partners or, in some cases, by other external stakeholders [1].

Following the KERs definition provided above, a preliminary list of KERs was identified during proposal preparation, which are summarized in Figure 3**Error! Reference source not found.**. Throughout the first six months of the project the identified KERs have been reviewed and updated by the lead partners of the

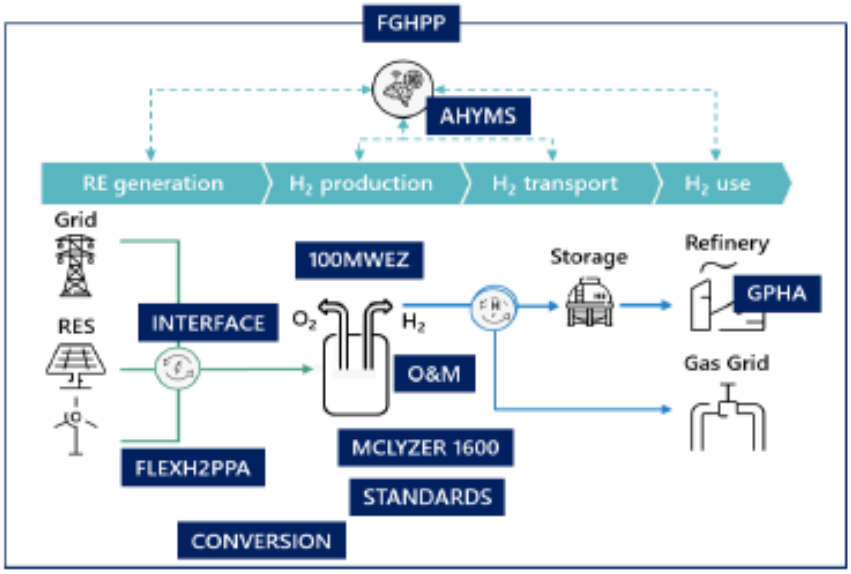


*Figure 3 – GreenH2Atlantic KERs at proposal stage*



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consortium. EDP, as task leader, arranged a dedicated workshop, during March 2022 (M4), involving all relevant partners to facilitate this process. Furthermore, dedicated meetings with specific partners have been arranged, to provide eventual clarifications and support.
The current identified KER, reflect the knowledge and position of M6 of the project, hence they will be subject, if relevant, to further refinement and revision. Eventual updated to the project KERs will be included in the next versions of the present deliverable.

**Error! Reference source not found.** shows the up to date identified KERs, being classified in the following four categories:

- **Acronym**: short name identifying each KER;
- **Work Package**: Related GREENH2ATLANTIC Work Package and, if applicable, specific task and deliverable, where the KER will be developed;
- **Owner**: Partner responsible to lead the generation of the KER;
- **Partners involved**: Partners directly involved and contributing to the generation of the KER;

*Table 1 – GREENH2ATLANTIC project KERs*

| KER | Work Package | Owner | Partners involved |
|---|---|---|---|
| FGHPP | WP7 | Equity Partners | |
| MCLYZER 3200 | WP2, WP4 | McPhy | |
| 100MWEZ | WP2, WP4 | McPhy | |
| HYBRID RES FORECAST | WP6 (T6.1) | Vestas | INESC-TEC |
| AHYMS | WP2, WP6, WP7 | ENGIE | |
| O&M | | GALP / EDP | Bondalti, Martifer |
| STANDARDS | WP8 | DLR | ISQ, EDP, GALP, McPhy, INESC TEC, CEA, AXL |
| GHPA | | Equity Partners | |
| RED II COMPLIANT PPAs | | Equity Partners | |
| CONVERSION | WP9 | EDP | Martifer |
| ELECTRO MAX | WP2, WP9 | INESC TEC | |
| GO TO MARKET | WP10 | AXELERA | |

The KER identified in the early stage of the project include:

- **FGHPP**: a first of a kind 100 MW Flexible Green Hydrogen Production Process (FGHPP). The FGHPP, as shown in Figure 3, encloses the overall GREENH2ATLANTIC concept covering the entire hydrogen value chain. In fact, the 100 MW electrolyser platform will be integrated with a hybrid renewable plant, composed of wind and solar and two



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local off-takers: the Sines refinery and the nearby Natural Gas grid. Within the FGHPP the GREENH2ATLANTIC project plans to:

  - demonstrate a steady supply of green hydrogen to the Sines refinery and the Natural Gas grid;
  - Demonstrate commercialisation of affordable green hydrogen to the refinery, leveraging all sources of additional value (electrolyser flexibility, hydrogen injection into gas grid);
  - Develop initial knowledge as a basis for the development of an economically sustainable 1 GW-scale RE-powered hydrogen value chain.

- **MCLYZER 3200**: a novel, more compact, pressurized 16 MW Alkaline (ALK) electrolyser modules allowing fast cyclability. The McLyzer 3200 process unit configuration will be a XL 16MW module, composed of 16 stacks of 1 MW each. This is a first step for the integration of larger stacks to be developed (5 MW – XL stacks) to form module of 20 MW composed of four stacks. The increasing capacity of the core components of the electrolyser (i.e. stacks and module process unit) will lead to significant cost reduction supported by two main ingredients: size effect and system optimisation (performance, footprint). Besides, the automation of stacks manufacturing will drive down stack's costs drastically thanks to economies of scales. Overall, the McLyzer 3200 constitutes a new electrolyser product line meeting market expectation at competitive market price of 480€/kW.
- **100MWEZ**: scalable 100 MW ALK electrolyser platform and system configuration. Based on the McLyzer 3200, the 100 MW electrolyser system will be a scalable and modular configuration that can be associated by blocks of 100 MW to reach a GW-scale combination. Compared to the current available solutions on the market. GREENH2ATLANTIC project will deliver a qualified optimal 100 MW platform that can be applied for capacity build-up or replication in other locations, fostering production cost reduction. Overall, the 100MWEZ will provide the following expected outputs:
  - Optimal large-scale architecture and selection of sub-systems;
  - Mastered technological and safety risks for large scale systems thanks to demonstrated performance and reliability;
  - Suitable to reach GW-scale production needs.
- **HYBRID RES FORECAST**: A novel approach will be taken to develop customized power forecast for hybrid plants (wind + pv) on day-ahead, intraday and very short term (minutes to hours) time horizons. Ensemble weather forecasts with multiple scenarios of physically consistent weather parameters (wind, solar irradiation, etc.) will be considered. Additional, remote-sensing instruments on the site will be used to improve accuracy and granularity of the very short-term RE forecasts.
- **AHYMS**: An AI-enhanced Advanced Hydrogen Management System (AHyMS) for optimised value creation, composed of 3 software's: a Digital Twin, Value



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Optimization System (VOS) and Operational Control System (OCS). The AHYMS will rely on several external inputs to function:

  - Renewable production forecasts by Vestas developed by Vestas (HYBRID RES FORECAST KER), external to AHYMS solution;
  - Market price forecasts, which will be provided by ENGIE GEM, based on external sources of information;
  - All realized information of the hydrogen plant and Renewable fields performance;
  - Dynamic hydrogen consumption profiles of the hydrogen off-takers.

- **O&M**: Through GREENH2ATLANTIC project Operation and Maintenance services for large-scale green hydrogen assets know-how will be developed and expanded.
- **STANDARDS**: The GREENH2ATLANTIC project has a dedicated Work Package (WP8) to Standardization, Qualification and Certification, led by DLR, with the following specific objectives**:**
  - Advancement and harmonisation of international standards, and qualification programs to assess operational performance and durability of large-scale electrolysers operating dynamically;
  - Recommendations to develop specific qualification protocols for grid balancing services for electrolyser at European level;
  - Assessment of any other standards relevant for the activity beyond the boundaries of the electrolyser, identifying and trying to solve contradictions, giving feedback to the relevant ISO and IEC working groups and making recommendations for pre-normative research and standard proposals to CEN/CENELEC.
- **GHPA**: Green Hydrogen Purchase Agreements (GHPA), aiming to set a reference for green hydrogen off-take contracts in Europe.
- **REDIIPPA**: Innovative RED II compliant PPAs leveraging electrolyser flexibility in benefit of RE producers and consumers.
- **CONVERSION**: GREENH2ATLANTIC project aims at converting fossil-based power plants, namely coal-fired power plants (CFPP), to integrate green hydrogen within an industrial cluster. The work performed within the project aims at:
  - Facilitate the use of circularity by repurposing existing phased-out infrastructures in green hydrogen initiatives;
  - Training programs for former CFPP staff to operate an electrolyser plant.
- **ELECTRO MAX**: Within the scope of WP2 and WP9 a new control system (hardware and software) will be developed, with the goal to enable electrolysers to participate in the provision of balancing ancillary frequency regulation services, such as Frequency Containment Reserve (FCR) and Frequency Restoration Reserve (FRR). The novel control system is expected to:



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  - Generate additional income from the operation of the electrolyser in the system services market;
  - Reduce overall hydrogen production costs;
  - Improve the incorporation of renewable generation into the electricity system.
- **GO TO MARKET**: Methodology to support industrial companies in their investment decisions to switch to green hydrogen The final output will be a pragmatic, de-risked, systemic roadmap and investment plan for the emergence of the local hydrogen Hub with a schedule, a budget, KPIs, flagships, milestones, objectives, roles and commitments. The roadmap will schedule techno-economic and FEED studies, which will be implemented with local stakeholders beyond the budget of GREENH2ATLANTIC. The first roadmap will be completed on the Auvergne Rhône-Alpes Region (France). Then the methodology will be replicated in 3 EU cluster commitments.

## 2.2. GREENH2ATLANTIC innovation and expected results

Following the project's KERs identification, a thorough state-of-the-art revision was performed to map GREENH2ATLANTIC innovation and how the project contributes to advance the current SOTA. A summary of the performed analysis is included in **Error! Reference source not found.**, which is structured in the following categories:

- **GREENH2ATLANTIC KER acronym**: aligned with the ones identified in Table 1;
- **State-of-the-art (SOTA)**: The current SOTA of the identified GREENH2ATLANTIC KERs. This includes scientific literature and relevant European R&D&I projects;
- **GREENH2ATLANTIC (GH2A) advancements**: The identified innovations brought forward by the GREENH2ATLANTIC project to advance the SOTA;
- **Technology Readiness Level (TRL)**: Indicates the technological maturity of the KER based on a scale of nine different levels of maturity, based on the EC definition [2]. In this case the current TRL and expected TRL to be achieved by the end of the project are identified.



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*Table 2 – GREENH2ATLANTIC advancements beyond SOTA*

| KER | SOTA | GH2A advancements | TRL | |
|---|---|---|---|---|
| | | | Start | End |
| FGHPP | Current H2 production based on water electrolysis is not flexible and has not yet demonstrated its flexibility at a large scale only (McLyzer 800). | McPhy will flexiblilise the current electrolyser technology and develop a 100 MW electrolyser system (McLyzer 3200) which will be integrated into a FGHPP operating in an operational environment interfacing a dedicated hybrid RE plant and a refinery as well as the NG grid. Moreover, the system will be qualified for the provision of grid balancing services thereby lifting the overall technological maturity from current technology (TRL6/7) to TRL8 | 6/7 | 8 |
| MCLYZER 3200 | (to be detailed in next version of the Exploitation plan) | (to be detailed in next version of the Exploitation plan) | 6 | 8 |
| 100MWEZ | (to be detailed in next version of the Exploitation plan) | (to be detailed in next version of the Exploitation plan) | 6 | 8 |
| HYBRID RES FORECAST | Wind and photovoltaic (PV) power forecasting has been in focus of research activities over the past decades (R&D projects like ANEMOS, ANEMOS.plus, SafeWind, DNICast, Performance Plus, and many others). Technology for wind and PV power (RE) forecasting on day-ahead and intraday time horizons with hourly or sub-hourly granularity has matured to high technology readiness and automated point power forecasts are offered as a standard service by commercial providers. The RE forecast skill has been improving through more accurate and customized numerical weather predictions as well as statistical methods and use of available data (e.g., AI /ML methods, plant production and other data, meteorological measurements, etc.). Most commonly used measure of forecast skill is mean absolute error (MAE) on day-ahead horizon averaged over a period of one | Instead of using existing methods for separate wind and PV power forecasting, a new approach will be taken by developing customized power forecast for hybrid plants considering ensemble weather forecasts with multiple scenarios of physically consistent weather parameters (wind, solar irradiation, etc.). Additional, remote-sensing instruments on the site will be used to improve accuracy and granularity of the very short-term RE forecasts.<br>The main highlights of this innovation:<br>1) Ensure that realistic temporal correlations between wind and irradiation are preserved<br>• Use of ensemble weather forecasts will provide realistic weather scenarios (trajectories) which are most likely in each situation<br>• Expected reduction in day-ahead forecast error for the hybrid plant of up to 1% points | 6 | 8 |



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| | year and normalized by installed plant capacity. Today, skill of SOTA RE forecasts is expected to be below 12% for day-ahead horizons, and below 8% for intraday.<br>However, the ways RE forecasts are being used have also grown in complexity, and that has reflected on requirements and higher expectations on accuracy, granularity, uncertainty measures, etc. Traditionally, the forecast models are tailored for a specific RE technology, but not necessarily adapted for hybrid power plants. One of the challenges is to consider physical dependencies between forecast weather parameters, e.g., wind, solar irradiation, temperature, in hybrid power forecasts and the power forecast uncertainty. Another challenge is to improve wind and especially PV forecasts on very short-term horizons (minutes to hour) to better predict high variations in production (ramps) caused by e.g., weather fronts, broken clouds which are poorly captured in standard forecasting methods. | 2) Uncertainty of the power forecasts will be estimated more reliably by using realistic weather trajectories<br>• Trajectories in ensemble weather forecasts represent physically consistent most likely evolutions of atmospheric conditions and provide a more realistic input for estimating RE forecast uncertainty in each situation, compared to statistical methods derived from previous forecast performance.<br>3) Very short-term (minutes to hour) RE forecasts will be augmented with data from on-site remote sensing instruments for measuring rapid changes in wind (Lidar) or solar irradiation (sky cameras).<br>• The remote sensing instruments provide high resolution information of wind and solar and will be used to get accurate information on both timing and magnitude of significant changes in upstream conditions. This will improve accuracy of power ramp forecasts in 0 – 30 minutes time horizon.<br>• Expected improvement is lowering the forecast error by half in the very short-term horizon compared to standard intraday forecasting methods. | | |
| AHYMS | From an initial State-of-the-art assessment in 2021, updated in Q1 2022, The inclusion of hydrogen into currently available energy management system (EMS) solutions and the interfaces between the electric and gas systems are not sufficiently incorporated into one holistic EMS. Indeed, no integrated EMS that allows for an optimal operation and control of the entire green H2 hydrogen production process from RE generation up to H2 offtake has been identified as | GREENH2ATLANTIC will develop and demonstrate the innovative AHYMS at TRL8 that will optimise the management and control of the FGHPP. The AHYMS will advance the current state-of-the-art by integrating multiple RES as well as electric grid (power markets) and develop novel control algorithms optimally steering the dispatch of the multiple electricity sourcing options to produce green H2. The AHyMS will also integrate a digital twin model that | 6/7 | 8 |



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| | commercially demonstrated to date. In spite of several recent announcements of ongoing developments, the closest commercial SOTA is Toshiba's H2EMS , which can monitor power generation from PV plants, electricity use, and H2 production as well as storage of hot water and H2 to automatically control and optimise the operation of an integrated energy system. However, since 2020 there have been no public news regarding the continuation of this product line of Toshiba . In addition, Toshiba's H2EMS has yet only been demonstrated at kW-scale operating a 30 kW solar power system and batteries. | mimics the electrolysis plant and H2 dispatching.<br>Interfaces to the power and ancillary services market will allow the AHyMS to steer the FGHPP and provide, if relevant, grid balancing services contributing to system reliability. Also, the AHyMS will investigate different AI levels. The<br>AHyMS will constitute a fully-functional EMS holistic approach by synergizing and optimizing the following vectors:<br>(i) Day-ahead and long-term hybrid wind and solar power production forecasts with uncertainty (external input),<br>(ii) forecast market prices (external input),<br>(iii) Balancing with the refinery operating set points,<br>(iv) Control Natural Gas grid injection,<br>(v) Control electrolyser fast-cyclability to match the RE profile through upstream flexibility dispatch,<br>(vi) Monitor storage state of charge (if applicable),<br>(vii) Dispatch decisions for downstream H2 supply, and<br>(viii) Forecast H2 intraday and day-ahead production capacities. | | |
| O&M | (to be detailed in next version of the Exploitation plan) | (to be detailed in next version of the Exploitation plan) | | |
| STANDARDS | Existing standard for electrolysers ISO 22734, last published update from 2019. is presently being assessed in ISO TC197 WG 34. This standard is primarily addressing safety issues of electrolysers and the update now worked on is trying to incorporate topics relevant for larger electrolysers. However there is still little experience with large scale and dynamically operated electrolysers. DLR is member of this working group trying to make, based on past experience relevant contributions. In parallel DLR is leading the | With the experience in GREENH2ATLANTIC project building, testing, qualifying and operating a large scale electrolyser lacks in available standards will be identified and reported to the existing ISO working group. The activity of ISO TC197 WG32 will be used for an initiative to work out a standard on performance evaluation of electrolysers and supporting the activity of JRC. Standardized electrolyser requirements help electrolyser industry to turn from high cost, individually fit electrolysers for every project to large- | 6 | 8 |



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| | working group ISO TC197 WG 32 working on an ISO technical report for electrolyser grid service qualification tests based on the past EU project QualyGridS. There are no standards on electrolyser performance evaluation and determination of KPIs, only an activity lead by JRC trying to harmonize electrolyser testing in EU projects. | scale, cheaper production of standard-fit electrolysers. It also helps electrolyser customers to compare offers of various manufacturers. Beyond boundaries of electrolysers many other standards are relevant in our project and it is expected that there might be some contradictions or not well defined description. Feedback of these problems with applying the standards will be given to the relevant standardisation working groups. | | |
| GHPA | Sines Refinery currently has a dedicated consumption of about 60 000 ton/year of grey hydrogen produced through SMR process. To reduce the CO2 emissions coming from the refinery, long-term green hydrogen purchase agreements (GHPAs) will be established with GALP to cover with green H2 about 5% of the Sines refinery consumption. The concept of GHPAs was initially studied by SANDIA in the United States in a feasibility study on a Zero Emission High Speed H2 Ferry, but the concept is still mostly unknown in Europe [3]. | GREENH2ATLANTIC will then be the first-of-its-kind initiative in Europe to build commercially binding GHPAs, supplying green H2 to the Sines refinery and the gas grid. GALP will use their experience setting up commercial PPAs to apply what they've learned to GHPAs. | | |
| RED II compliant PPA | GREENH2ATLANTIC will contribute to fulfilling the obligation to incorporate renewable and low-carbon gases such as H2 in the NG grid, stated in Decree Law nº. 62/202031, by injecting about 7 000 ton/year of green H2. The RE character of the H2 produced in GREENH2ATLANTIC will be guaranteed through the direct couple of the electrolyser, developed in WP4, with the RE hybrid plant. While, in times where there is no direct RE electricity production, the electricity will be procured from the grid through green PPAs. To preserve the refinery competitiveness, among other state aids and support schemes, the RED II directive was identified as an important enabler to achieve this goal. In fact, the directive establishes a common framework for the promotion of | RED II compliant PPAs to leverage electrolyser flexibility in benefit of RE producers and consumers.<br>The RED II directive is currently under revision and the main challenge will be to make it compatible with the upcoming regulation [4]. | | |



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| | energy from renewable sources, including the development of support schemes applied to renewable based H2, such as Guarantees of Origin (GoO).<br>'The Guarantee of Origin is a certification required to determine the amount of energy consumed produced from renewables. It is an electronic document whose issuance is linked to renewable energy production, but which can be disconnected from the electricity that is sold. It is a transferable certificate with a market value. It is thus possible for electrolysers operators to "clean-up" their electricity by buying GOs afterwards. | | | |
| CONVERSION | "Repurposing CFPPs to run on NG, H2 or biomass is considered as a viable way to reduce emissions and cut costs, although it brings several societal concerns related with sources of jobs, local tax revenues, public services, and power grid stability. There are several possibilities of CFPP conversion:<br>(i) Conversion from CFPP to NG: Several equipment's that need be installed/modified. Also, NG assets struggle for profitability in the European power market.<br>(ii) Conversion from CFPP to biomass: EDF is demonstrating in its CFPP in Cordemais through the Ecocombust project, the substitution of 80% of coal by black pellets. Although, biomass conversion leads to emissions reduction, its combustion releases approximately the same number of fine particles and 50% more carbon monoxide and it leads to biodiversity losses. Therefore, conventional solutions for CFPP conversion do not seem to convince most utilities and local authorities and there is a need for new, systemic approaches. For example, the EDP's Ribatejo combined cycle power plant in Portugal, within the FLEXnCONFU project is | GREENH2ATLANTIC is included in a bolder perspective to shift totally from a carbon-based CFPP site to a green H2 production site, generating RE to directly power a 100 MW electrolyser. In this context, a systemic conversion approach is applied to EDPP CFPP in Sines which was phased out on January 15th, 2021. GREENH2ATLANTIC will repurpose existing utilities, infrastructures and the local workforce to develop, operate and maintain the FGHPP at the former CFPP. Extensive site conversion activities will ensure the usage of the former CFPP site for GREENH2ATLANTIC. | 6/7 | 8 |



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| | currently being integrated with an innovative 1 MW Power-to-X process to inject H2/NG mixtures into the conventional combustion process at TRL7." | | | |
| ELECTRO MAX | Electrolysers can be used as dynamic loads being capable to respond to frequency excursions and providing balancing ancillary services. This response can be obtained within the first seconds following a power system disturbance, in a way that electrolysers will respond providing primary frequency control (FCR - Frequency Containment Reserve) via local controllers and responding also to AGC set points sent from the power system dispatch center providing secondary frequency control (aFRR and or mFRR). The existing state of art results mainly from small scale laboratorial tests and simulation developed in some Universities like Delft and Melbourne. There is a lacking on the understanding of how far the exploitation of these ancillary services can go for different type of electrolysers (Alkaline and PEM) and what will be the best control strategies to get the best performance and benefits for power system operation under large scale integration of renewable power sources together with a large fleet of electrolysers. | In GREENH2ATLANTIC an advanced control system including hardware for the AC/DC power converter and control software will be developed in order to provide fast balancing ancillary services (FCR, aFRR) including also fast frequency response (FFR) and inertia emulation to get the best performance from electrolysers when responding to grid disturbances. Tests will be performed under a Power Hardware in the Loop (PHIL) with a small scale electrolyser to understand the limits of this solution and to identify the requirements for a future large fleet of electrolysers. | | |
| GO TO MARKET | "AXELERA starts to determine the framework of the methodology to be deployed for the decision toolbox, with the different tools that we will have to develop. Moreover, we start discussion with different industrial companies.<br>A first Strategic Intelligence Bulletin has been sent to the consortium partners end of March and contributes to understand the market and also make strategic decision." | | | |



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## 2.3. KER characterization methodology

Once the GREENH2ATLANTIC value proposition and related KERs is defined and assigned to each partner, an appropriate exploitation strategy is key to detail the relevant characteristics of each KER, with the ultimate goal to bring a clearer view on how to ensure the post project activities and market entry.

The present paragraph describes the KER characterization table, that will be used throughout the project and its results will be included in the next versions of the present deliverable. The KER characterization table is the tool identified to summarize the main characteristics of each KER and provide information on the selected exploitation route. The table does not focus on the technical dimension and details of each KER, but rather on the dimensions to be considered when dealing with the use of a result, following a demand driven approach.

Each partner responsible for the KER will be responsible to collect meaningful information to complete the table, the results will be used as basis to further develop the exploitation strategy both at consortium as well as at partner level.

The KER characterization table is structured as follows:

- **The novel solution**: A short description of the problem each KER aims at solving (user perspective), compared to the current available solutions; the Unique Value Proposition highlighting which is the innovativeness or the competitive advantage compared to the existing Products or Services;
- **Market**: market context in which the KER will be introduced;
- **External factors**: Identification of legal, normative or ethical requirements to implement and commercialize the KER;
- **Go to market**: Identifies the cost for solution implementation, time to market, estimated product or service price, Adequateness of consortium staff, External partners/experts involved;
- **IPR management**: Details the Background and Foreground IPs and the role of the involved partners;
- **Exploitation strategy**: Detailing Exploitation means (e.g. direct industrial use, technology transfer, license, publication, standard); Partner's main contributions in terms of know-how, licensing; Partner's expectations; Foreseen financing sources after the end of the project.

**Error! Reference source not found.** shows the template of the KER characterization table which will be used in the next steps of the Exploitation Plan



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*Table 3 – KER characterization template*

| KER | |
|---|---|
| **Novel solution** | |
| **KER owner** | Partner responsible for the identified KER |
| **Description** | Short description, of the problem the KER aims at solving/improving |
| **Alternative solution** | Description of the traditional solutions already present in the market |
| **Unique value proposition** | Describe the competitive advantages, the innovative aspects. What does your solution do better, what are the benefits considering what your user/customer wants, how does your solution solve his/her problem better than alternative solutions, what distinguishes the KER from the competition / current solutions? |
| **Market** | |
| **Target market** | Define the targeted customer segments or potential buyers, eventual early adopters, expected market size of the proposed solution (e.g. geographical location) |
| **Competitors** | Who are your "competitors" (note: they are the ones offering "alternative solutions")?<br>What are their strengths and weaknesses comparing to you? |
| **Market trends/public acceptance** | Description of market trends and of the hypothetical level of acceptance of the Product/Service by consumers. If applicable include possible risks/reasons why end users might be hesitant in adopting the product/service |
| **External factors** | |
| **Requirements** | Identification of legal, normative or ethical requirements to implement and commercialize the KER; |
| **Go to market** | |
| **Cost of implementation** | Describe the expected costs for solution implementation (e.g. development costs, operational costs) |
| **Time to market** | Expected time for solution marketability |
| **Foreseen price** | Expected selling price of the solution.<br>Revenues: licensing revenues (royalties, service upgrade), spin-off revenues (software development to third parties, subscriptions of the platform, advanced services (upgrades), sale of equipment. |
| **Adequateness of consortium staff** | Assess the Adequateness of consortium staff |
| **External experts/partners to be involved** | Include external Partners and/or experts involved in the implementation of the solution + participation to hydrogen EU Symbiosis Meeting. |



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| IPR management | |
|---|---|
| **Background IPR** | Include the present status and agreement with other partners involved. |
| **Foreground IPR** | Include the present status and agreement with other partners involved. |
| **Exploitation Strategy** | |
| **Exploitation means** | e.g. direct industrial use, technology transfer, license, publication, standard |
| **Partner's contributions** | Partner's main contributions in terms of know-how, licensing, patents |
| **Involved partners expectations** | Description of partner's expectations |
| **Financing sources** | Description of the foreseen financing sources after the end of the project (venture capital, loans, other grants, etc.) |



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# 3. Exploitation framework

A sound and efficient management of the intellectual property of GREENH2ATLANTIC project is fundamental to accomplish efficient utilization of the Project outcomes and to identify and solve potential conflicts among GREENH2ATLANTIC partners early on.
GREENH2ATLANTIC IPR strategy is defined in the project's Consortium Agreement, which was signed by all the project partners, before the start of the project. IPR management entails a variety of tasks, the most important of which is assessing project partner's prior knowledge (background), their expected contribution to the project's IP (Results, previously known as Foreground), the potential overlap of IP among partners to establish and plan the consortium's IP strategy.
To develop exploitation agreements, it is recommended to always refer to the prescriptions included in the Consortium Agreement and Grant Agreement, and to consult the Project Coordinator and the Exploitation Manager for any issue concerning IPR protection.

## 3.1. IPR background

Background Information (B) means, in the context of Horizon 2020, "any data, know-how or information whatever its form or nature, tangible or intangible, including any rights such as intellectual property rights, which is:

1. held by participants prior to their accession to the action,
2. needed for carrying out the action or for exploiting the results of the action; and
3. identified by the participants." [5]

In fact, Background IP shall include all IP rights as well as know-how and business and trade secrets of one Partner irrespective of whether such rights are eligible for IP registration, that is required for the project's completion. Relevant Background IPs came into existence prior to the Effective Date or were acquired or generated prior to the start of the Project or outside the scope of the Project and independently of the use of the Information and which this Partner may lawfully dispose of and use.
It is vital to ensure that any information required for the proper operation of the project is accessible to project partners prior to the start of the project, for this reason, access rights have already been addressed in the GREENH2ATLANTIC Consortium Agreement.

Some preliminary Background IPs were identified during the Grant Agreement Preparation and included in the Consortium Agreement. Moreover, throughout the first 6 months of the project, some new Background IPs were identified and agreed with the Project Coordinator.



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## 3.2. Results and BFMULO Analysis

Results, previously defined as Foreground, "in the context of Horizon 2020, mean any tangible or intangible output of the project, such as data, knowledge or information, that is generated in the project, whatever its form or nature, whether or not it can be protected, as well as any rights attached to it, including intellectual property rights.". [5]

It is important to highlight that Result owners must ensure adequate protection for the Results capable of industrial or commercial application in conformity with Grant Agreement and Consortium Agreement, in absence of protection and transfer of Results, owner(s) shall inform the EC, which may take the responsibility of protection and granting of access rights.
Several Results to be generated during the project, and their connection (if any) to the identified KERs, have been identified during the first phase of the project, following the template presented in Table 4. Ownership was assigned to each identified Result, "It enables its holder to exercise exclusive rights of use in relation to the subject matter of the IP and to restrict others from using these IP rights." [5]
Table 4 will be constantly updated throughout the GREENH2ATLANTIC project as soon as new Results are identified.

*Table 4 – Results (Foreground IP) template*

| Results | Connected KER (if any) | WP | Task/ Deliverable | Owner |
|---|---|---|---|---|
| | | | | |
| | | | | |

In the first phase of the GREENH2ATLANTIC project, the identified background (**B**) and foreground (**F**) owned by the partners involved in each linked exploitable result will be assessed. The exploitation means are resumed in the following four cases identified by a single letter, describing the intention of the partner to exploit the results by:

- **M** = Making the products, manufacturing, and selling or directly implementing through own facilities and skills
- **U** = Using the result, implemented with own knowledge to develop new ranges of products or newer processing. Furthermore, the direct or indirect use of foreground in further research activities other than those covered by the project, or for developing, creating, and marketing a product or process, or for creating and providing a service
- **L** = Licensing the result, therefore earning from a negotiation towards third parties outside the Consortium
- **O** = Other, any other exploitation means (e.g.: consultancy, services, etc.)



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Table 5 shows the BFMULO matrix template, which serves as a tool to facilitate how each partner could exploit the identified KERs, leading to identify exploitation intentions. Table 5 will be populated throughout GREENH2ATLANTIC project and the complete table will be included in the final version of the present deliverable.

*Table 5 – BFMULO matrix template*

| #KERs<br><br>Partners | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Name | U? | | | | | | | | | |
| | | M? | | | | | | | | |
| | | | | | | | | | | |
| | | | | | U? | | | | | |
| | | | | | | | | | | |
| | | | L? | | | | | | | |
| | | | | | | | | | O? | |

### 3.3. Results and Transfer of Results

As stated in the GREENH2ATLANTIC Consortium Agreement, in line with the Horizon 2020 Rules for Participation and Grant Agreement: Results are owned by the Party that generates them, unless otherwise agreed under a Separate Rendering Agreement applicable to such Party. If the Result with related IP is solely attributed to one Party, it is identified as Individual IP. In other cases, given the nature of collaborative projects it is likely that several partners are involved in fostering project results. In this case "joint ownership" of results may arise. Joint IP is defined as follow: intellectual property that has been created in the context of the Project implementation solely by two or more Parties in connection with a task attributed solely to such Parties under the Consortium Plan. The identified IPR ownership is managed as follows, according to what is stated in the Consortium Agreement:

Individual IP: shall be owned by the Party that has created it

Joint Ownership: shall be owned jointly by the Parties that created it, who shall enter into a joint ownership agreement to establish the terms and conditions applicable to such joint ownership as per Article 26.2 of the Grant Agreement, provided that, unless otherwise agreed:

(i) each of the joint owners shall be entitled to use their jointly owned Results for non-commercial research activities on a royalty-free basis, and without requiring the prior consent of the other joint owner(s), and



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(ii) each of the joint owners shall be entitled to otherwise Exploit the jointly owned Results and to grant non-exclusive licenses to third parties (without any right to sub-license), if the other joint owners are given:

a. at least 45 days' advance notice; and

b. Fair and Reasonable compensation.

Given the complexity of GREENH2ATLANTIC project the following clause applies to Result ownership: Project Company shall be granted with a right to use the IP rights created in connection with the project and required for the implementation of the project (royalty-free). The same conditions apply for the use of generated IP rights for the purpose of GREENH2ATLANTIC project, valid until the decommissioning of the project.

The Project Company, is composed of the Equity Partners, defined above in the document.

Transfer of Results:

As established in the Consortium Agreement for the project, the transfer of results need to be conducted while respecting the following conditions:

- Each Party may transfer ownership of its own Results following the procedures of Article 30 of the Grant Agreement.
- The transferring Party shall, at the time of the transfer, inform the other Parties of such transfer and shall ensure that the rights of the other Parties will not be affected by such transfer.
- The obligations above apply only for as long as other Parties still have – or still may request – Access Rights to the Results.

Furthermore, as per the Grant Agreement, unless agreed otherwise (in writing) for specifically identified third parties or unless impossible under applicable EU and national laws on mergers and acquisitions, a beneficiary that intends to transfer ownership of results must give at least 45 days advance notice (or less if agreed in writing) to the other beneficiaries that still have (or still may request) access rights to the results. This notification must include sufficient information on the new owner to enable any beneficiary concerned to assess the effects on its access rights.

Unless agreed otherwise (in writing) for specifically identified third parties, any other beneficiary may object within 30 days of receiving notification (or less if agreed in writing) if it can show that the transfer would adversely affect its access rights. In this case, the transfer may not take place until agreement has been reached between the beneficiaries concerned.



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### 3.4. Access Rights

Access Rights are, for the purposes of Horizon 2020, rights to use the project's results or background.[5] Access right conditions have been agreed and are detailed in the GREENH2ATLANTIC Consortium Agreement. To summarize, during project implementation, Access Rights to Results and Background needed for the performance of the own work of a Party under the Project shall be granted on a royalty-free basis, unless otherwise agreed for Background in the Consortium Agreement.

On the other hand, access rights to Results for Exploitation purposes shall be granted on Fair and Reasonable conditions and are subject to specific agreements among the interested Parties. A request for Access Rights may be made up to twelve months after the end of the Project or after the termination of the requesting Party's participation in the Project

Table 6 gives an overview of the general conditions concerning the granting of access rights as established in the Consortium Agreement.

*Table 6 – General conditions for granting Access Rights*

| Purpose | Access to background | Access to results |
|---|---|---|
| Implementation of project | Royalty – free, unless otherwise agreed by partners in the Consortium Agreement. | Royalty - free |
| Exploitation of owned project results | Subject to agreement, access rights shall be granted under fair and reasonable conditions | |



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## 4. Exploitation Plan per partner

The present section will detail how each of the consortium partners envisages their role in the future exploitation of the results of GREENH2ATLANTIC. Each partner will define their individual plan as per their own strategy and resources. This plan should include the results they expect and how they plan to advance them to market readiness. The goal is that all exploitable results should reach the market uptake phase.

The plan can be broken down into these steps:

- Detail the individual expected results (products/services/knowledge generated in the project)
- Identify potential users/clients for the expected results
- Identify sales channels to reach potential users/clients
- Quantify the anticipated jobs created during and after the project
- Specify the exploitation type of the individual expected results (e.g., Know-how licensing, internal product development, R&D Services, etc.)

The individual exploitation plans by each partner will be detailed as part of the second deliverable of the exploitation plan. Table 3 is a sample format for how the Partner exploitation will be outlined.



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# 5. Consortium Exploitation Plan

During project development, the Consortium-level exploitation strategy, based on the identified joint exploitable knowledge will be defined.

The Consortium exploitation Plan will detail an overall action framework comprising:

(i) Exploitable knowledge,
(ii) Exploitable activities,
(iii) Exploitation timeline,
(iv) Exploitation channels

to guide the consortium and explore the synergies between the individual exploitation plans of each partner.



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# 6. Conclusion and next steps

The present deliverable is the first version of the Exploitation Plan, developed within Task 10.2 of *Work Package 10 – Replication, Exploitation and EU-wide Industrialization*, which will last for the whole duration of the project and will be constantly updated, following GREENH2ATLANTIC developments.

In line with the Exploitation Plan goals to provide insights in relation to how the PR will be used by each partner, the following results were achieved:

- Preliminary identification of KERs starting from the PR. For each KER ownership was assigned and a description of the expected advancement beyond SOTA is provided for most of them.
- KER characterization methodology was outlined and agreed with GREENH2ATLANTIC project partners
- An overview of the Exploitation Framework and IPR management strategy was introduced, as well as an initial identification of Background and Foreground IP is included in Chapter 3

As next steps, the present deliverable will be updated throughout the project and the following activities to be performed were identified:

- KERs will be refined and, where relevant, updated according to the development of the project.
- KERs will be characterized following the proposed methodology by each responsible partner, necessary to detail partners and overall consortium exploitation strategies.
- IP protection plans will be further extended and the BFMULO analysis will support this process.



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# 7. References

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