



## D8.4: Second update of risk management plan

### Public Document

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### Executive summary

This document presents an update of the risk management strategy applied in GAMER. In addition, an update of the risks identified during the preparation of the project has been carried out.

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## 1 The GAMER project

The GAMER project aims at developing a novel cost-effective tubular Proton Ceramic Electrolyser (PCE) stack technology integrated in a steam electrolyser system to produce pure dry pressurized hydrogen. The electrolyser system will be thermally coupled to renewable or waste heat sources in industrial plants to achieve higher AC electric efficiency and efficient heat valorisation by the integrated processes. The project aims at establishing a high volume production of novel tubular proton conducting ceramic cells. The cells will be qualified for pressurized steam electrolysis operation at intermediate temperature (500-700°C). They will be bundled in innovative single engineering units (SEU) encased in tubular steel shells, a modular technology, amenable to various industrial scales. GAMER focuses on designing both system and balance of plant components with the support of advanced modelling and simulation work, flowsheets of integrated processes, combined with robust engineering routes for demonstrating efficient thermal and electrical integration in a 10 kW electrolyser system delivering pure hydrogen at minimum 30 bars outlet pressure.

The consortium covers the full value chain of the hydrogen economy, from cell and SEU manufacturer (CMS), system integrators (MC2, CRI), through researchers (SINTEF, UiO, CSIC), to end users in refineries, oil and gas, chemical industry (CRI, SGSI, with advisory board members YARA and Air Liquide). All along the project, these experienced partners will pay particular attention to risk management (technical, economic, logistic, business) and ensure progress of the technology from TRL3 to TRL5. The overall consortium will perform strategic communication with the relevant stakeholders in order to ensure strong exploitation of the project's results.

## 2 Organisational and management structure

The management of GAMER aims at providing the necessary structure to continuously support and monitor R&D activities. The project organization structure comprises: **The Coordinator, the General Assembly (GA), and the Executive Board (EB)**. In addition, the Coordinator and the Executive Board are assisted by the Management Support Team and the Innovation and Dissemination managers. The proposed structure is designed to swiftly address deviations/risks that may arise during the project, and provides the necessary tools and internal procedures allowing their anticipation and/or management.

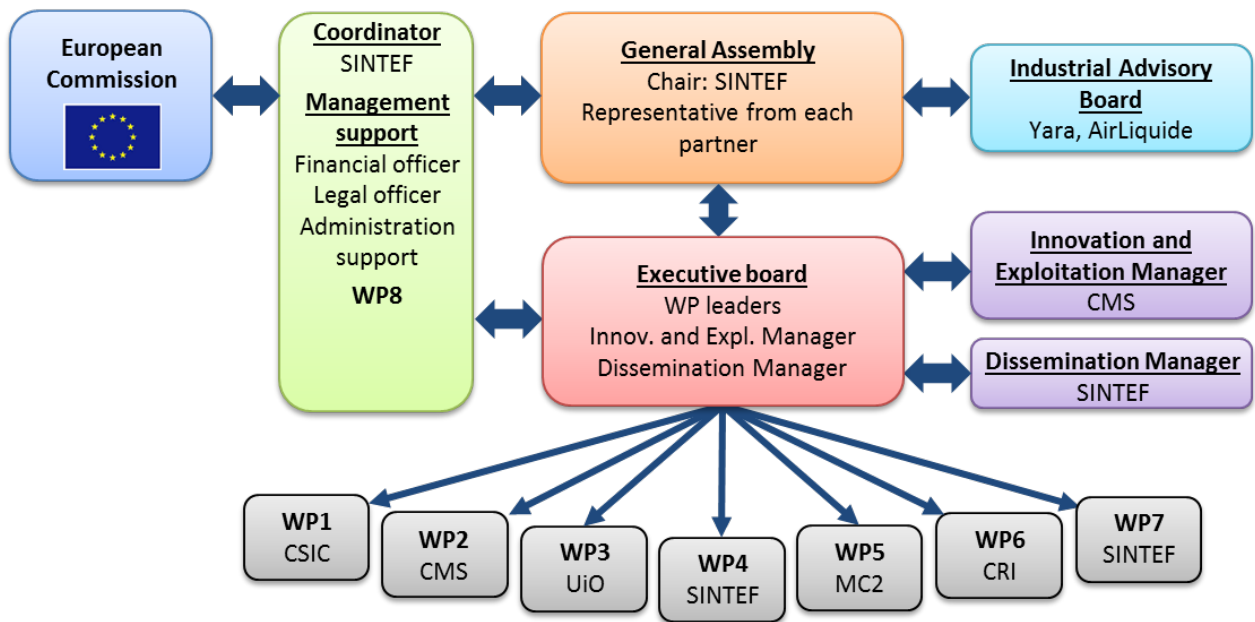


Figure 1: Management structure of GAMER.

### 3 Risk management strategy

GAMER progress is monitored on a monthly basis during the EB meeting. The Executive Board reviews the risks associated with the execution of tasks and achieving GAMER targets. This risk assessment involves identifying project risks, assessing their probability and the nature of the consequences should the risk be incurred. Where discrepancies between plans and progress are observed (or predicted), corrective actions are initiated following risk mitigation measures defined in the description of work whenever possible. A set of critical risks has already been identified (see Table below). It serves as the basis for risk assessment, and is continuously updated.

Deviations requiring re-planning of detailed tasks at the *Work Package level* are monitored by the Work Package Leader, in consultation with all partners involved in the work package. Results are reported to the Coordinator. *Project level* changes will be the responsibility of the Executive Board (except in the case of *major* changes - see below).

Project re-planning that results in changes deemed to be *major* are handled by the General Assembly using voting procedures if necessary. Changes will be deemed to be major if any one partner protests about a proposed change, or automatically if the change involves:

- Modifications to the Consortium Agreement or to the management structures and principles or
- Problems with the performance of any partner, or the desire of a partner to leave the Consortium or
- Re-allocation of budget among work packages and/or partners

Implementation of major changes may necessitate a change in the overall project plan, detailed project plans or the work breakdown structure of the project.



## 4 Possible risks and proposed mitigation measured

A set of possible risks were identified during GAMER preparation. They are listed below and their status has been updated at M18. When the project is running according to plan, the overall status is marked "nothing to report here".

Description of risk ( <i>level of likelihood</i> )	Main WP involved	Proposed risk-mitigation measures applied in GAMER	Status by M19
Computational requirements are too demanding for CFD modelling ( <i>medium</i> )	WP1	<ul style="list-style-type: none"> <li>▪ Use alternative model simplification strategies</li> <li>▪ Access / Acquisition of more powerful computational resources</li> </ul>	Nothing to report here
Delay in delivery of KET components/cells for qualification tests ( <i>low</i> )	WP2, WP3	<ul style="list-style-type: none"> <li>▪ Existing cells and components already available at partners;</li> <li>▪ For optimized components: sub-contracting volume production of parts</li> </ul>	<p>- A novel SEU design is developed in GAMER and is under patenting evaluation. This has required the development of new current collection system, which has contributed to delay in cells, SEU delivery to M18</p> <p>- A mitigation plan has been implemented to address these new developments</p>
Degradation of functionality and/or integrity of KET components/Cells preventing to reach project targets ( <i>low for most elements; medium for cathode</i> )	WP2, WP3	<ul style="list-style-type: none"> <li>▪ Potential routes for optimization defined in WP2 based on materials optimisation / interface improvement</li> <li>▪ Two types of cathodes are available in GAMER, one including LSM oxide largely used in SOEC/SOFC technology</li> </ul>	As both electrode sets meet most but not ALL criteria in term of ASR target + stability target + faradaic efficiency + high current density + up-scalability, an extension of 3 months is requested to overcome the remaining limiting factor. A mitigation plan is established with a milestone set at M23.
Delay in delivery of SEUs for performance evaluation ( <i>low</i> )	WP2, WP4	<ol style="list-style-type: none"> <li>1. Allocate more time to SEU production with reduced testing campaign before</li> </ol>	A simplified design of the SEU was implemented enabling to improve current collection and fluid dynamics



		<p>"go/no go" decision at M18</p> <ol style="list-style-type: none"> <li>2. Allocate more resources for the work by shifting resources from other tasks (to be taken by the managing board)</li> <li>3. Focus on one generation only: trade-off between performance and timely delivery</li> <li>4. Use simplified design (less cells per SEU): this may increase system size and/or reduce system power</li> </ol>	<p>More resources have been shifted towards the testing of SEUs</p> <p>At M18, a few SEUs have been tested. Additional testing is required in line with the optimization of the electrodes and the need for carrying stability test campaign. This shifts the evaluation of SEU performance to M24.</p>
Degradation of functionality and/or integrity of SEUs above the target of the project ( <i>low if previous risks mitigated</i> )	WP2, WP4	<ul style="list-style-type: none"> <li>▪ Potential routes for optimization defined in WP2 based on materials optimisation / interface improvement</li> <li>▪ Use simplified design (less cells per SEU): this may increase system size and/or reduce system power</li> </ul>	No degradation has been observed within the limited testing campaign.
Poor performance of SEU requiring large system ( <i>low</i> )		<ol style="list-style-type: none"> <li>1. Potential routes for optimization defined in WP2 based on materials optimisation / interface improvement</li> <li>2. Possibility to connect in series tubular cells using CMS process with optimisation of cell configuration in WP2</li> </ol>	As reported above, optimization of electrode is in progress to increase SEU performance.
Delay in delivery of SEUs for system integration in WP5 ( <i>medium</i> )	WP2, WP5	<ol style="list-style-type: none"> <li>1. All parts will be produced using high volume manufacturing routes by CMS and sub-contractors for some specialized parts</li> <li>2. Allocate more time to SEU production which</li> </ol>	A delay for the delivery of SEUs is anticipated due to the shift of validation of SEU design and performance to M24. The SEUs are expected to be delivered with 8 months delay.



		may reduce testing campaign of system	
Sub-contractors are not delivering timely <i>(low)</i>	WP3, WP5	<ul style="list-style-type: none"> <li>▪ Continuous dialog will be established with sub-contractors</li> <li>▪ A dedicated person from GAMER will be appointed to follow up each task to strengthen communication channel</li> <li>▪ Only subcontractors with suitable reputation for high quality work will be considered</li> </ul>	This is going according to plan
Safety associated with failure of cells/SEU/system during testing <i>(low)</i>	WP5	<ul style="list-style-type: none"> <li>▪ Consideration for safety is including in design phase of components, when defining suitable protocols for operations and within each partner working environment rules</li> </ul>	This is going according to plan
System does not reach cost and performance targets at the end of GAMER <i>(medium to high)</i>	WP6 WP5 WP1	<ul style="list-style-type: none"> <li>▪ Cost targets are expected to be met based on actual evaluation of the SEU technology</li> <li>▪ Performance targets could be further improved based on activities in WP2 and in WP1,WP6 for improved design and integration of the system</li> </ul>	Nothing to report here
Low impact of the project's results <i>(low)</i>		<ul style="list-style-type: none"> <li>▪ Exhaustive dissemination and exploitation plans prepared by the partners with various dissemination channels</li> <li>▪ At least one exploitation workshop open to stakeholders</li> </ul>	Nothing to report here



		will be organized in GAMER	
Early publication hinders patent application (and vice versa: patent application work delays publication) ( <i>low</i> )	WP6/WP7	Rules for publishing project results will be established and agreed in the Consortium Agreement. The rules will allow sufficient time for partners to react, but will also avoid jeopardizing decisions on patent or publications to occur. Rules will be reminded to the partners in every Consortium meeting.	Nothing to report here