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Deliverable D6.2

Intermediate overview of reached and provided results as outcome of the innovation process

Revision 1.2

Preparation date 2023-12-31 (M60)

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Lead contractor .....EFCF

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Dissemination level		
PU	Public	X
CO	Confidential, only for members of the consortium (including the Commission Services)	

Deliverable administration							
No & name	**D6.2 – Intermediate overview of reached and provided results**						
Status	Final	**Due**	M32	**Date**			
Author(s)	Michael Spirig (EFCF) and all partners of the consortium						
Description of the related task and the deliverable. Extract from DoA	**WT6.2: Innovation management, M1-M48** (EFCF, All) The goal of this WT is guide the innovation management process, which allows the consortium to respond to external and internal opportunities as needed. The aim is the identification and evaluation of creative ideas, which meet the focus specifications of the products (BoP), as well as manufacturing and market needs. The identified, feasible solutions will be consolidated and further handled in WP 2-4, as well as analyzed for suitability to target markets in WP 5**. In the middle of the project an overview of already reached and possible results i.e. improved products, processes or services including business models (D6.2, M23) will become the base for intensified external communication activities** (WT 6.3 and 6.4, see also 3. Innovation Management in the Draft 'plan for the dissemination and exploitation of the project's results').						
Planned resources PM of WP1	VTT	Sunfire	SP	NE	EFCF	3E	Total
	2,0	3,0	1,0	1,0	5,7	0,5	13,2
Comments							

V	Date	Authors	Description
1.0	2022-09-22	EFCF	Draft for review
2.0	2022-09-30	EFCF & all partners	Final version, revised in accordance with review & comments at PMC meeting 2022-10-06
3.0	2023-12-31	EFCF & all partners	Last Final version, revised in accordance to revision requests and final cleaning actions

Table of contents

Sunfire-Remote 400 powered microwave radio stations in Alaska

1. INTRODUCTION

The goal of the "the intermediate overview of already achieved and possible results" is to collect all publishable achievements and improvements of RoRePower to generate a pool of publishable information. This information will then be used in the final phase of the project for increased dissemination and deployment actions to support the OEMs' in the successful exploitation of the RRP results. It is planned to use the information for the RRP web (www.RoRePower.com), mailings, and for posts on social media (www.twitter.com/RoRePower, www.linkedin.com/in/RoRePower), as well as for the creation of further dissemination material.

The goal of the RoRePower project is to develop and demonstrate solid oxide fuel cell systems for continuous off-grid power generation in remote regions with harsh climate conditions (from -40 to +50°C). The economic project goal is to achieve a 30-40% reduction in manufacturing and BOP component procurement and system costs. Taking into account the total cost of ownership, which is low due to the already leading energy efficiency and minimized maintenance and service requirements, the competitiveness and profitability of the European FC solution is so convincing that it can replace conventional products as the new standard. Furthermore, three European integrated stack and system manufacturers working together for the same market, sharing access efforts and covering complementary power levels, sends a convincing message to the market, showing clients broadness and stability of the future market cultivation.

To achieve these goals, the RRP partners collaborated on several levels, which are also reflected in the work packages: Component, system and manufacturing improvements, data collection for system monitoring to reduce maintenance and service cost.

2. RESULTS & IMPROVEMENTS

2.1 Engineering and Components

WP2: First objective is to identify potential shared BOP components and their requirements and provide the common basis on which each manufacturer can improve their system design in WP3 separately. Second objective is to avoid redundant work and decrease the cost of general BOP component.

- Harsh climate approved BoP components
  - Based on thorough market research about specific aspects and components, the best BoP components were selected together with the project partners.
  - The critical components were tested in a climate chamber and approved to meet low temperature demands.
- Cold start-up units and management
  - For the very crucial cold start-up devices two commercial units with appropriate ratings were found and approved, for both cases propane and natural gas.
  - Adequate operation strategies and thermal management of the total fuel cell system are implemented.

2.2 Cost optimization and Manufacturing

WP3: Objective of this working package is the detailed engineering, cost optimization and manufacturing of demonstration SOFC systems. Total amount of the demonstrated SOFC systems will be from 15 to 30 units and system costs reduction will be at least 30% until the end of project.

TCO: **Reduction** of total-cost-of-ownership

- A significant reduction is achieved by cost reduction of specific **BOP component, stack and its periphery.**
- The **joint supply chain** and joint **procurement** for system manufacturers in the case of generic components and spare parts reduces costs.

2.3 Demonstration, maintenance and service

WP4: The main objective of this work package is to install the demonstration units and organize all the activities related to data collection, maintenance and service. In addition, survey of stakeholders, practices and business models in the target markets will be conducted.

The following key statements can be summarised based on the work of this work package:

- Operating know-how and experience
  - Over 20 demonstration units are installed and successfully running at the time, when this report was completed.
  - All together **45 - 50 units** will be installed during the project and operated between 10 and 20 months, i.e. in the sum ca. 600 month, resp. up to **450'000h of operating experience**.

- Bankable business-case
  - The field demonstrations during the project deliver the relevant **long-term evidence** and **data** for **reliability, service and maintenance**.
  - It provides evidence that **European fuel cell OEMs can offer robust remote power generation** for very harsh environments.
  - A **bankable fuel cell business case** for local distributors and investors is available. This is a **breakthrough** for the high temperature fuel cell technologies and the FCH JU i.e. Clean Hydrogen JU program.

- Market diversity
  - Systems are delivered to both the oil/gas and telecommunication sectors allowing in future **higher number of systems** and is more **market diversity**, which is less dependence and more stability

- Market advantages
  - **TOC: Lower** total-cost-of-ownership (see also 2.2. Cost optimisation)
    The fuel cells provide increased electrical **efficiency** in those markets compared to the incumbent technologies. Fuel cells with higher electrical efficiency also offer **reduced maintenance** requirements. The overall total cost of electricity will be decreased with the RoRePower products already at relatively modest product volumes.

- Fewer emissions
  With respect to the thermoelectric generators, an **80% CO_2 emission decrease** can be expected. With respect to Diesel combustion engines, the change from Diesel to natural gas or LPG on its own provides a 70% CO_2 reduction in the power range of the project (2 kWe). Compared to conventional diesel generators, the fuel cell systems have **much less NO_x, CO and particle emissions**, which increase the wellbeing of e.g. people working around them.
- Higher power supply security
  Beside less emission also **noise, vibrations** and the risk of **soil contamination** by liquid fuels are reduced and finally, **higher power supply security** will be reached.

- Target Market Survey

  The survey results in the following relevant **statements for positive decision making** to apply a fuel cell based robust remote power supply in harsh environment:

  - General **willingness** to invest on the sector e.g. prospects for oil show declining trends
  - **Local aspects** that delimits alternatives (like standards)
  - Regional/country specific **attitudes and regulation** regarding environmental performance (like emissions)
  - **Location-specific aspects** guiding the selection (like risk for theft, available footprint)
  - **Technical aspects** that are considered more over the others (like reliability)
  - Unambiguous **technical specification** determining whether the power source is suitable for the purpose or not (like suitability to operate in harsh climate conditions, the need for energy per day or year, required voltage levels, peak load capacity).
  - **Cost** evaluation based both on CAPEX and OPEX

2.4 Monitoring, system effectiveness and applicability

WP5: This work package has two main objectives:
1) to ensure uniform data collection and reporting from all the demonstration units and
2) to analyse system effectiveness and applicability
   to off-grid power generation in harsh climate conditions.

Results and advantages relevant to dissemination and exploitation in this work package are:

- **Homogenous data collection** from all RoRePower units
  - FC manufacturers collect data from all RoRePower units
  - Upload data in standard format to the common project database
- Ability for **flexible monitoring solutions**
  - Very different client-, region- and confidentiality-specific expectations and requirements of data acquisition and transmission can be handled.
  - Solutions from continuous remote access to log files based transmission in monthly basis.

2.5 Collaboration & Signal to the markets

In the RRP Project, the three leading European manufacturers of integrated stacks and systems, SUNFIRE GMBH, SOLIDPOWER SPA, SUNFIRE FUEL CELLS GMBH, convincingly demonstrate how, even as competitors, product development and improvement can be driven forward together in an efficient, time saving and solution-oriented manner.

This shows clients broadness and stability of the future market cultivation. It also provides the European component and material suppliers increased economies of scales and more stable demand conditions, which strengthen the whole European sector.

Achieving the following objectives is a strategic milestone for successful market introduction and market development:

- Economies of scale begin to take effect
  By working together and comparing specifications the number of units and the reliability of acceptance of similar components increase for the suppliers. Together, they increase volumes and purchase certainty of similar components for the suppliers so that due to **economies of scale cost reductions** result and **price become negotiable**.
- Positive signal to market
  Between them, they share access and cover complementary performance levels. This is a **compelling message** to the market, customers and suppliers showing stability and growth for the future market is.
- Strengthened value chain
  For **strengthening** the **European value chain**, industrial partners agreed **on shared BOP components** and performed an intensive market research for specific parts as well as shared BoP components for the extended climate requirements.
- Market entry
  In order to introduce SOFC technology to the niche market, the industry partners first successfully focused on intensifying contacts with **existing customers** and then moved on to acquiring **new end users** and **use cases** (e.g. semi harsh environment, standalone application for monitoring and security).

3. FINAL OVERVIEW - REACHED & POSSIBLE RESULTS

Reached Results:

Major progresses have been made on all levels: Component, system and manufacturing improvements, data collection for system monitoring to reduce maintenance and service cost. All intermediate results confirm the viability and competitiveness of SOFC solutions for continuous off-grid power generation in remote regions with harsh climate conditions. Here is the overview of the main progresses i.e. relevant advantages:

- ✓ Harsh climate approved BoP components - tests in climate chamber and running systems
- ✓ Cold start-up units and system temperature management is implemented and reliable
- ✓ TCO reduction:
  by cost optimised BOP component, stack and its periphery, joint supply chain and procurement, but also due to higher higher electrical efficiency, reduced maintenance
- ✓ Finally deep specific knowhow and up to 450'000h operating experience
- ✓ Bankable business-case, based on long-term track record and data for reliability, service and maintenance
- ✓ Market diversity, i.e. less dependence and more stability, higher number of systems by delivering to oil/gas and telecommunication sector
- ✓ Market advantages due to lower TOC, fewer emissions and higher power supply security
- ✓ The target market survey showed that the fuel cell solutions optimally meet most of the decision aspects like standards, emissions, risk for theft, footprint, specification due to harsh climate, cost evaluation based on CAPEX and OPEX (TOC)
- ✓ Flexible data collection and monitoring to survey and learn from running units
- ✓ Economies of scale begin to take effect due to aligned joint development, which is a positive signal to market and strengthen the value chain
- ✓ Market entry is ongoing with existing customers and new end users and use cases.

Reached & Possible Results:

As the installation tracker shows, **many devices have already been installed at customer sites** or will be installed in the coming month (see final Deliverable D4.10: RoRePower units reached following demonstration times: 11 units > 24 months, 8 units > 12 months, 31 units < 12 months). An important result of the acquisition and persuasion activities is the **achievement of cooperation** with industrial partners. It is always a real breakthrough when they are prepared to carry out a pilot installation and test the products in detail together with the OEMs to meet their requirements. Such an investment (in terms of personnel, finance and space) also means that there is a **willingness to go further with the technology and its benefits**.

In the final phase, robustness of the installed demonstration units will be evaluated. Intervals for proactive maintenance together with the performance level and degradation of the systems

give a base for this analysis. The **overall suitability of the solid oxide fuel cell technology to the off-grid power generation** in both oil/gas infrastructure and telecommunication sites will be analysed.

The final degradation of the systems in the demonstration sites will be studied in detail and **estimation for the lifetime of the systems** will be given. Special attention will be given to the analysis of the **system tolerance to harsh climate** conditions. The effect of these conditions to the **maintenance requirements** and system lifetime will be studied. During the project, knowledge on the critical components will be gathered and recommendations for further development will be given to the system integrators as well as BoP component manufacturers. Analysis will also take account the operation and maintenance costs. The comparison with current off-grid power generation solutions will be deepened, and based on the deepened results, the oil/gas infrastructure and telecom markets can be further focused addressed. It should be noted that especially the oil/gas industry has a special rather very conservative market behaviour.

To strengthen the **common voice of the EU Fuel Cell industry** including the supply chain stakeholder the **collaboration with FCH-JU i.e. Clean Hydrogen Partnership** for communication and presentation **will be intensified**. Clean Hydrogen Partnership with its status as PPP (Public Private Partnership) is a diplomatic door opener to high-level business contacts, and the joint appearance under an EU project increases credibility and financing power. This sends a strong, convincing signal to the markets with the message: The European Fuel Cell solves the challenges - Get it, it is leading, available and has the relevant added values.

In the next phase, possible business models and **new or related products**, which have market advantage due to the RoRePower technology, should also be considered. Especially in the **ITC industry**, there seems to be a lot of **potential in terms of remote and standalone applications**.