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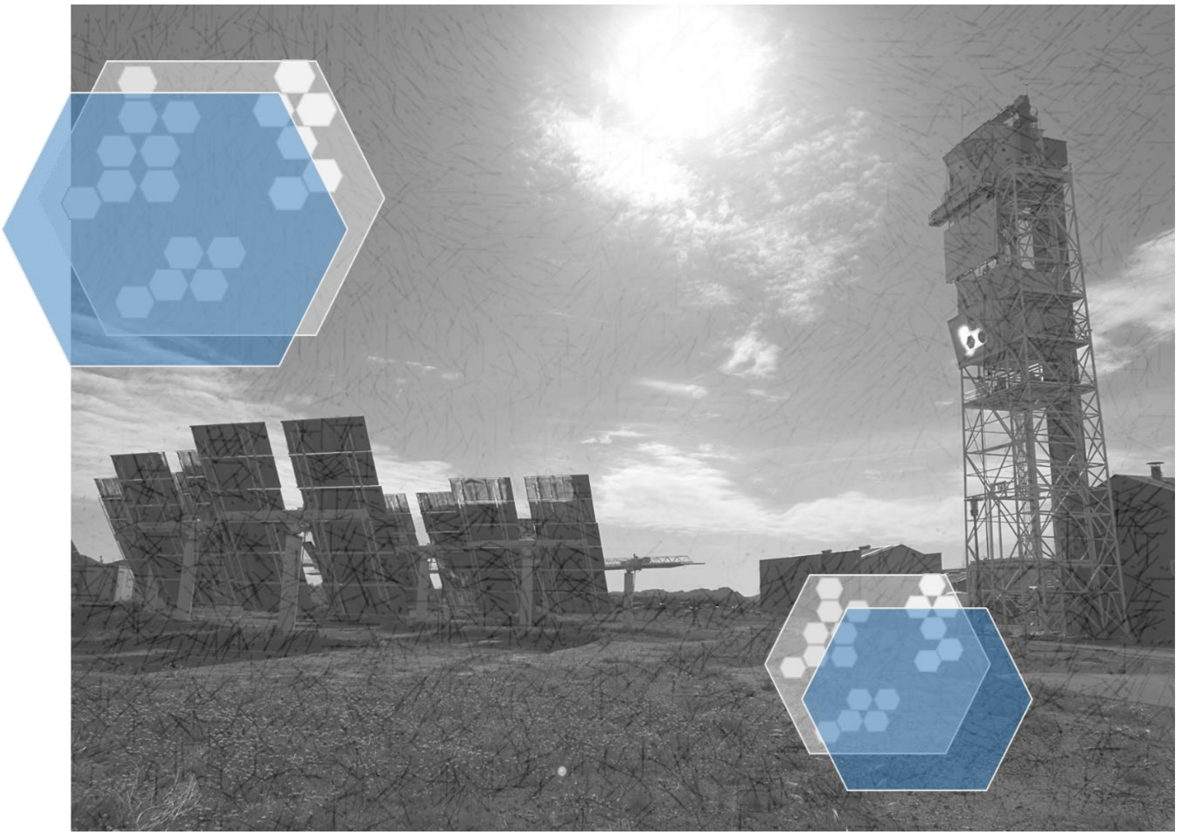

Supported by

Fuel Cells & Hydrogen Joint Undertaking (FCH-JU)

DELIVERABLE 9.2

PLAN FOR THE DISSEMINATION AND EXPLOITATION OF RESULTS (MID TERM)

Dissemination Level: **Public**

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1 Introduction

The objective of the dissemination and exploitation plan is to identify and organize all necessary activities that will be performed in order to effectively promote the HYDROSOL-beyond's achievements, attaining the widest possible dissemination of knowledge from the project. The Consortium will aim at targeted dissemination activities to the most wide and relevant audience as well as to the general public; more specifically the proposed plan will be expanded in four directions:

- **International networks of researchers and industry experts;** for the development and marketing of renewable and clean energy (e.g. SolarPACES & Mission Innovation Challenge), in order to further strengthen the EU leadership on renewables, through demonstration of successful results among which the Consortium is targeting at high performance of key materials and key components at large scale suitable for solar-thermochemical water splitting;
- **Multipliers and Interest Groups**; such as EC, IEA, EERA, IEEE, National Ministries and other National and International Agencies; researchers and industry experts global grid for the development and commercial exploitation of concentrated solar thermal power systems and solar chemistry technologies;
- **The transport sector**. This effort will aim to increase the incorporation potential of solar fuels – *such as solar hydrogen* – in the forthcoming strategies of the transport sector targeting to increase the use such energy carriers and minimize the carbon footprint occurring from the use of conventional fuels/technologies;
- **The general public**, via using journalist contacts of the Consortium partners, in order to generate recognition by a wider public, e.g. the readers of more popular magazines (i.e. Science, Nature, etc.), as well as via social media networking;

In order to maximize the impact of the project's results, the Consortium unanimously recognized the significance of a work package dedicated solely to the Dissemination and Exploitation activities (i.e. WP9). For that purpose a wide set of dissemination and exploitation activities were indeed planned, with synergies/connection among the two activities, in order to increase the potential impact. Exploitation and dissemination activities therefore, since the proposal stage, are foreseen to proceed in parallel ways over the entire duration of the project (Figure 1). The Consortium strongly believes that it is essential to constantly capture, monitor and manage results of the project (including the accompanying IP Rights) and adjust communication activities, as well as dissemination and exploitation plans, accordingly. Regular tracking of the project's progress will allow monitoring the results once they are achieved and will help identify possible outcomes that were not originally foreseen at the start of the project. These unforeseen results should be closely evaluated to determine their exploitation potential and further application in various fields since the potential successful breakthrough achievements of the project go well beyond the field of solar thermochemistry.

Even though the dissemination and exploitation activities span through the whole duration of the project, these activities are expected to gain their maximum momentum towards the end of the project when the bulk of expected outcomes will typically emerge, and can be brought together to address the call challenges and expected impacts in an integrated way. Consequently, the proposed plan will have to extend even after the project completion (i.e. continuation of results' publication), creating inevitably an increasing awareness and interest amongst potential users, which in turn fuels further exploitation of results. A fact that is expected to enable further increase of the overall HYDROSOL-beyond impact, is that the project not only will rely and build on previous experience and technological know-how – stemming from the former FCH-JU HYDROSOL-Plant project – but will also be in close cooperation with the numerous scientific programs in which the Consortium members are participating and are related to solar thermochemical processes (considering both EU, nationally funded or projects funded by own sources).

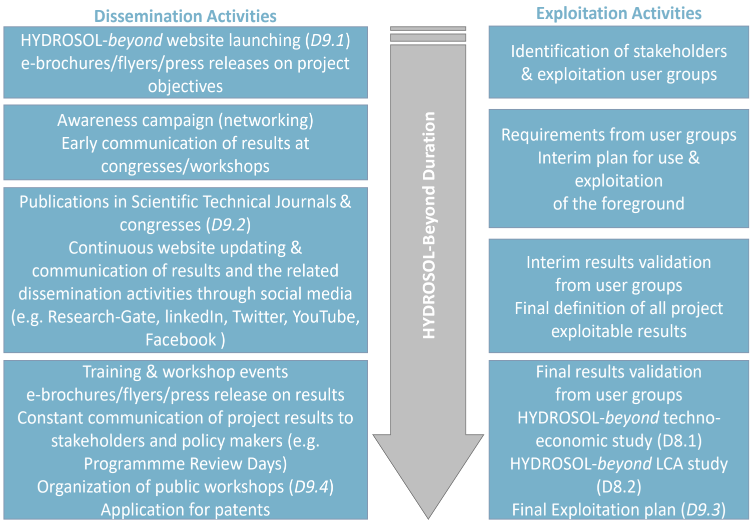


Figure 1. Indicative planed Dissemination and Exploitation activities, as foreseen at the proposal stage.

In addition, following the instruction of the FCH2-JU on measuring the impact/leverage of the programme in the sector, the following apply: Unless it goes against their legitimate interests, each beneficiary must – as soon as possible – 'disseminate' its results by disclosing them to the public by appropriate means (other than those resulting from protecting or exploiting the results), including in scientific publications (in any medium).

Figure 2. Concentrated solar tower plant.

The actions for the exploitation of the Project's outcome within and outside the partnership (licensing/royalty agreements) are the subject of a specific work package (WP9). As already stated before all exploitation actions will proceed in parallel and will interact with the dissemination activities. For this reason, both strategies will be examined as a single entity and will be reported within common deliverables. Two deliverables are planned within Hydrosol-beyond to report the relevant actions (D9.2 & D9.3). In the first deliverable, the involved partners will provide an updated and more detailed Plan for the Exploitation and Dissemination of occurring Results, explaining how they intend to further exploit and disseminate both the preliminary and the oncoming results.

In the second deliverable the Consortium will come up with the Final Plan that in addition to correlating the current exploitation achievements to the dissemination activities, it will predict the required future actions of the consortium that should be followed after the completion of the official Project Period.

2 Dissemination plan

The objective of the dissemination activities is to spread the knowledge, information and results of the Hydrosol-beyond project.

The Dissemination Plan, in section 2.1, summarizes the Consortium's Strategy and the concrete actions to achieve the dissemination and protection of the foreground generated by a project. This plan should serve as a guideline to the Consortium for the Dissemination activities to be carried out in the context of the Hydrosol-beyond project, this plan should be considered as versatile and flexible tool.

Dissemination activities have been classified in the different categories indicated below:

- Publications: related to publication of results in peer reviewed journals, non-scientific publications, proceedings for congress.
- Participation in scientific and specialized Events: symposia, conferences, seminars, summits, meetings, workshops, trademark shows in the most interest areas of the project.
- Activities related to education.
- Coordination with another EU funded projects with a similar or related topic.
- Dissemination towards industry or investors.
- Dissemination towards Policy Makers.
- Workshop Organization.
- Other Dissemination activities outside the Consortium: promotional material produced for the diffusion of the project, development of potential patents, contact with European Service to strengthen the dissemination activities.
- Dissemination via website or social networks: as the creation of the website and other activities using social media.

The dissemination activities carried out from the beginning of the Project until December 2020 (M24) are reviewed in section 2.2, while the foreseen activities are indicated in section 2.3 of this deliverable.

2.1 Dissemination plan

There is a Dissemination Plan for Hydrosol-beyond Project inside the Consortium and beyond the Consortium. This plan is focused in the following key elements:

a. the subjects of dissemination (what will be disseminated)
b. the target audience (to whom it will be disseminated)
c. the dissemination methods (how it will be disseminated)
d. the distribution of responsibilities for dissemination (who will perform the dissemination) and rules for planning and performing of dissemination activities are described here.

The HYDROSOL-beyond partners are actively encouraged to disseminate the project results the soonest possible to the public by any appropriate means, unless it goes against their legitimate interests. To avoid confidentiality and classification for the protection of knowledge, the dissemination activities that may occur during the Project Duration are subjected to review/-screening from the HYDROSOL-beyond General Assembly (GA) committee. In each case, the GA will decide if the action is eligible to receive a written permission to immediately go public, or if it should be withheld for an agreed reasonable time period to allow appropriate protection of the IP to be sought. Every decision making will be in accordance to the definitions included in the Consortium Agreement approved (and to be signed in case the HYDROSOL-beyond proposal is approved) by the project partners.

Since the dissemination activities are considered a core element for the successful implementation of HYDROSOL-beyond results in future solar thermal energy applications for fuel production and in particular for solar hydrogen production, all the actions undertaken will make the most of the long-term professional experience of the partners in the writing of scientific articles – experience held mainly by the partners in the research sector – and in technology-oriented/-more commercial activities – expertise held mainly by the industrial partners. In addition, the fact alone that the proposed Consortium forms a collaboration among partners located in six different European countries, will ensure the existence of a constant trans-European dissemination.

More specifically the partners intend via HYDROSOL-beyond to contribute to the European social and technological progress by disseminating the project results throughout the whole project's duration and for a period of up to four years after the end date of the action. The most commonly employed dissemination routes for scientific results are congresses (oral and poster presentations and publication in conference proceedings), specialized workshops, an open access part of the project website, publications in scientific journals (especially those aimed at the key audience such as scientists and engineers) and non-technical/scientific articles published in popular science magazines or websites. In the following paragraphs a more detailed description of the overall dissemination strategy to be followed is presented:

2.1.1 Dissemination of Knowledge within the Consortium

Considering that the performance of the HYDROSOL-beyond work plan requires intensive collaboration among the project partners, an efficient and extensive knowledge exchange mechanism is essential for project success. Therefore, different management tools will be applied to ensure this information and knowledge exchange.

- For a fast start-up, an introduction of the different areas of expertise, research areas and involved research staff as well as for development of cooperation and communication rules, a kick-off meeting will be organized by the coordinator. In this way the project will be launched effectively, and explicit communication patterns will be established.
- To guarantee on-going, fast and complete flow of information to all involved partners, the coordinator will establish an electronic mailing list.
- For data and document exchange, a file and project management tool will be implemented that allows for easy handling and sharing of simulation and testing data, results, reports and further documents. By that, efficient collaboration is possible avoiding unnecessary coordination effort (and thus optimum use of available resources).
- For sufficient documentation of the developed knowledge, a minimum number of technical reports is predicted. All public reports will be available on the public area of the project website *(more details are provided below)*, while confidential reporting will be available for exchanging within the consortium members through a password-protected area of the website.
- Furthermore, periodic meetings will be organized twice a year, and will be held each time at the premises of a partner to give the opportunity to visit the facilities where experimental campaigns are taking place and to facilitate a more efficient communication of results and work planning.
- Finally, when required, telephone conferences will keep communication open and active throughout the project, ensure the steady flow of information and resolve any issues the moment they arise.

2.1.2 **Dissemination of Knowledge beyond the Consortium**

Dissemination of developed knowledge beyond the Consortium is the key to improving knowledge and to support the development of solar hydrogen thermochemical production. Therefore, WP9 will cover the dissemination part and ensure that the dissemination and exploitation plan is followed. The part of the dissemination plan addressed beyond the Consortium will cover the following issues:

Dissemination on the scientific level / Scientific Publications

As defined in Task 9.2 (and two associated deliverables), the Consortium will ensure that the project results are sufficiently communicated to the rest of the scientific community by being submitted as scientific papers in leading project-field-related peer-reviewed journals/magazines and chapters in edited volumes. As set out in the Consortium Agreement, each partner will be required to inform others about the release of any public documentation. This will facilitate the approval and release of information into the public domain. For each of those journal publications, HYDROSOL-beyond beneficiaries will ensure open access to the scientific publications and their bibliographic metadata relating to the project by depositing them as soon as they are published - at the latest within 6 months of publication - in online repository for scientific publications such as the EC commissioned Zenodo and OpenAIRE. The beneficiaries will also aim in parallel deposition of any research data needed to validate the results presented in the corresponding deposited scientific publications. In all cases, the dissemination results will acknowledge the funding source. To further ensure open-access to the project’s results both Green and Gold Model of Open Access Publishing will be used. The Gold model will be used by submitting manuscripts to open-access journals and by requesting and ordering open access from conventional publishers e.g. Elsevier. Selection per individual publication will be decided on a case-by-case basis. The former Model is straightforward to apply by adding the publication to one of the partner's publication portals e.g. DLR's ELIB (Electronic Library System) or to online scientific social networking websites/databases such as ResearchGate and Academia.edu enabling to grant access to publications to a general public – on demand and after the embargo period set by the publisher.

Dissemination on the scientific level / Participation at symposia/meetings
National and international (mainly virtual because of current pandemic situation) conferences will be approached to identify whether the project information can be disseminated as part of conference proceedings and discussed at the related scientific fora. Conferences to which partners have already participated will be approached in particular. The partners will search participation at relevant international symposia to dissemination publishable project results and to link the project to the international scientific context. These include dedicated energy, specifically renewable energy and chemical engineering meetings and conferences (like IRES, SolarPACES, ASME-ES, AIChE Annual Meeting, the ECerS conference etc.). Naturally, only non-confidential or already adequately secured via patenting activities results of the project will be presented at such conferences.

Dissemination activities in education
The research results of the HYDROSOL-beyond project are expected to directly affect master and doctoral students in the different research organizations (i.e. APTL/CERTH, DLR, CIEMAT, SUPSI, CEA): the new knowledge gained will be incorporated in MSc and PhD training programs of the partner universities/research institutes - training and education courses, including integration of results in the future MSc courses and PhD education). In addition, students cooperating with the research institutes could be employed by the industrial partners. During the project around 4-6 post-docs and doctoral candidates will be involved directly in the RTD work. Promotion of the science to pre-university students will also be reinforced. The project could be presented at larger groups of pre-university students and school-teachers during open days, through other training and education actions including short courses, dedicated seminars, workshops etc. The technologies will be also disseminated in workshops and through the receipt of training secondments to several of the partners. It is planned that there will be 2-3 researcher's mobility missions between some partners.

Dissemination and integration of know-how into other projects
The project partners will apply and communicate the developed knowledge in related projects and by that contribute to an extension and application of the developed knowledge. The partners will disseminate their knowledge within their respective scientific and industrial networks and so improve and further develop the knowledge in related technologies.

Dissemination towards industry
HYDROSOL-beyond results will be presented within the industry communities where applications have been identified (e.g. hydrogen consumers, chemical industries, energy intensive industries, the transport sector, etc.) in order to ensure a future easier transfer of the knowledge generated towards industrial applications. Exhibitions and science fairs will be important tools for dissemination activities towards a broader professional audience. The feedback obtained from them should also be disseminated within the Consortium.

Dissemination towards policy makers

HYDROSOL-beyond results will be presented to European regulations authorities and policy-making bodies as well as to related associations/initiatives (SOLARPACES, IEA, JP CSP in EERA, IPHE, European Green Vehicles Initiative, EGVI; European Automotive Research Partners Association EARPA;) in order to contribute to the dissemination of the project. The consortium will participate in Fuel Cell & Hydrogen Joint Undertaking 2 (FCH-JU 2) public events. Traditionally the FCH2-JU is an organization that actively supports the dissemination of the results of its projects. The HYDROSOL-beyond will exploit any such dissemination mechanism (publication of project information on the official sites and special reports of the FCH2-JU, participation in public events and meetings organized and at the Programme Review Days annual event).

Dissemination via own website and social networks

Within the Consortium, a website will be created, and a part will be dedicated to Member's only. This facilitates the communication and information transfer between partners and serve as a comprehensive information database. This is a secure site with password protection. The website will include new features to improve communications between researchers in different laboratories. Examples are: a tracking system so that the progress of the tests can be monitored; a discussion forum so that researchers can ask questions, request information or help from other partners; a diary so that partners can follow the progress of other researchers in other laboratories and keep up to date with the latest findings.

In addition to the website, the consortium will make use of any modern social networking tool that is considered able to serve well in order for the Consortium to communicate the project to the rest of the scientific community and the general public. Thus the project-related results and the dissemination activities in general, will also be promoted via networks such as LinkedIn, ResearchGate, Academia.edu, as well as Twitter and YouTube.

Workshop Organization

The organization of a workshop is foreseen at the end of the Project. Major stakeholders and external experts in the field will be invited to attend and be informed on the project's final results and visit the actual integrated platforms. An attendance of at least 50 external experts will be sought who will be invited to share their visions and proposals for the future of the technology.

Other Dissemination activities outside the Consortium

Publication of white papers on websites of (a) the RTD performers and (b) the industrial partners will ensure that the wider scientific community will have access to the publishable project's results. Newsletter and brochures (support for conferences): this type of material might consist of a small set of technical pages to be used as printed support on exhibitions, demonstrations and mailings. Specific, targeted publications and announcements will be agreed and promoted by the partnership to disseminate information and stimulate the interest of other industrial partners currently not participating in the Consortium. Researcher's Night, Open Days (also in online mode) activities will be also used for disseminating the projects achievements to the greater public. Strong links and interactions are already established with the most relevant technical journals in the respective fields, whereas Consortium members have already a successful track record as regular organizers of International Conferences as well as participants in International Trade Fairs. Emphasis will be given on the promotion of the Project within key opinion-maker bodies (European parliament, National/Local parliaments, Industrial and Commerce Chambers) as well as to the wider public (newspapers, magazines etc.) with skilled personnel either already existing among the partners or with new one to be specifically hired for that purpose.

2.2 Past dissemination activities

The dissemination activities carried out during the first (2019) and the second (2020) year of the Hydrosol-beyond Project are described in this section.

2.2.1 Dissemination of Knowledge within the Consortium

Periodic meetings of the Consortium were taken place:

- M1- Thessaloniki (APTL/CERTH).
- M6- Switzerland (SUPSI).
- M12- Cologne (DLR).
- M24- online meeting due to pandemic situation.

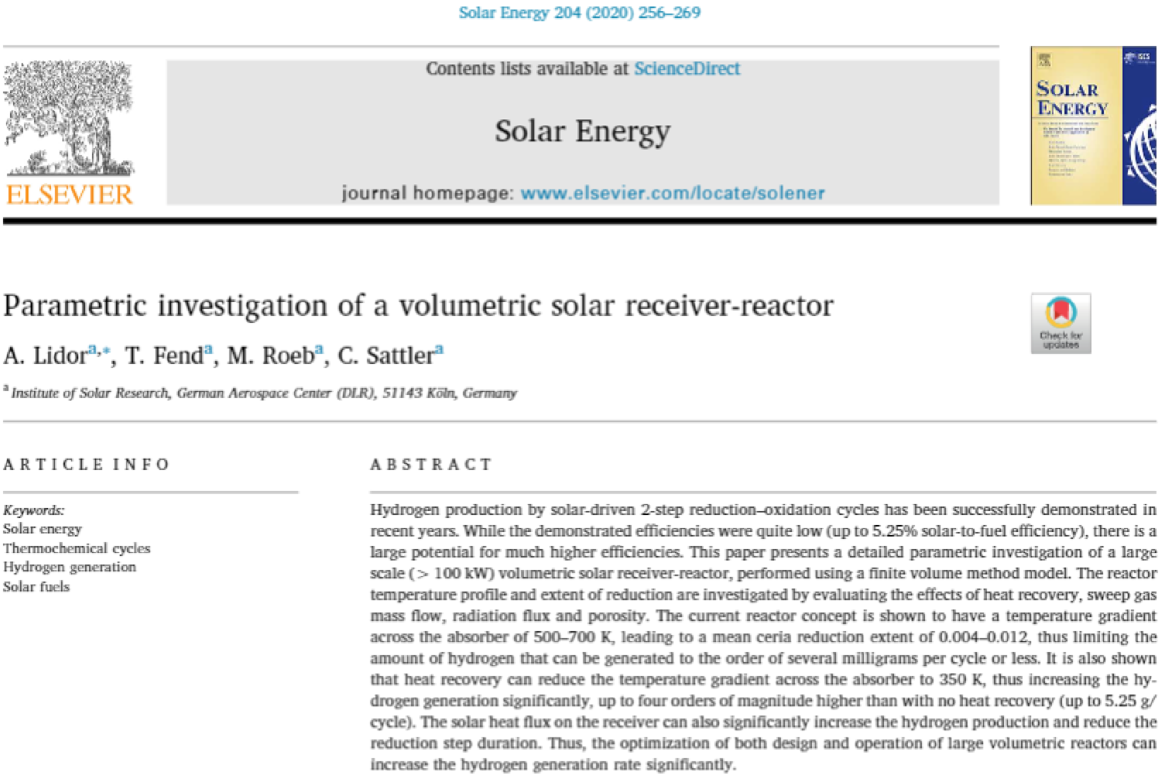
The flow of information will continue via emails, conference calls (when it will be required) and via the project website.

2.2.2 Dissemination of Knowledge beyond the Consortium

Dissemination on the scientific level / Scientific Publications

The Scientific Publications related to Hydrosol Beyond are the following.

- Article "Parametric investigation of a volumetric solar receiver-reactor". Solar Energy. Partner involved: DLR (Green Open Access).



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Parametric investigation of a volumetric solar receiver-reactor

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ABSTRACT

Hydrogen production by solar-driven 2-step reduction–oxidation cycles has been successfully demonstrated in recent years. While the demonstrated efficiencies were quite low (up to 5.25% solar-to-fuel efficiency), there is a large potential for much higher efficiencies. This paper presents a detailed parametric investigation of a large scale (> 100 kW) volumetric solar receiver-reactor, performed using a finite volume method model. The reactor temperature profile and extent of reduction are investigated by evaluating the effects of heat recovery, sweep gas mass flow, radiation flux and porosity. The current reactor concept is shown to have a temperature gradient across the absorber of 500–700 K, leading to a mean ceria reduction extent of 0.004–0.012, thus limiting the amount of hydrogen that can be generated to the order of several milligrams per cycle or less. It is also shown that heat recovery can reduce the temperature gradient across the absorber to 350 K, thus increasing the hydrogen generation significantly, up to four orders of magnitude higher than with no heat recovery (up to 5.25 g/cycle). The solar heat flux on the receiver can also significantly increase the hydrogen production and reduce the reduction step duration. Thus, the optimization of both design and operation of large volumetric reactors can increase the hydrogen generation rate significantly.

Figure 3. Screenshot of the article "Parametric investigation of a volumetric solar receiver-reactor".

Dissemination on the scientific level / Participation at symposia/meetings

The Consortium partners have disseminated the knowledge of Hydrosol Beyond in the following events through abstracts or presentations:

- "Deposition of Ceria on Si-SiC (first results)", 44th International Conference and Expo on Advanced Ceramics and Composites, ICACC 2020. Partner involved: SUPSI.
- "Lessons Learnt During the Construction and Start-Up of Hydrosol-Beyond Plant". Solar Paces 2019. Partner involved: Partner involved: CIEMAT.
- "Solar Fuels". Solar Paces 2020. Partner involved: CIEMAT.
- Plenary session about Solar Fuels, presentation of HYDROSOL project, Journées Nationales de l'Energie Solaire. Partner involved: CEA.

Dissemination activities in Education

APTL/CERTH disseminated the knowledge of Hydrosol-beyond through PhD thesis and Diploma thesis.

CIEMAT participated in the Master Renewable energies (University of Almería) sharing the most relevant information (not confidential) of the Project. It took place during some sessions in February 2020.

Dissemination and integration of know-how into other projects

- ARROPAR-CEX (01/01/2016 - 31/12/2019), "Methodology and characterization of materials and components for receivers for solar applications under extreme conditions (RESPACE)". The information to be exchange is related to materials for thermochemical applications. Partner involved: CIEMAT.
- Hydrosol Plant (01/01/2014 - 31/12/2017): The HYDROSOL-PLANT project aimed to construct and operate a 750 kW_{th} plant for thermochemical hydrogen production in a solar monolithic reactor. Lessons learned in Hydrosol Plant are taken as a starting point in the Hydrosol Beyond project. Partners involved: APTL/CERTH, DLR, CIEMAT.

Dissemination towards industry

Not specific dissemination activities were carried out for this target audience until now.

Dissemination towards policy makers

- Interviews for the European Parliament__from HYDROSOL-beyond members (APTL/CERTH; CIEMAT; DLR) displayed in the visitor center of the European Parliament (Parlamentarium).
- Participation in the Programme Review Days, 2020 (presentation) and 2019 (poster). Link: https://www.fch.europa.eu/page/programme-posters-and-presentations-2020)

Workshop organization

The organization of a Dissemination Workshop will be at the end of the Project, no additional activities will be done regarding this issue.

Dissemination via website

The link to the HYDROSOL-beyond project website is: http://www.hydrosol-beyond.certh.gr

It was officially launched in April 2019, is expected to serve as a major dissemination tool in terms of project's concept, objectives and outcomes and report uploading. More details about the website are included in the relevant deliverable D9.1.

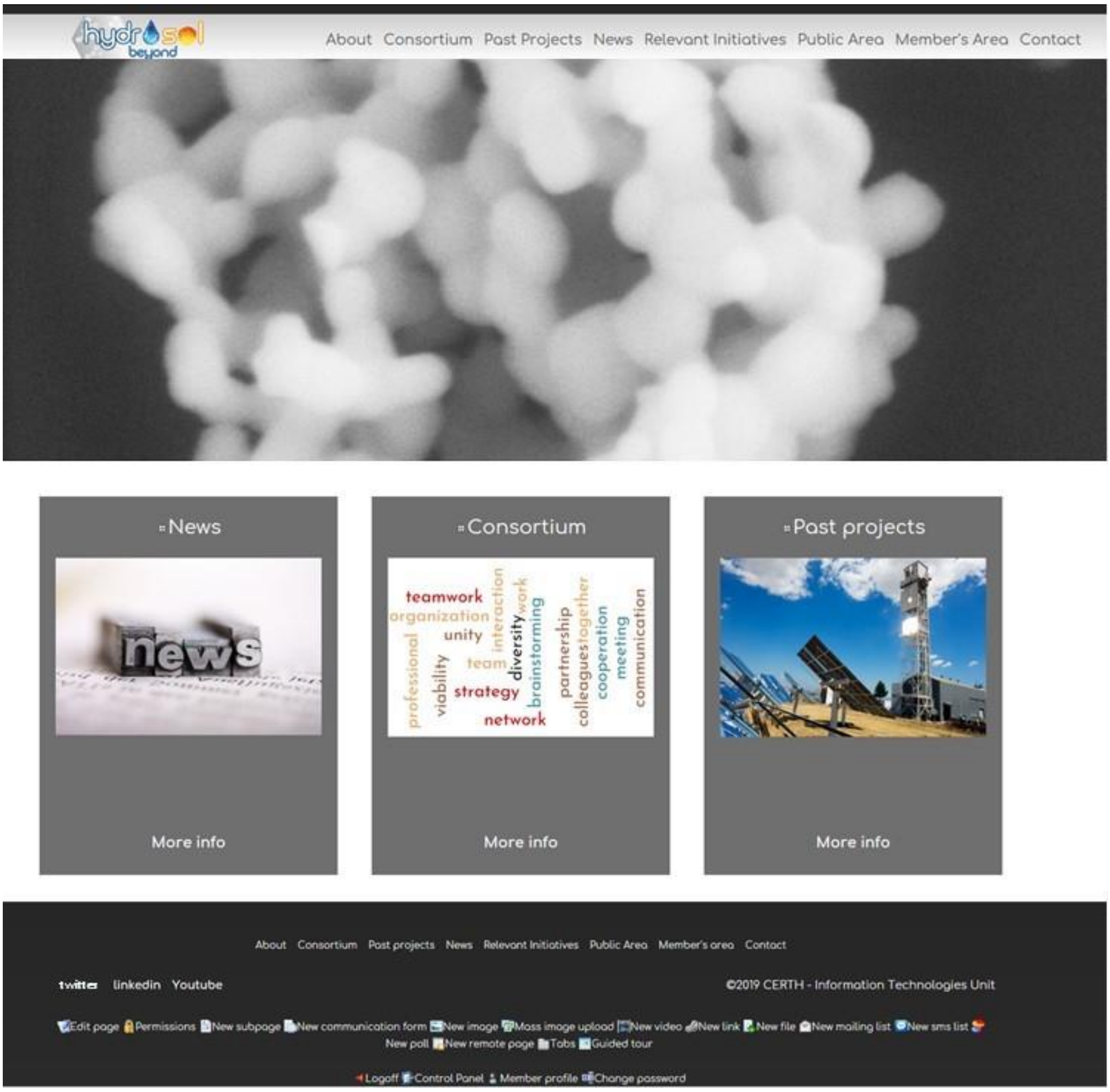


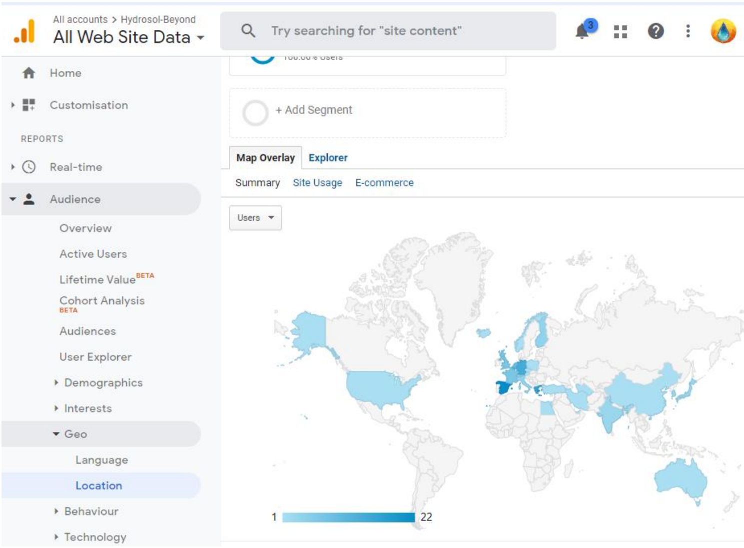
Figure 4. Screenshot from the HYDROSOL-BEYOND PROJECT WEBSITE.

The website has two levels of accounts: the "Public" and the "Member's area".

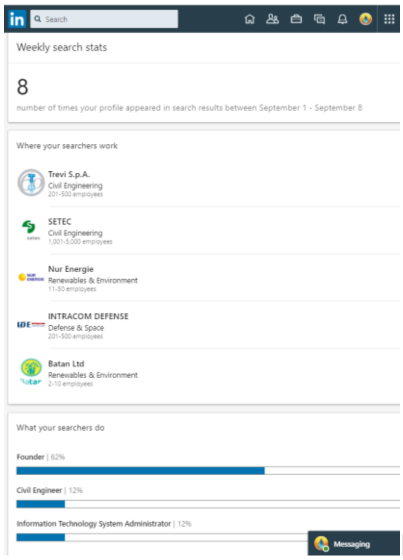
The public area of the website is accessible by everyone and contains general non-confidential information, via which one is briefly introduced to the general concepts of HYDROSOL-beyond and to the relevant partners' main descriptions and activities. The specific section also contains news links aiming to inform the public on any major project events and an interface via which anyone interested to the project is able to communicate with the project coordinator.

The Member's area is accessible only by the relevant project partners and the EU officer and is password-protected. This part contains confidential information such as links for the required reports and deliverables, the minutes and pictures taken during project meetings, several document templates, and an 'electronic library' etc.

The Website appearance is coherent with the brand and the general communication strategy. Periodically updates of the Website has been carried out. The website activity is also monitored through Google Analytics in order to gather information about the website traffic and how visitors interact with the website. Moreover, in order to assure a good visibility in search engines (such as Google) on page and off page SEO actions will be taken.



a)



b)

Figure 5. Screenshot from statistical analysis provided by the HYDROSOL-beyond social media accounts; a) google analytics, b) Linkedin.

Dissemination via Social Media

HYDROSOL-beyond project has an online presence in social media channels such as LinkedIn (https://www.linkedin.com/in/hydrosol-beyond-2b999418b/), Researchgate, Youtube and Twitter (https://twitter.com/HydrosolBeyond) in an attempt to communicate the project outside of the consortium. Based on the statistics maintained from the aforementioned communication channels, the project seems to constantly attract international interest from various business sectors. Through those communication channels, the consortium has joined via HYDROSOL-beyond's profile, several groups (within relevant content about the project will be shared) as follows:

1. European Commission
2. FCH JU
3. Horizon 2020
4. SolarPaces

In the following figures, the screenshots of main social media are shown below:

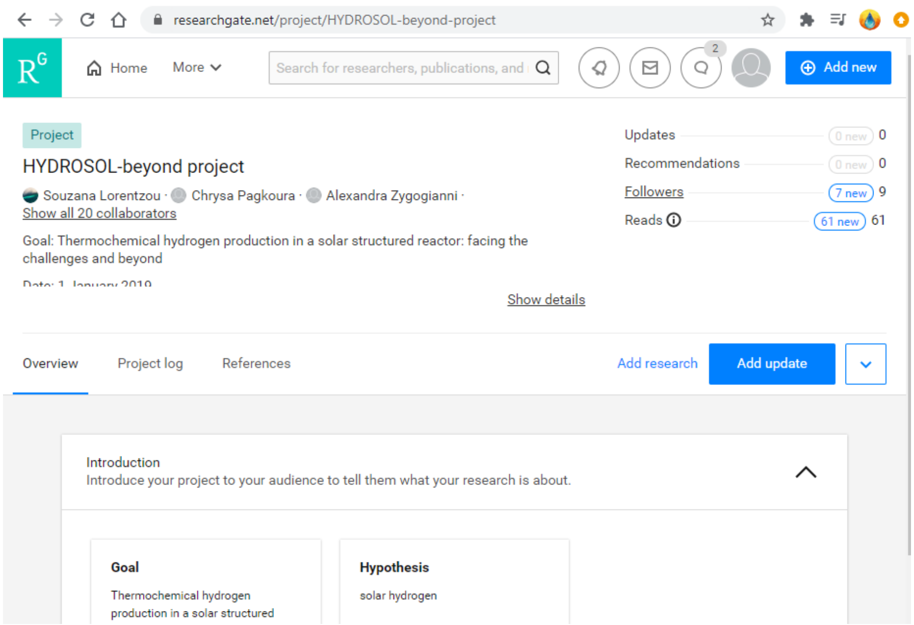
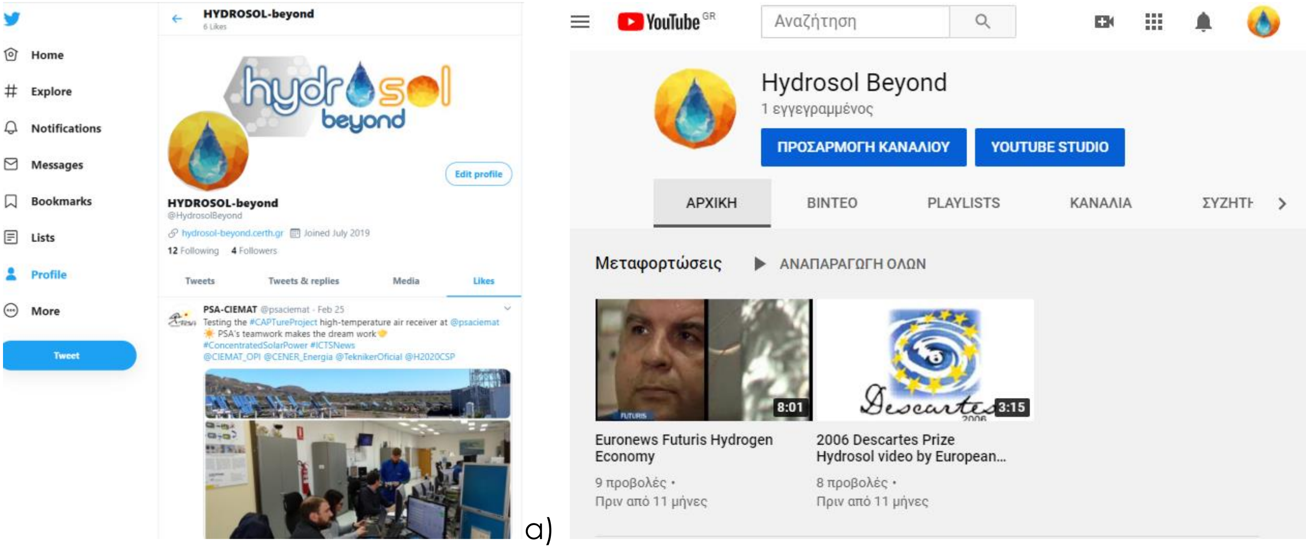


Figure 6. Screenshot from the HYDROSOL-BEYOND project created in the Research Gate platform.



a) b)

Figure 7. Screenshot from the HYDROSOL-beyond account at a) Twitter and b) YouTube.

Other Dissemination activities outside the Consortium

Public information from Hydrosol Beyond was included in the PSA´s website CIEMAT: https://www.psa.es/en/areas/atycos/proyectos/hydrosol_beyond.php

2.3 Next dissemination activities

For the next period, the HYDROSOL-beyond progress and results will be disseminated via activities similar to those presented in Section 2.2 (i.e. in addition to technical meetings taking place within the consortium, dissemination via scientific publications and participation at (virtual or traditional) symposia, dissemination activities towards education). The objective of all the different proper means of dissemination that will be employed, will share the same objective of communicating the most promising findings at different social groups, ranging from scientific community, to stakeholders and authorities up to concerned citizens, and exchanging knowledge within the Consortium. Finally, the consortium will also plan activities to reach out to industry something that could be endeavored at a significant extent toward the end of the project and via the organization of a workshop presenting the overall Project activities and findings.

2.3.1 Dissemination of Knowledge within the Consortium

Periodic conference calls of the whole Consortium (twice a year) will continue to be hold in the next period. The meetings in person will be re-started as soon as the pandemic era will be overcome.

The flow of information will continue via emails, conference calls (when it will be required) and via the project website.

2.3.2 Dissemination of Knowledge beyond the Consortium

Dissemination on the scientific level / Scientific Publications

Some of the partners will submit scientific papers in leading project-field-related peer-reviewed journal. It is foreseen mainly for 2022 in order to include the most relevant results of the Project.

Dissemination on the scientific level / Participation at symposia/meetings

It is foreseen to participate in national and international events and conferences (mainly virtually). Some of the potential events to attend are the SolarPaces 2021 and 2022.

Dissemination activities in education

The research organizations (as for example, APTL/CERTH) of Hydrosol-beyond Project will disseminate the knowledge generated through PhD thesis and Diploma thesis.

Dissemination and integration of know-how into other projects

The partners will continue to apply its developed knowledge from another projects to Hydrosol-beyond Project and in related projects and vice versa.

Dissemination towards industry

HYDROSOL-beyond results will be disseminated through the attendances to the exhibitions and science fairs (not or not online), in order to reach the industry sector.

At the end of the Project, a workshop will be organized in PSA taking into account the importance to reach industrial and research sectors in order to promote the technology developed, to disseminate the results and main achievements.

Dissemination towards policy makers

In the second half of the HYDROSOL-beyond Project, the progress and results of the project will be disseminated to European authorities, FCH JU and related associations (for example, participating in the following editions of the Programme Review, 2021 and 2022).

Workshop organization

The organization of a Dissemination Workshop is foreseen for the end of the Project at the facilities of PSA. If pandemic will continue, it will be evaluated if the Workshop could be organized in virtually mode.

Dissemination via networks

- **HYDROSOL-beyond website**

  The HYDROSOL-beyond project website (http://www.hydrosol-beyond.certh.gr) will be continuously updated for external dissemination (news section) and will be monitored through Google Analytics.

- **HYDROSOL-beyond Social Media accounts**

  Social media channels (LinkedIn, Researchgate and Twitter) will be used continuously for HYDROSOL-beyond dissemination.

Other Dissemination activities outside the Consortium

It is foreseen that white papers, news or articles will be published on websites of the RTD partners and the industrial partners. Brochures could be also generated if there are required for some in-person event in the future.

3 Exploitation plan

The HYDROSOL-beyond dissemination strategy presented above originates from the exploitation strategy and is targeted to specific directions. As already stated, since the Proposal stage, both the exploitation and dissemination plans proposed here should be considered as versatile and flexible tools that should continuously adapt to the arising project's results and the unforeseen potential users.

For sure, the foreseen exploitation activities will seek to create communication channels with fellow researchers in the field of renewable energy and specifically in the field of exploiting solar energy for the generation of decarbonized solar fuels such as water deriving hydrogen, potential end-users and uses of the generated results, companies, investors, standardization bodies, regulatory bodies, patient organizations, sectoral organizations, NGOs, the education sector, the public sector, etc. For the establishment of these communication channels the Consortium has ensured that the HYDROSOL-beyond will produce solid technology with sufficient evidence for its proof of concept, prototyping, and demonstration of cost effectiveness, standardization issues, potential regulatory, health or safety barriers and solution on how to overcome them. The high level of innovation targeted through the HYDROSOL-beyond project, will create the potential to focus on the business opportunity and concept for commercialization, of the innovative products and services expected to emerge.

In the first instance, the main route for the exploitation of the outputs and results from Hydrosol-beyond will be through existing Consortium partners and their contacts and customers that could immediately benefit from the results of this project. In the second instance the HYDROSOL-beyond plans to follow a proactive exploitation strategy in order to ensure effective communication of its outputs beyond the Consortium and ensure maximization of economic, commercial and developmental impacts of all innovative Hydrosol-beyond findings.

At least for the duration of the project - and for a period up to four years after the end of the action - the exploitation of project results will be managed by the Exploitation Committee. According to the course of generation of exploitable project results, the Project Coordinator, in co-operation with the Exploitation Committee, the involved partners and the General Assembly responsible for the enforcement of the necessary dissemination activities, will take measures for potential patenting of deliverables and for the exploitation of the outcome within and outside the partnership.

3.1 Key Exploitation Results (KER)

The focus of mid-term exploitation plan is to identify gap and the market opportunities for the innovative products developed in the Hydrosol-beyond Project. In this project, pure green hydrogen is produced from solar thermal water splitting. High purity hydrogen is suitable for use in fuel cells and as raw material in chemical industries. Blue hydrogen is produced by reforming methane from natural gas, but this hydrogen is not pure enough to use in fuel cell vehicles. Only green hydrogen can contribute to decarbonize the different sectors.

As a part of exploitation activity, all the partners of consortium attended 2 days Exploitation Strategy Seminar (ESS) organized by Booster service to work on the exploitation plan and to learn about the tools to be used to develop the exploitation plan. ESS was organized on the date 03-10-2020 from 9:00 am to 11.00 am and on the date 04-12-2020 from 9:00 am to 11:30 am.

During the ESS, partners learned to use following tools: Characterization, Risk analysis, Priority map, Road map and Exploitation model.

Before the seminar, there were three KERs identified by the partners of consortium and each KER has one responsible assigned. These KERs were shared with Booster service to start working on these KERs:

- KER 1 Novel Reactor Design
- KER 2 Hydrosol Process
- KER 3 High Temperature Heat Exchanger

The first KER that was selected, was the Novel reactor design, an innovative design developed for water splitting at high temperature in this project. Second KER, i.e. the High temperature heat exchanger, was selected for exploitation because heat exchangers of this type, i.e. operating at 1000°C, are not commercially available, offering a unique value proposition to the specific development sought within Hydrosol-beyond. Third KER, i.e. the hydrogen production process, was selected to exploit the overall HYDROSOL-technology process which employs high temperature heat from solar thermal plant and produces green hydrogen.

Characterization table prepared by Booster service was shared with partners to fill the information for each KER to discuss later in seminar. Risk assessment table was also shared by Booster service to include the identified risks related with each KER with ways to mitigate the risk. The risk assessment and priority map for each KERs were revised during the webinar.

A Risk Assessment is an action-oriented tool to analyze the most important potential risk factors to be faced. For each KER, potential risk factors have been identified and evaluated by the quantification of their degree of importance and likelihood of risk happening. Evaluation included potential intervention and their feasibility to conclude in a proposed action (Control, Action, No Action and Warning) depending on the region of the Priority Map where there were allocated.

Use Options were discussed depending on the exploitation routes preferred by the Consortium.

3.1.1 -KER 1 Novel Reactor Design

KER 1 is defined as Novel Reactor Design. A first definition and evaluation analysis has been performed by the HYDROSOL consortium. Characterization Table, Risk Assessment& Priority map, and Use Options that have been obtained are described below as results of the exploitation analysis.

Characterization Table

Definition and characterization of main parameters of KER 1 are summarized in Table 1.

Table 1 Characterization Table of KER 1 Novel Reactor Design

KER 1 Novel Reactor Design	
Problem	General: feasibility of green hydrogen production process by means of solar thermal energy: 1. Heating up a porous ceramic structure made of REDOX-materials (at temperatures ≥1100°C) in order to split steam into Oxygen and Hydrogen. 2. Further heating up of the porous ceramic structure to temperatures ≥1400°C 3. Generating a very low oxygen partial pressure 4. Leading the reactant-gases from a system of pipes to the reactor 5. Leading the product gases to separate system of pipes
Alternative solution	- Electrolysis - High temperature electrolysis - Using REDOX particles - Using an evacuated REDOX-Reactor
Unique Selling Point USP - Unique Value Proposition UVP	- Avoiding the use of high amount of electricity required in electrolysis as primary source - High efficiency potential - Low thermal losses using volumetric absorption - Producing hydrogen with zero CO_2 footprint
Description	The design and prototype of an innovative combined receiver/reactor is provided, which receives concentrated solar radiation of up to 1000kW/m² through a quartz window to heat up an amount of app. 200 kg of REDOX-material. By employing a two stage REDOX-Process, Hydrogen is produced during the first step and material regeneration occurs during the second step. - Reactor design ready to be object of further approval and investigation - Reactor capable to generate 1 kg of hydrogen a week - Reactor capable to be operated with a 250 kilowatts heliostat field
"Market" – Target market	- Experts in related companies (renewable fuels and transport sector) to act as further co-operation partners and to raise interest in a technology, which might be capable to generate hydrogen to competitive process in the mid-term future - Experts in politics and persons responsible for research funding - SolarPACES - Researchers from powerful research institutions, which have influence on decision makers - Experts in related companies (materials) to act as further co-operation partners - Concentrated solar plants could integrate in their current process parallel green H_2 production, which could be sold either as a fuel or a chemical or being used as carrier for thermal storage.

	towards international networks of researchers and industry experts for the development and marketing of renewable and clean energy *(e.g. SolarPACES & Mission Innovation Challenge), in order to further strengthen the EU leadership on renewables, through demonstration of successful results among which the Consortium is targeting at high performance of key materials and key components at large scale suitable for solar-thermochemical water splitting;* ***towards Multipliers and Interest Groups such as EC, IEA, EERA, IEEE, National Ministries and other National and International Agencies****; researchers and industry experts global grid for the development and commercial exploitation of concentrated solar thermal power systems and solar chemistry technologies* ***towards the transport sector.*** *This effort will aim to increase the incorporation potential of solar fuels* such as solar hydrogen *in the forthcoming strategies of the transport sector targeting to increase the use such energy carriers and minimize the carbon footprint occurring from the use of conventional fuels/technologies;* *and finally,* ***towards the general public****, via using journalist contacts of the Consortium partners, in order to generate recognition by a wider public, e.g. the readers of more popular magazines (i.e. Science, Nature, etc.), as well as via social media networking;*
"Market" – Early Adopters	Experts in the related research communities and I*ndustries which need to decarbonize their activities.*
"Market" - Competitors	Companies and research institutions active in: - Electrolysis - High temperature electrolysis - Using REDOX particles - Using rotary reactor concepts - Using an evacuated REDOX-Reactor ***Alternative research projects*** employing techniques with significantly lower investment cost
Go to Market – Use model	- Further, more application-oriented research - co-operation with strong industrial partners - co-operation with end-users (concentrated solar plants) - co-operation with leading experts from science (concentrated solar plants) - integration of the technology to existing chemical infrastructure
Go to Market - Timing	*In the next period (3-5 years): contract research, publications, patents* *In following period (5-10 years): demonstrative installations* *Potential market: 10-15 years*
Go to Market – IPR Background	Expert knowledge on selected research field - APTL/CERTH: material synthesis, concept development - HyGear: Gas separation, gas cleaning technologies - CIEMAT: plant operation, chemical processes - ENGICER: porous ceramics development and manufacture - SUPSI: thermal management, materials development - ABENGOA: large scale plant engineering and EPC - CEA: system analysis, solar technology, LCA - DLR: concentrated solar engineering, plant control

Go to Market – IPR Foreground	- Hardware: operating reactors in SPAIN (CIEMAT) and Germany (DLR) - Practical operating experience (APTL/CERTH, CIEMAT, DLR) - Separation of product gases (HyGear) - Heliostat-field operation and lay-out (CIEMAT, DLR) - Safety issues (CIEMAT) - Manufacturing of reactor (APTL/CERTH, DLR) - Plant lay-out (APTL/CERTH, DLR) - System analysis (CEA, ABENGOA) - Cost analysis (CEA, ABENGOA) - LCA Analysis (ABENGOA) - Thermal management with innovative components (SUPSI) - Production of REDOX materials (Engicer, APTL/CERTH)

Risk Assessment and Priority map

Potential risk factors evaluation and analysis for KER 1 are presented in Table 2 and Figure 8 (Priority map).

Table 2 Risk Assessment for KER 1 Novel Reactor Design[1].

	KER Risk Assessment Map						
	Description of Risks	**Degree of criticality of the risk related to the final achievement of this Key Exploitable Result**	**Probability of risk happening**	**Risk Grade**	**Potential intervention**	**Estimated Feasibility/ Success of Intervention**	**Conclusion**
	Partnership Risk Factors						
1	Partners loose interest in KER Technology	8	6	**48**	regular meetings to improve performance and update partners on new devlopments, exchange on experiences etc, Licensing to a third company (?)	9	**Control.**
	Technological Risk Factors						
2	Partner playing the role as an end-user leaves the market	7	9	**63**	intensify discussions on realsitic steps to rise the TRL	9	**Action!**
3	TRL lower than promised	7	8	**56**	convince decision makers to intensify investment in research	6	**Action!**
4	Competing institutions and companies are more successful	6	8	**48**	intensify rearch activties Licensing to a third company (?)	7	**Control.**
5	Partners are pessimistic about the success of the KER	6	8	**48**	identify technological problems and cocentrate on solution oriented work, to establish specific planning periods	8	**Control.**
	Market Risk Factors						
6	Nobody buys the product, fossil fuels are cheaper	7	8	**56**	initialise projects aiming at cost reduction	3	**Warning;**
7	small scale units not competitive	7	7	**49**	initialise projects aiming at small scale units collect more information on scaling effects	7	**Control.**
8	scaling effects appear slowly	5	10	**50**	- convince investors to think about more long-term investments - start with small pilots	7	**Between Control & Action**
	IPR/Legal Risk Factors						
							Not Filled
	Financial/Management Risk Factors						
9	Marketing and distribution fails due to a weak strategy	7	9	**63**	Revise the strategy	6	**Action!**
10	Marketing and distribution fails due to a lack of resources	7	10	**70**	a) Adapt strategy to low cost activities b) Dedicate staff more specifically	2	**Warning;**
11	Investors hesitate investing in non-stable counties	6	8	**48**	New markets searching	8	**Control.**
	Environmental/Regulation/Safety risks:						
12	Global carbon trading does not work	7	8	**56**	strenghten international initiatives	7	**Action!**

[1] Rates range from 1 to 10, with 1 being the lowest and 10 the highest

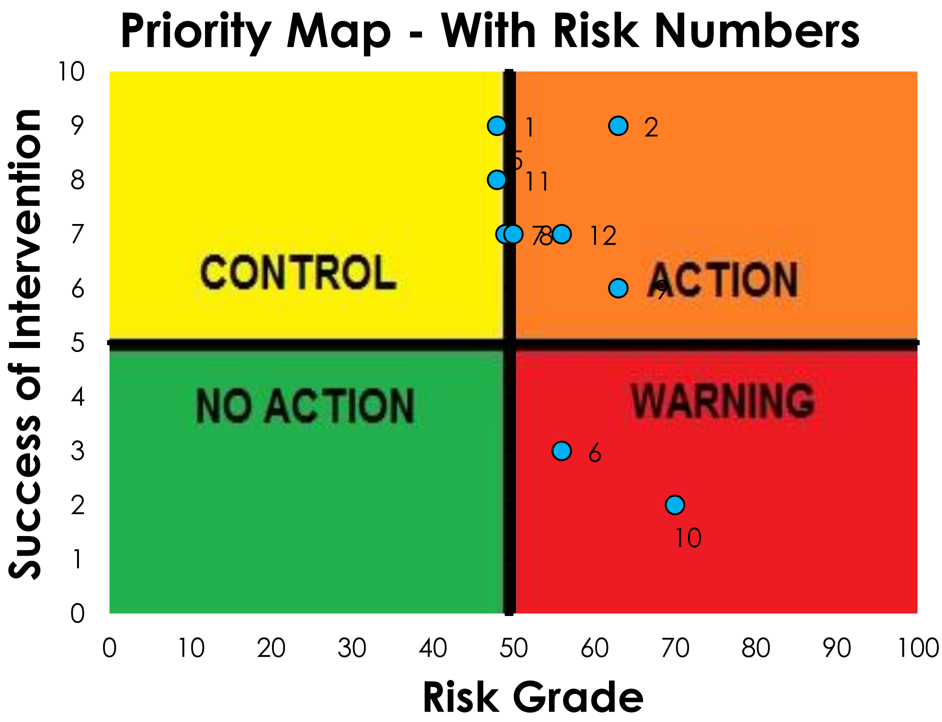


Figure 8. Priority Map for KER 1 Novel Reactor Design

Main conclusions and proposed actions obtained of the Risk Assessment for KER 1 are:

Partnership Risk Factors
Partnership risk factors present a low-risk grade coupled with a high probability of success of the planned remedy. Here is defined a situation where it would be preferable to keep an eye on what is happening (Control) to be ready to act. A potential intervention could be to hold regular online meetings and clarity priorities giving motive to everybody.

Technological Risk Factors
Technological risk factors present a situation between medium-risk grade and a low probability of success (Action) and the one with a low-risk grade and a high probability of success (Control). Experienced partners seem to have set the appropriate mechanisms to control technological risks.

Market Risk Factors
Market risk factors present a high-risk grade coupled with a low to medium probability of success of the planned remedy. Here we have a warning for the risk concerning competition from low cost fossil fuels. The response would be to initialise projects aiming at cost reduction. Also scaling problems identified, would be preferable to keep an eye on, monitoring regularly (Control) to be ready to act.

Financial/Management Risk Factors
Financial risk factors present a high-risk grade coupled with a fluctuation from low to high probability of success of the planned remedy. Some strategies are identified where it would be preferable to keep an eye on, monitoring regularly (Control) to be ready to act. While the lack of resources could be lethal and the project should adapt its strategy to low cost activities.

Environmental/Regulation/Safety risks:

Environmental risk factors present a situation between high-risk grade and a high probability of success (Action) and the push here would be to strengthen international initiatives on Global carbon trading.

Use options

Exploitation routes preferred by the Consortium as Use Options for this KER are summarized in Table 3.

Table 3 KER's Exploitation route (Use Options) for KER 1 Novel Reactor Design

KER's Exploitation route (how the KER will be further exploited) **Note: only an option is to be selected**			
	Selected route	**Implementing actor**	**Yes**
DIRECT USE	Commercialisation: *deployment of a novel product/service (offered to the target markets)*	One partner[2]	
		A group of partners[3]	
	Contract research (*new contracts signed by the research group with external clients*)	A partner	X
		A group of partners	X
	A new research project (*application to public funded research programmes*)	A partner	X
		A group of partners	X
	Implementation of a new university – course (*Note that a training course is a service*)	A partner	
		A group of partners	
		A new partnership	
INDIRECT USE	Assignment of the IPR	A partner	
		A group of partners	(?)
	Licensing of the IPR	A partner	
		A group of partners	(?)
	Development of a new legislation/standard	A partner	
		A group of partners	
	Spin- off	A partner	
		A group of partners	
		By assignment	
		By licensing	
	Other (*please describe*)	Patent?	

3.1.2 KER 2 Hydrosol Process

KER 2 is defined as Hydrosol Process. A first definition and evaluation analysis has been performed by the HYDROSOL consortium. Characterization Table, Risk Assessment & Priority map, and Use Options that have been obtained are described below as results of the exploitation analysis.

Characterization Table

Definition and characterization of main parameters of KER 2 are summarized in Table 4.

Table 4 Characterization table of KER 2 Hydrosol Process

KER 2 Hydrosol Process	
Problem	Nowadays, global energy consumption registers a sustained growth that will continue in the coming decades. This demand is supported significantly by fossil fuels, whose reserves are limited and do not guarantee energy supply indefinitely. In addition, the emission of pollutants and carbon dioxide produced in the combustion of fossil fuels directly influences climate change.

[2] Partners identifies the partners of the project receiving the ESS, not third parties that may be partner in the future.

[3] Provide the names of the partners

	All these factors have led the international community to become aware of the need to find solutions and alternatives to this problem. A future sustainable economy based on hydrogen will require large-scale hydrogen production processes in a CO_2 emission-free way. Furthermore, total decarbonisation of certain sectors, such as transport, industry and uses that require high-grade heat, may be difficult purely by means of electrification. This challenge could be addressed by hydrogen from renewables, which allows large amounts of renewable energy to be channeled from the power sector into the end-use sectors.
Alternative solution	The most obvious alternate solution is to drive a conventional water electrolyser using the electrical output of PV or wind turbines devices (renewable energy). Given that typical conversion efficiencies are 11.5–17.5% for commercial PV systems and 63–73% for electrolyzers, overall conversion efficiencies of approximately 12% can be expected and have been reported for optimized, combined PV–electrolyzer systems.
Unique Selling Point USP - Unique Value Proposition UVP	The theoretical solar-to-fuel efficiencies estimated for this route reach as high as 35–50%. These estimations, assume high rates of fuel production and a high level of heat recovery. Solar thermochemical process provides a clean, efficient, direct and sustainable route for producing carbon-free hydrogen from water. The proposed process, aims at tackling challenges such as reductions of heat losses during the two separate steps of the process cycle, scaling up and enhanced coupling of key components, i.e. coupling of the solar concentrators with the solar reactors, in order to achieve sufficiently high temperatures that may lead to the desired results by making use of appropriate combinations of materials able to withstand the elevated temperatures.
Description	A two-step thermochemical cycle consists of two reaction stages, taking place in a sequential mode inside the reactor. A metal oxide is thermally reduced with concentrated solar radiation to release oxygen. Then, the reduced metal oxide is re-oxidized with steam to produce hydrogen. The thermochemical cycle used in the Hydrosol-beyond project consists of two steps carried out at different temperature levels with different energy requirements. The regeneration step is endothermic and takes place at 1300-1400°C; the water splitting step is slightly exothermic and takes place at 1000-1100°C. Those temperatures are achieved by integrating in a concentrated solar plant.
"Market" – Target market	The main current customers are the industry sector that consume 90% of total hydrogen in Europe and use fossil fuel as main feedstock source. Concentrated solar plants could integrated in their process the green H_2 production for selling it as a fuel/ chemical product or to use the hydrogen produced as carrier for thermal storage. Furthermore, the transport sector can be an attractive target in the effort to reduce CO_2 emissions. Experts from related companies and academic environment can be potential partners for future research projects in order to evolve the proposed technology and make it competitive to current H_2 production routes (i.e. steam reforming and electrolysis).

"Market" – Early Adopters	The main current customers who could be interested in hydrogen are largely represented by the industry sector, in particular chemistry, refineries, metal processing. Industries which need to decarbonize their activities.
"Market" – Competitors	Other hydrogen production technologies, reforming, electrolysis, etc. from renewable energies (solar and wind). **Alternative research projects** employing techniques with significantly lower investment cost.
Go to Market – Use model	*Technology transfer, license agreement, contract research, publications, patents.*
Go to Market – Timing	*10 years regarding technology transfer, license agreement* *Next 2 years: contract research, publications, patents*
Go to Market – IPR Background	Expert knowledge on selected research field - APTL: material synthesis, concept development - HyGear: Gas separation, gas cleaning technologies - CIEMAT: plant operation, chemical processes - ENGICER: porous ceramics development and manufacture - SUPSI: thermal management, materials development - ABENGOA: large scale plant engineering and EPC - CEA: system analysis, solar technology, LCA - DLR: concentrated solar engineering, plant control
Go to Market – IPR Foreground	None

Risk Assessment and Priority map

Potential risk factors evaluation and analysis for KER 2 are presented in Table 5 and Figure 9 (Priority map).

Table 5 Risk Assessment for KER 2 Hydrosol Process [4].

	KER Risk Assessment Map						
	Description of Risks	Degree of criticality of the risk related to the final achievement of this Key Exploitable Result	Probability of risk happening	Risk Grade	Potential intervention	Estimated Feasibility/ Success of Intervention	Conclusion
	Partnership Risk Factors						
1	Partners do not follow the training schedule but invent new content	4	6	24	Regular meetings to improve performance and update partners on new devlopments, exchange on experiences etc	6	Control.
2	Partners carry out low quality trainings/consultancy	4	8	32	Regular meetings to improve performance and update partners on new devlopments, exchange on experiences etc	6	Control.
3	Disagreement on ownership rules	8	7	56	Legal mediation of downership disputes and patent review	6	Action!
	Technological Risk Factors						
4	Clients do not like the platform and thus also the trainings are not of interest	7	9	63	Adapt the trainings so that they are more methodological and focus less on one specific software	9	Action!
5	Better technology emerges	7	2	14	Re-evaluation of technology and further optimisation to match/outperform new benchmark	5	Between Control & No Action
	Market Risk Factors						
6	Nobody buys the product ...	8	10	80	Offer services that do not demand investment by the partners (replicable material like tutorials etc). Bad for business but good for social impact	3	Warning;
7	Difficulty in market penetration/customer reception and acceptance of technology	5	5	25	additional market studies, customer surveys and assessment of product shortfalls	2	No Action'
8	Performance lower than market needs	7	7	49			No Action'
	IPR/Legal Risk Factors						
9	competitors replicate technology	1	1	1	stricter control in in patent usage and aggressive pursuit of legal action	5	Between Control & No Action
10	Patent application is rejected	4	5	20	reformulating patent claims	4	No Action'
	Financial/Management Risk Factors						
11	Marketing and distribution fails due to a weak strategy	7	9	63	Revise the strategy	6	Action!
12	Marketing and distribution fails due to a lack of resources	7	10	70	a.) Adapt strategy to low cost activities b.) Dedicate staff more specifically	2	Warning;
13	Weak explotation	6	5	30	New markets searching	5	Between Control & No Action
	Environmental/Regulation/Safety risks:						
14	Not in compliance with regulations	5	1	5	assessment of legal/regulatory requirements and alteration of product to comply	4	No Action'

[4] Rates range from 1 to 10, with 1 being the lowest and 10 the highest

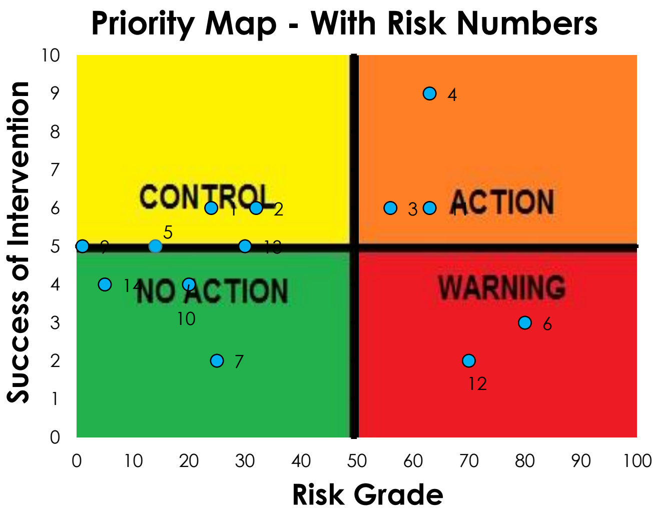


Figure 9. Priority Map for KER 2 Hydrosol Process

Main conclusions and proposed actions obtained of the Risk Assessment for KER 2 are:

<u>Partnership Risk Factors</u>
Partnership risk factors present a medium-risk grade coupled with a medium probability of success of the planned remedy. Here is defined a situation where it would be preferable to keep an eye on what is happening (Control) to be ready to act. The Action necessary would be to clarify ownership.
<u>Technological Risk Factors</u>
Technological risk factors present a situation between medium-risk grade and a high probability of success (Action) and the one with a low-risk grade and a high probability of success (Control). The main action here would be to Adapt the trainings.
<u>Market Risk Factors</u>
Market risk factors present a high-risk grade coupled with a low to medium probability of success of the planned remedy. Here we have a warning for the risk concerning non acceptance from the market. The response would be to offer services that do not demand investment by the partners. The other risks are in the non-action area.
<u>IPR/Legal Risk Factors</u>
These represent no action areas as they are low probability with medium success of intervention
<u>Financial/Management Risk Factors</u>
Financial risk factors present a high-risk grade coupled with a fluctuation from low to high probability of success of the planned remedy. Some strategies are identified where it would be preferable to keep an eye on, monitoring regularly (Control) to be ready to act. Some like the weak strategy require Action, while the lack of resources could be lethal, and the project should adapt its strategy to low cost activities.
<u>Environmental/Regulation/Safety risks:</u>
Environmental risk factors present a situation between low-risk grade and a high probability of success (No Action) and the partnership should just keep an eye on compliance with regulations.

Use options

Exploitation routes preferred by the Consortium as Use Options for this KER are summarized in Table 6.

Table 6 KER's Exploitation route (Use Options) for KER 2 Hydrosol Process

KER's Exploitation route (how the KER will be further exploited) Note: only an option is to be selected			
	Selected route	Implementing actor	Yes
DIRECT USE	Commercialisation: *deployment of a novel product/service (offered to the target markets)*	One partner[5]	
		A group of partners[6]	
	Contract research (*new contracts signed by the research group with external clients*)	A partner	
		A group of partners	x
	A new research project (*application to public funded research programmes*)	A partner	x
		A group of partners	x
	Implementation of a new university – course (*Note that a training course is a service*)	A partner	
		A group of partners	x
		A new partnership	
INDIRECT USE	Assignment of the IPR	A partner	
		A group of partners	X
	Licensing of the IPR	A partner	
		A group of partners	
	Development of a new legislation/standard	A partner	
		A group of partners	
	Spin- off	A partner	
		A group of partners	
		By assignment	
		By licensing	
	Other (*please describe*)		

3.1.3 KER 3 High Temperature Heat Exchanger

KER 3 is defined as High Temperature Heat Exchanger. A first definition and evaluation analysis has been performed by the HYDROSOL consortium. Characterization Table, Risk Assessment & Priority map, and Use Options that have been obtained are described below as results of the exploitation analysis.

Characterization Table

Definition and characterization of main parameters of KER 3 are summarized in Table 7.

Table 7 Characterization table of KER 3 High Temperature Heat Exchanger

KER 3 High Temperature Heat Exchanger	
Problem	In high/very high temperature processes heat needs to be recovered at the highest temperature possible in order to obtain a high efficiency. Standard commercial heat exchangers (HX) are not suited for these applications. Special materials must be used to withstand harsh working conditions linked not just to the very high temperature, but also to possible interactions between heat transfer fluid (HTF) and HX walls. Therefore, these HX require a specific design that can optimize performance accounting for suitable special alloys, application of ceramic material to enhance heat transfer and tailored efficacy.
Alternative solution	In current systems, the heat is recovered at lower temperatures, resulting in an efficiency penalty. Existing HX cannot guarantee the performance requested by the very high temperature processes. To the knowledge of the Partners there is not a HX delivering the performance requested by the processes described by the present Project. The point is that the available HX cannot even withstand the required operating conditions without complete component failure.

[5] Partners identifies the partners of the project receiving the ESS, not third parties that may be partner in the future.
[6] Provide the names of the partners

Unique Selling Point USP - Unique Value Proposition UVP	The heat exchanger developed can be applied in many high temperature systems where high temperature heat recovery is needed. It offers: Very high temperature resistance (up tp 1000 °C) Unique hybrid, metal alloy-ceramic, design; High efficacy for gas-gas heat exchange. Up to today, no similar components can be found on the market.
Description	The high temperature heat exchanger (HT-HX) is a counter-current plate & fin matrix configuration heat exchanger consisting of plates made from a high temperature resistant alloy and ceramic lattices inserts (fins) which are mounted between the plates to increase the heat exchanging surface.
"Market" – Target market	The target market is where high temperature heat needs to be exchanged between two gases. The customer segments are energy conversion, chemical processes, extreme conditions cooling. ***towards international networks of researchers and industry experts for the development and marketing of renewable and clean energy*** *(e.g. SolarPACES & Mission Innovation Challenge), in order to further strengthen the EU leadership on renewables, through demonstration of* *successful results among which the Consortium is targeting at high performance of key materials and key components at large scale suitable for solar-thermochemical water splitting;* ***towards Multipliers and Interest Groups such as EC, IEA, EERA, IEEE, National Ministries and other National and International Agencies****; researchers and industry experts global grid for the development and commercial exploitation of concentrated solar thermal power systems and solar chemistry technologies* ***towards the transport sector.*** *This effort will aim to increase the incorporation potential of solar fuels such as solar hydrogen in the forthcoming strategies of the transport sector targeting to increase the use such energy carriers and minimize the carbon footprint occurring from the use of conventional fuels/technologies;* *and finally,* ***towards the general public****, via using journalist contacts of the Consortium partners, in order to generate recognition by a wider public, e.g. the readers of more popular magazines (i.e. Science, Nature, etc.), as well as via social media networking*
"Market" – Early Adopters	Early adopters are sectors like CSP-systems and solar fuel production.
"Market" - Competitors	Suppliers of heat exchangers, like SWEP and Alfa Laval even though that these competitors do not offer, today, a product with similar performance. ***Alternative research projects*** employing techniques with significantly lower investment cost
Go to Market – Use model	At first the KER will be demonstrated in the system under development in the Hydrosol Beyond Project. Following that, the HT-HX will become a new product manufactured by the partners and offered, as a customized component, to interested third parties.
Go to Market - Timing	Market entry is expected to be after the finalisation of the Hydrosol Beyond Project.
Go to Market – IPR Background	HyGear: knowledge on designing a heat exchanger and assembly. EngiCer: advanced ceramic structures, high performance ceramic materials. SUPSI: high temperature heat exchange and HT-HX design, high performance ceramic materials for heat exchange. APTL-CERTH: experimental tests at high temperature.
Go to Market – IPR Foreground	• Hardware: operating reactors in SPAIN (CIEMAT) and Germany (DLR) • Practical operating experience (APTL/CERTH, CIEMAT, DLR) • Separation of product gases (HyGear) • Heliostat-field operation and lay-out (CIEMAT, DLR) • Safety issues (CIEMAT) • Manufacturing of reactor (APTL/CERTH, DLR) • Plant lay-out (APTL/CERTH, DLR) • System analysis (CEA, ABENGOA) • Cost analysis (CEA, ABENGOA)

	• LCA Analysis (ABENGOA) • Thermal management with innovative components (SUPSI) • Production of REDOX materials (Engicer, APTL/CERTH)

Risk Assessment and Priority Map

Potential risk factors evaluation and analysis for KER 3 are presented in Table 8 and Figure 10 (Priority map).

Table 8 Risk Assessment for KER 3 High Temperature Heat Exchanger[7].

KER Risk Assessment Map							
	Description of Risks	Degree of criticality of the risk related to the final achievement of this Key Exploitable Result	Probability of risk happening	Risk Grade	Potential intervention	Estimated Feasibility/ Success of Intervention	Conclusion
	Partnership Risk Factors						
1	Disagreement on ownership	7	5	35	Discuss ownership in an early stage of the development	8	Control.
	Technological Risk Factors						
2	Effectiveness of the heat exchanger is less than expected	7	7	49	Use simulations and experimental results to improve design	9	Control.
3	Material incompatibility	5	5	25	Test compatibility of new materials and select proper ones	7	Control.
4	Maximum sustainable temperature too low	8	6	48	Search for different, more performing materials	8	Control.
	Market Risk Factors						
5	Nobody buys the product	7	7	49	Show resuslts from project, promote technology and performance, explore new markets	8	Control.
6	Expensive KER	7	7	49	Study cost reduction strategies	5	Between Control & No Action
	IPR/Legal Risk Factors						
	Financial/Management Risk Factors						
7	Marketing and distribution fails due to a weak strategy	7	9	63	Revise the strategy	7	Action!
	Environmental/Regulation/Safety risks:						

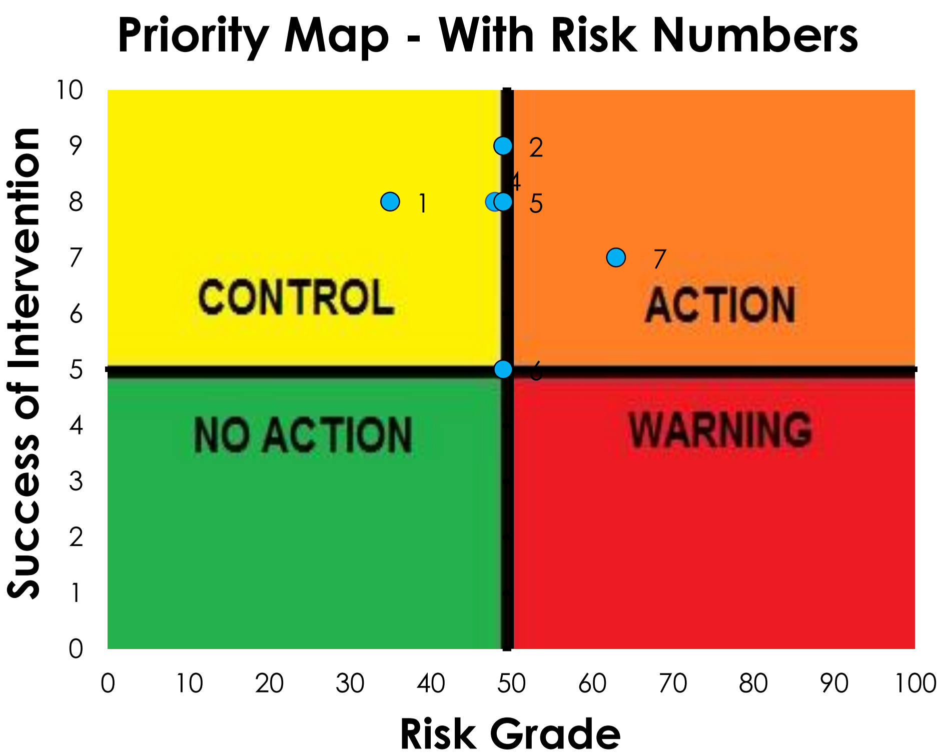


Figure 10. Priority Map for KER 3 High Temperature Heat Exchanger

[7] Rates range from 1 to 10, with 1 being the lowest and 10 the highest

Main conclusions and proposed actions obtained of the Risk Assessment for KER 3 are that all risks associated with the release of the heat exchanger are in the control area with the exception of the Financial/Management Risk Factors, which present a medium-risk grade coupled with a low to medium probability of success of the planned remedy. Here we have an indication of Action warning for the risk concerning Marketing and distribution fails due to a weak strategy. The response would be to revise the strategy probably aiming at cost reduction.

Use options

Exploitation routes preferred by the Consortium as Use Options for this KER are summarized in Table 9.

Table 9 KER's Exploitation route (Use Options) for KER 3 High Temperature Heat Exchanger

KER's Exploitation route (how the KER will be further exploited) Note: only an option is to be selected			
	Selected route	**Implementing actor**	**Yes**
DIRECT USE	Commercialisation: *deployment of a novel product/service (offered to the target markets)*	One partner[8]	
		A group of partners[9] HyGear, EngiCer, Supsi	yes
	Contract research (*new contracts signed by the research group with external clients*)	A partner	
		A group of partners	yes
	A new research project (*application to public funded research programmes*)	A partner	
		A group of partners	yes
	Implementation of a new university – course (*Note that a training course is a service*)	A partner	
		A group of partners	
		A new partnership	
INDIRECT USE	Assignment of the IPR	A partner	
		A group of partners	yes
	Licensing of the IPR	A partner	
		A group of partners	
	Development of a new legislation/standard	A partner	
		A group of partners	
	Spin- off	A partner	
		A group of partners	
		By assignment	
		By licensing	
	Other (*please describe*)		

[8] Partners identifies the partners of the project receiving the ESS, not third parties that may be partner in the future.
[9] Provide the names of the partners

3.2 Preliminary Roadmap

Preliminary roadmap was also developed during the ESS in association with partners of consortium. There are defined the next steps to be implemented for the short-to-midterm commercialization of the KER.

Main parameters considered for the roadmap are:

Actions

Briefly describe actions planned to be executed 3-6 months after the end of the project. Make sure you do not just focus on technical activities (realisation of a prototype, software interface, etc.) but also consider the finalisation of a business plan, the protection of intellectual property, the collection of authorisations, all it will be needed to start implement what is in your exploitation plan.

As general comment, the intellectual property (IP) rights of HYDROSOL-beyond Project will be generated based of only HYDROSOL-beyond project results and experiments.

Roles

Roles of partners involved in the actions defined above.

Milestones

List the milestones and KPIs to be used for monitoring the implementation of the actions listed above. Add timeline.

Financials Costs

Cost estimation to implement planned activities (1 year, 3 years). Provide information on the costs/investments needed to bridge the end of the project to the next steps planned and increase TRL or go to market (you may invest in a patent, in the realization of a prototype, etc.).

Revenues

Projected revenues and eventual profits once the KER will be used (1 and 3 years after use). Consider revenues you will expect to collect by licensing, or thanks to service provision or sale of devices. They generate the cash flow that will make the use of the result sustainable over time (provide an estimation concerning the first year and what is expected after 3 years, if possible). It is recommended that you estimate the revenues according to your early adopters and potential customers and include the information in the draft exploitation plan.

Other sources

Resources needed to bridge the investment needed to increase TRL and ensure the result is used. Financial resources to cover costs incurred before collecting the first revenues (during the "time to market" – see costs) and their sources. Sources can be partners` own budget, other project grants, national/regional incentives, risk capital, loans, etc. Make sure to obtain them at the right timing.

Impact in 3-year time

Describe impact in terms of growth/benefits for the society Impact is the objective of H2020. Impact should mobilize measurable changes in terms of growth/benefits for the society (i.e. jobs created, investments mobilized, turnover generated).

It is remarkable that the technology of Hydrosol- Beyond Project is linked to the Concentrated solar power (CSP), and for this reason, it is more suitable for the countries which this type of solar energy is more available and widespread. In Figure 11, it is shown the CSP projects around the World.

Hydrogen Cost depends on hydrogen production, hydrogen transportation and hydrogen delivery. In order to minimize and optimize hydrogen cost, it could be better to look for consumers close to the CSP facilities (industrial consumers, hydrogen for transport). During the next period of the Project and for developing the Final Roadmap, there will be done a more detail analysis in order to identify potential consumers.

3.2.1 KER 1 Novel Reactor Design

Preliminary roadmap summary for KER 1 is presented in Table 10.

Table 10 Preliminary Roadmap Summary for KER 1 Novel Reactor Design.

Exploitation roadmap	
Actions	Communicate results for Marketing purposes Use reactors in follow up projects Optimisation Identify potential financial mechanisms
Roles	APTL explore potential for upscaling DLR Modification and Optimisation of reactor
Milestones	Success of plant upscaling with multi-reactor systems Success in finding funding Durability of reactor
Financials Costs	Grant sufficient for small scale prototype not ready for the market and in need of upscaling
Revenues	Concept so far
Other sources	Projects
Impact in 3-year time	Production of PhD, Knowledge Environmental impact

The reactor results from the project will be published in the conferences and journal for marketing purpose. In addition, responsible of this KER will look for potential financial mechanism and follow-up projects to optimize the reactor design.

After this project, APTL will explore potential for upscaling the reactor to be developed in Hydrosol Beyond and DLR will work on modification and optimization of reactor performance. Main milestones identified were upscaling multi-reactor systems and get the funding.

KER responsible will look for grants/funding sufficient to develop the small scale prototype and upscaling. There are no revenue expected for far as the concept of reactor is in developing stage.

Impact in 3 year: It is expected to produce know-how and PhD thesis related with development of reactor.

This exploitation roadmap for Novel reactor will be updated in the remaining period (2021-2022) of the project.

3.2.2 KER 2 Hydrosol Process

Preliminary roadmap summary for KER 2 is presented in Table 11.

Table 11 Preliminary Roadmap Summary for KER 2 Hydrosol Process

Exploitation roadmap	
Actions	Look for continuation of Grant Feasibility study and cost analysis Already a patent application pending Potential for protection Stronger cooperation with non EU countries
Roles	All partners have specific topic of interest
Milestones	Efficiency of the process Validate the process
Financials Costs	Covered by the grant Try to achieve lower cost. Have cost efficiency as an objective also for future proposals.
Revenues	New research project to continue and finalise
Other sources	Participation in events for visibility
Impact in 3-year time	Trained Workforce Input in the Green energy concept

For improvement and optimization of hydrogen production process, partners will look for grant for continuation. Some other actions like patent, feasibility study, cost analysis and look for partnership in non-EU countries, are also part of roadmap. All partners are involved in taking part in development of this KER.

In the exploitation roadmap, milestones will be optimizing process efficiency and process validation. The expenses will be covered by the grant for further development and optimization of hydrogen production process. In the next project, one of the objective would be to bring down the cost of the process.

It is expected that new research project will continue.

Partners will participate in the events for visibility. Contribution of the project would be training the workforce and working on green hydrogen concept.

This exploitation roadmap for Hydrogen production process, will be updated in the remaining period (2021-2022) of the project.

3.2.3 KER 3 High Temperature Heat Exchanger

Preliminary roadmap summary for KER 3 is presented in Table 12.

Table 12 Preliminary Roadmap Summary for KER 3 High Temperature Heat Exchanger

Exploitation roadmap	
Actions	Freedom to operate analysis and Patent search Cost Analysis Marketing Plan Business Plan
Roles	HyGear, SUPSI, ENGICER
Milestones	Potential of the heat Exchanger, Success of the material
Financials Costs	Covered by the HORIZON2020 Grant
Revenues	Nothing equivalent yet in the market, Training for Technical staff
Other sources	Keep applying for research funding
Impact in 3-year time	More efficient reactors, Know how Less space in order to develop the complete system for CSP compared to PV + electrolysis Solid oxide fuel cell system developers are also using high temperature heat exchangers they can also be early adopters

Patent search, cost analysis, developing marketing and business plan would be the possible actions in the roadmap. HyGear, SUPSI and ENGICER are developing together this KER.

Material compatibility and performance of heat exchanger are the expected milestones.

Financial costs are covered by Horizon 2020 grant.

Contribution of the project would be the development of know-how and heat exchanger for high temperature applications.

4 Market Intelligence

Market analysis including analysis of current situation, related projects, patents, standards and competitors has been elaborated.

4.1 Related links

This chapter reports the results of specific related links found with Key Words « Concentrated solar power (CSP), green hydrogen production, hydrogen reactor, heat exchangers» is presented below.

In 2020, the pipeline of planned green hydrogen projects globally exceeds 60 gigawatts, roughly the equivalent of 187.5 million solar cells, 25,000 wind turbines, or to put it in consumption perspective, enough to light 6.6 billion LED bulbs. Long story short, our green hydrogen production capacity is expanding and 2020 has been a great year for hydrogen development.

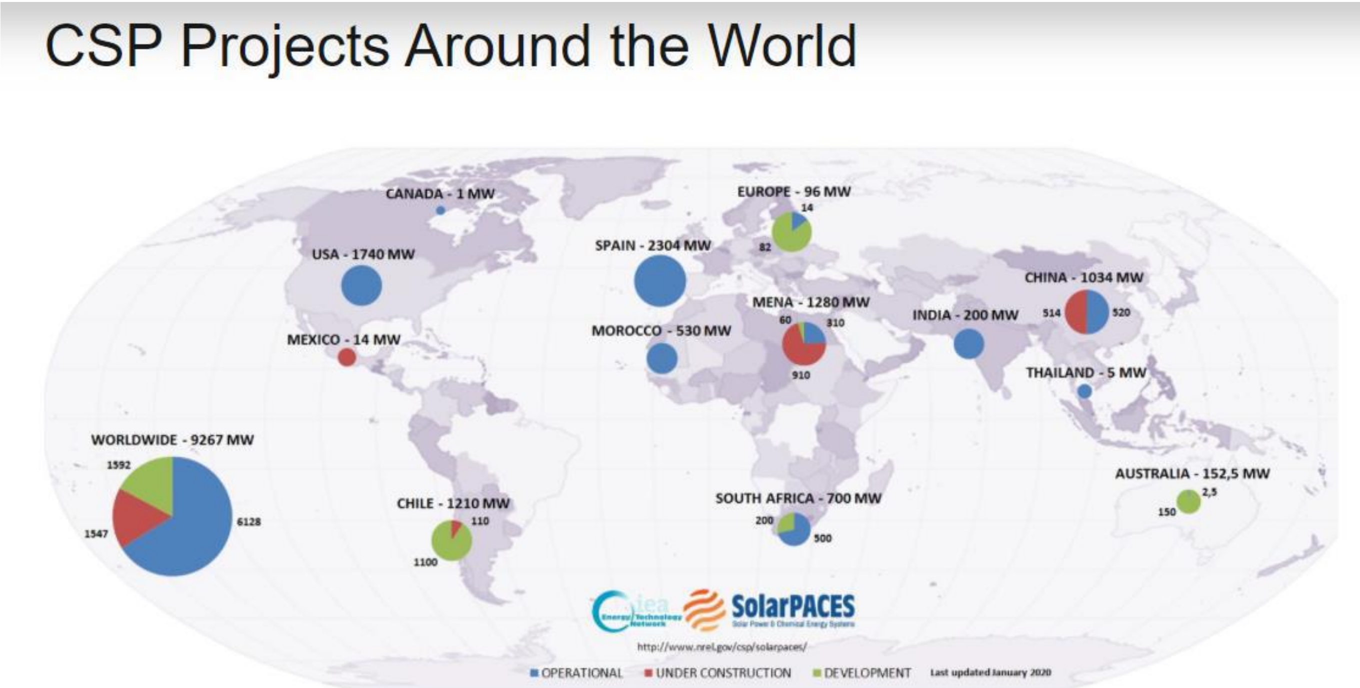


Figure 11 CSP Projects Around the World

Global green hydrogen project pipeline reaches 50 GW

International thinktank IEEFA says there are 50 viable green hydrogen projects under development with an estimated renewable energy capacity of 50 GW and the potential to produce 4 million tonnes of the fuel annually

The new fuel to come from Saudi Arabia

On the edge of the Saudi Arabian desert beside the Red Sea, a futuristic city called Neom is due to be built. The $500bn (£380bn) city – complete with flying taxis and robotic domestic help – is planned to become home to a million people. And what energy product will be used both to power this city and sell to the world? Not oil. Instead, Saudi Arabia is banking on a different fuel – green hydrogen. This carbon-free fuel made is from water by using renewably produced electricity to split hydrogen molecules from oxygen molecules. This summer, a large US gas company, Air Products & Chemicals, announced that as part of Neom it has been building a green hydrogen plant in Saudi Arabia for the past four years. The plant is powered by four gigawatts of electricity from wind and solar projects that sprawl across the desert. It claims to be the world's largest green hydrogen project – and more Saudi plants are on the drawing board.

The Green Hydrogen Revolution Is Now Underway

With the announcement of its 10-year $10.5 billion Green Hydrogen roadmap earlier this month, Spain joins a slew of other countries seeking to develop this once 'dirty' chemical feedstock into a zero-emission fuel for trucking, aviation, and shipping.

Korea and Japan have both rolled out roadmaps to guide hydrogen-related investment and policy in coming years, including encouraging hydrogen fuel cell vehicle (HFVC) production. The Toyota Mirai is an HFCV unveiled in 2014 and has 10,300 worldwide sales since December 2019, and Korea's Hyundai is producing the hydrogen powered SUV Nexo. China's Hebei province approved $1.2 billion of projects for hydrogen equipment manufacturing, filling stations, fuel cells and hydrogen production, including electrolysis.

Perhaps the most ambitious project so far is the Asian Renewable Energy Hub based in Pilbara, Western Australia. The 6,500 square kilometer wind and solar farm will produce over 50TWh of clean electricity, a large portion of which will power on-site hydrogen and ammonia production for delivery to local and export markets. The $16 billion initiative could see green hydrogen shipments as early as 2027.

The market for hydrogen mobility is expected to significantly grow over the coming decade, with some estimates as high as a $70 billion by 2030.

New system for widespread availability of green hydrogen

The Fuel Cells and Hydrogen Systems Working Group at TU Graz's Institute of Chemical Engineering and Environmental Technology – one of the leading international groups in the field of hydrogen research – has therefore been looking for ways to make hydrogen production more attractive. As part of the HyStORM (Hydrogen Storage via Oxidation and Reduction of Metals) research project, the team led by working group head Viktor Hacker developed a so-called "chemical-looping hydrogen method", a new sustainable and innovative process for decentralised and climate-neutral hydrogen production. This award-winning research success resulted in a compact and space-saving on-site, on-demand (OSOD) system for filling stations and energy plants and is being developed and distributed by the Graz-based start-up Rouge H2 Engineering. This system is expected to become an important piece of the puzzle on the way to the widespread availability of sustainable hydrogen.

Figure 12 The inner workings of the OSOD H2 generator. The blue cuboid is the core development: a gas furnace with four tubular reactors in which the chemical looping process for hydrogen production takes place. (Image: RGH2)

Researchers discover a new way to produce hydrogen using microwaves

(Nanowerk News) A team of researchers from the Polytechnic University of Valencia and the Spanish National Research Council (CSIC) has discovered a new method that makes it possible to transform electricity into hydrogen or chemical products solely using microwaves – without cables and without any type of contact with electrodes.

This represents a revolution in the field of energy research and a key development for the process of industrial decarbonization, as well as for the future of the automotive sector and the chemical industry, among many others. The study has been published in the latest edition of Nature Energy ("Hydrogen production via microwave-induced water splitting at low temperature"), where the discovery is explained. The technology developed and patented by the UPV and CSIC is based on the phenomenon of the microwave reduction of solid materials. This method makes it possible to carry out electrochemical processes directly without requiring electrodes, which simplifies and significantly cheapens its practical use, as it provides more freedom in the design of the structure of the device and choosing the operation conditions, mainly the temperature.

4.2 Related projects

A list of projects (found on Cordis) of similar interest with a brief description is included below:

CertifHy Developing a European Framework for the generation of guarantees of origin for green hydrogen

ID: 633107

From: 1 November 2014 to: 31 October 2016

The development of hydrogen as an energy carrier will be dependent upon the capacity of the market to offer low-carbon or carbon-free hydrogen to end-users and consumers. However, the production of green hydrogen and its consumption will most likely be unbundled in order to o...

Djewels Delfzijl Joint Development of green Water Electrolysis at Large Scale

ID: 826089

From: 1 January 2020 to: 31 December 2025

Djewels demonstrate the operational readiness of 20 MW electrolyser for the production of green fuels (green methanol) in real-life industrial and commercial conditions. It will bring the technology from TRL 7 to TRL 8 and lay the foundation for the next scale-up step, towards...

Switch Smart Ways For In-Situ Totally Integrated And Continuous Multisource Generation Of Hydrogen

ID: 875148

From: 1 January 2020 to: 31 December 2022

Solid Oxide Cells are efficient ways to convert variable electricity from renewables in green hydrogen. At the same time, they can be used in a reversible mode to enable the use of other sources (e.g. methane, bio-methane) to match a variable energy production with

BIONICO BIOgas membrane reformer for deceNtrallzed hydrogen produCtiOn

ID: 671459

From: 1 September 2015 to: 31 December 2019

BIONICO will develop, build and demonstrate at a real biogas plant (TRL6) a novel reactor concept integrating H2 production and separation in a single vessel. The hydrogen production capacity will be of 100 kg/day.By using the novel intensified reactor, direct

GrInHy2.0 Green Industrial Hydrogen via steam electrolysis

ID: 826350

From: 1 January 2019 to: 31 December 2022

The European Commission and its roadmap for moving towards a competitive low-carbon economy in 2050 sets greenhouse gas emissions targets for different economic sectors . One of the main challenges of transforming Europe´s economy will be the integration of highly volatile...

REMOTE Remote area Energy supply with Multiple Options for integrated hydrogen-based TEchnologies

ID: 779541

From: 1 January 2018 to: 31 December 2021

REMOTE will demonstrate technical and economic feasibility of two fuel cells-based H2 energy storage solutions (integrated P2P system; non-integrated P2G+G2P system), deployed in 4 DEMOs, based on renewables, in isolated micro-grid or off grid remote areas. DEMO 1: Ginostra...

H2Future HYDROGEN MEETING FUTURE NEEDS OF LOW CARBON MANUFACTURING VALUE CHAINS
ID: 735503

From: 1 January 2017 to: 30 June 2021

Under the coordination of VERBUND, VOESTALPINE, a steel manufacturer, and SIEMENS, a PEM electrolyser manufacturer, propose a 26 month demonstration of the 6MW electrolysis power plant installed at the VOESTALPINE LINZ plant (Austria).

RGH2 OSOD system OSOD - 1 step process hydrogen generator for highly efficient, safe and cost competitive production and storage of hydrogen

ID: 774512

From: 1 June 2017 to: 30 November 2017

RGH2 engineering GmbH is a start-up company founded in January 2015 based in Graz, Austria. RGH2 focuses on the development of a decentralized, autonomous/remote-controlled, affordable and scalable system for hydrogen-production and hydrogen-storage

4.3 Patents

A summary of related patents is included below:

Power dispatch system for electrolytic production of hydrogen from wind power

WO EP US CN CA US9303325B2 Jim HINATSU Next Hydrogen Corporation

Priority 2008-10-30 • Filed 2012-03-23 • Granted 2016-04-05 • Published 2016-04-05

… energy. With recent increases in the cost of natural gas, the concept of using wind turbine generators in “wind farms” to supply sustainable, clean and relatively low cost electrical power to electrolysers for large scale production of “green” hydrogen is becoming an economically viable approach.

Thin film support substrate for use in hydrogen production filter and …

WO EP US CN US8562847B2 Hiroshi Yagi Dai Nippon Insatsu Kabushiki Kaisha

Priority 2002-07-25 • Filed 2011-09-09 • Granted 2013-10-22 • Published 2013-10-22

7. A production method of a hydrogen production filter according to claim 3 , wherein the Pd alloy is a Pd—Ag alloy. 8. A production method of a hydrogen production filter according to claim 4 , wherein the Pd alloy is a Pd—Ag alloy. 9. A production method of a hydrogen production filter.

Use of a process for hydrogen production

WO EP US CN JP AT AU US9561957B2 Ernst Hammel Bestrong International Limited

Priority 2005-10-31 • Filed 2014-06-20 • Granted 2017-02-07 • Published 2017-02-07

The present invention relates to the use of a process for hydrogen production in which at least a part of a hydrocarbonaceous feed gas (a) is passed into a reformer (c), wherein the feed gas is contacted in the reformer with a catalyst and the feed gas is converted to hydrogen and solid carbon.

Catalyst for hydrogen production via methanol steam reforming as well as …

CN CN103816921B Priority 2014-01-29 • Filed 2014-01-29 • Granted 2017-01-18 • Published 2017-01-18

A kind of hydrogen production process using catalyst for preparing hydrogen by reforming methanol and water vapour is it is characterised in that described hydrogen production process includes Following steps: Hydrogen production process includes reforming step, and in reforming step.

Catalyst for production of hydrogen and process for producing hydrogen using …

WO EP US CN KR US20190210009A1 Junji Okamura Nippon Shokubai Co., Ltd.

Priority 2009-03-17 • Filed 2019-03-12 • Published 2019-07-11

A process for producing hydrogen from a gas containing ammonia and oxygen by using a catalyst for production of hydrogen, wherein the catalyst for production of hydrogen comprises at least one metal element selected from the group consisting of cobalt, iron, and molybdenum, wherein the catalyst …

Trough-stirling concentrated solar power system

US US6886339B2 Joseph P. Carroll The Boeing Company

Priority 2003-05-19 • Filed 2003-05-19 • Granted 2005-05-03 • Published 2005-05-03

To address the above demand for solar power systems, many configurations have been designed and implemented. One such implementation is a concentrated solar power system that collects solar energy and concentrates that energy onto an absorber.

Systems for cost-effective concentration and utilization of solar energy

WO EP US AU CA TN ZA US9995507B2 Richard Norman Richard Norman

Priority 2009-04-15 • Filed 2009-04-15 • Granted 2018-06-12 • Published 2018-06-12

After watching the Myth Busters episode, the applicant explored ways of designing parabolic mirrors that would have been practical to build in Archimedes' time, and found several such designs that would easily have provided a sufficient amount of sufficiently concentrated solar power to set a ship on fire.

Concentrated solar system

WO US CA CA2698367C William Masek Quadra Solar Corporation

Priority 2007-09-07 • Filed 2008-09-05 • Granted 2013-02-12 • Published 2013-02-12

4c 3. Cost Effective Solar System Another goal of the invention is to obtain higher energy output and more cost efficient than that of comparable solar generation systems using concentrated solar photovoltaic cells.

Beam-forming concentrating solar thermal array power systems

WO US US9476612B2 Thomas A. Cwik California Institute Of Technology

Priority 2011-03-09 • Filed 2012-03-09 • Granted 2016-10-25 • Published 2016-10-25

The present invention relates to concentrating solar-power systems and, more particularly, beam-forming concentrating solar thermal array power systems. A solar thermal array power system is provided, including a plurality of solar concentrators arranged in pods.

4.4 Standards

A list of related standards is included in Table 13.

Table 13 List of related standards

Committee	Reference, Title
CEN/TC 312	EN 12975-1:2006+A1:2010 (WI=00312030) Thermal solar systems and components - Solar collectors - Part 1: General requirements
CEN/TC 312	EN 12976-1:2017 (WI=00312036) Thermal solar systems and components - Factory made systems - Part 1: General requirements
CEN/TC 312	EN 12976-2:2019 (WI=00312046) Thermal solar systems and components - Factory made systems - Part 2: Test methods
CEN/TC 312	EN 12977-1:2018 (WI=00312043) Thermal solar systems and components - Custom built systems - Part 1: General requirements for solar water heaters and combisystems
CEN/TC 312	EN 12977-2:2018 (WI=00312040) Thermal solar systems and components - Custom built systems - Part 2: Test methods for solar water heaters and combisystems
CEN/TC 312	EN 12977-3:2018 (WI=00312044) Thermal solar systems and components - Custom built systems - Part 3: Performance test methods for solar water heater stores
CEN/TC 312	EN 12977-4:2018 (WI=00312041) Thermal solar systems and components - Custom built systems - Part 4: Performance test methods for solar combistores
CEN/TC 312	EN 12977-5:2018 (WI=00312042) Thermal solar systems and components - Custom built systems - Part 5: Performance test methods for control equipment

4.5 Competitors

Blue Hydrogen is produced by reforming methane from natural gas, therefore it is not a renewable energy technology and depends on a finite resource. It can be a useful way to decarbonize the use of natural gas since it is easier to capture the carbon dioxide during centralized methane reformation than at the many final points of use. This form of hydrogen is relatively cheap but without expensive further processing it is not pure enough for use in fuel cell vehicles. Blue hydrogen, combined with carbon capture and storage, may have a useful role as a transitional technology for decarbonizing domestic and industrial heat.

'Green Hydrogen' is produced by splitting water into hydrogen and oxygen. This is currently done using electricity to perform electrolysis; solar reactors are also being developed which can directly split water. High purity hydrogen is produced suitable for use in fuel cells and it is only limited by the availability of electricity. Only green hydrogen could enable a hydrogen economy.

According to this, different technologies have been identified as competitors in the same market of the Hydrosol technology

- Electrolysis
- High temperature electrolysis
- Producers of REDOX particles
- Producers of evacuated REDOX-Reactor

5 References

- https://www.solarpaces.org/csp-technologies/csp-projects-around-the-world/
- https://interestingengineering.com/the-worlds-top-green-hydrogen-projects
- https://www.pv-magazine.com/2020/08/26/global-green-hydrogen-project-pipeline-reaches-50-gw/
- https://www.bbc.com/future/article/20201112-the-green-hydrogen-revolution-in-renewable-energy
- https://www.forbes.com/sites/arielcohen/2020/10/19/the-green-hydrogen-revolution-is-now-underway/?sh=1ba41f12232c
- https://www.nanowerk.com/news2/green/newsid=55226.php
- https://www.nanowerk.com/news2/green/newsid=56543.php

History of Changes		
Version	**Publication Date**	**Change**
1.0	30.12.2020	Initial version
1.1	21.05.2021	Correction of the 1st version based on officer's comments. A. Update the template with valid funding logos and document structure enhancement. B. Clarifying the open access to publications and a clear identification of IP rights on project results arising from multiple funded projects is not clear from the document. C. Answer on issues regarding the hydrogen production cost in correlation with the geographic location of the CSP plants..