Sunlight Production
of Chemical Fuels

SPOTLIGHT

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D6.3 HSE Engineering report

WP6 Techno-economic and environmental assessment

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ABBREVIATIONS

HAZOP	HAZard and OPerability
HS	Health and Safety
P&ID	Piping and Instrumentation Diagram

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1. INTRODUCTION

1.1. SPOTLIGHT overview and process

The main goal of the SPOTLIGHT project is to demonstrate the concept of sunlight-powered CO_2 conversion reactions (Sabatier process and reverse water-gas shift, rWGS) up to a technology readiness level (TRL) of 5 to 6. In order to achieve this goal, various technologies need to be developed. An overview of the technologies and how they are related to each other in the SPOTLIGHT project is shown in Figure 1.

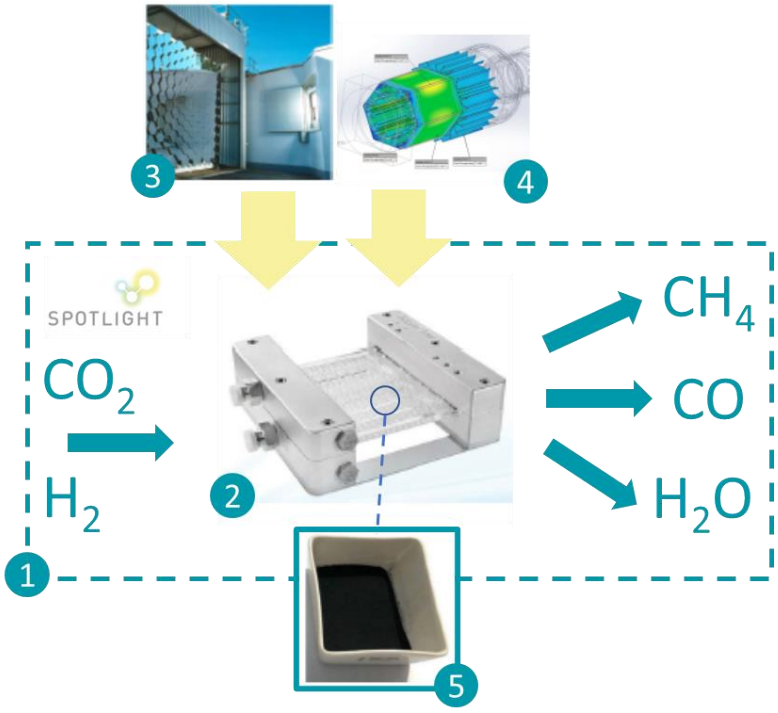

FIGURE 1: OVERVIEW OF THE SPOTLIGHT PROCESS, INCLUDING VARIOUS COMPONENTS. 1 INDICATES THE PROCESS AND ASSOCIATED REACTIONS, 2 INDICATES THE TRANSPARENT FLOW REACTOR, 3 INDICATES THE SECONDARY OPTICS, 4 THE LED LIGHT SOURCE AND 5 THE PLASMONIC CATALYST.

The various components listed below are numbered in accordance with Figure 1.

1 – The overall process. The core of the SPOTLIGHT process is related to (directly) sunlight-powered chemical reactions, namely the Sabatier reaction (Equation 1) and the rWGS (Equation 2):

$$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O \quad (1)$$

$$CO_2 + H_2 \rightarrow CO + H_2O \quad (2)$$

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In order to facilitate these reactions, reactive gasses in the form of CO_2 and H_2 should be available inside the transparent flow reactor. The targeted products CH_4 (Sabatier), CO (rWGS) and side product H_2O are a primary energy carrier or chemical, directly used for other chemical processes (intermediate product) or are to be re-used for other chemical processes, respectively.

2 – The transparent flow reactor, facilitating the targeted reactions by ensuring light is coupled into the catalyst, reactive gasses are supplied, product gasses are extracted and temperature and pressure conditions allow the plasmonic catalyst to operate at high efficiency while ensuring safety.

3 – The secondary optics are responsible to direct the solar light towards the transparent flow reactor. More specifically, the concentrated light bundle from the solar concentrator(s) is shaped to enable efficient usage of the sunlight-powered process.

4 – **The LED light** will enable the process to continue during dark or light-poor conditions. To keep the photonic catalysts efficiently high, the overall energy efficiency of the LED is required to be high.

5 – The photonic catalysts act at the core of the project, lowering the energy required to run the reactions listed (equations 1 and 2) using sunlight.

1.2. Scope and objectives

The scope of this report is to present how activities aimed at supporting the partners involved in the replicability and scale-up of the pilot-scale process have been performed, with specific reference to HS Engineering.

Specifically, a HAZOP study has been conducted, in order to identify and evaluate potential risks to personnel or equipment in FHa and ACEA feasibility studies for replication, especially on the implementation of the full-scale plant; relevant methodology is reported in the following.

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2. HAZOP METHODOLOGY

The HAZOP technique consists in a systematic analysis of the design in order to assess any operability problems or process-related hazards. The HAZOP study is developed reviewing each P&ID using a structured step by step approach that allows to comprehensively analyze the whole process via suitable guide-words, used to identify possible deviations from the intended operation.

The HAZOP study approach for the current SoW was based on internationally recognized Standards described in the publication (Ref. [1]), standardized in (Ref.[2]).

A summary flow chart of the HAZOP process is shown in the following Figure 2.

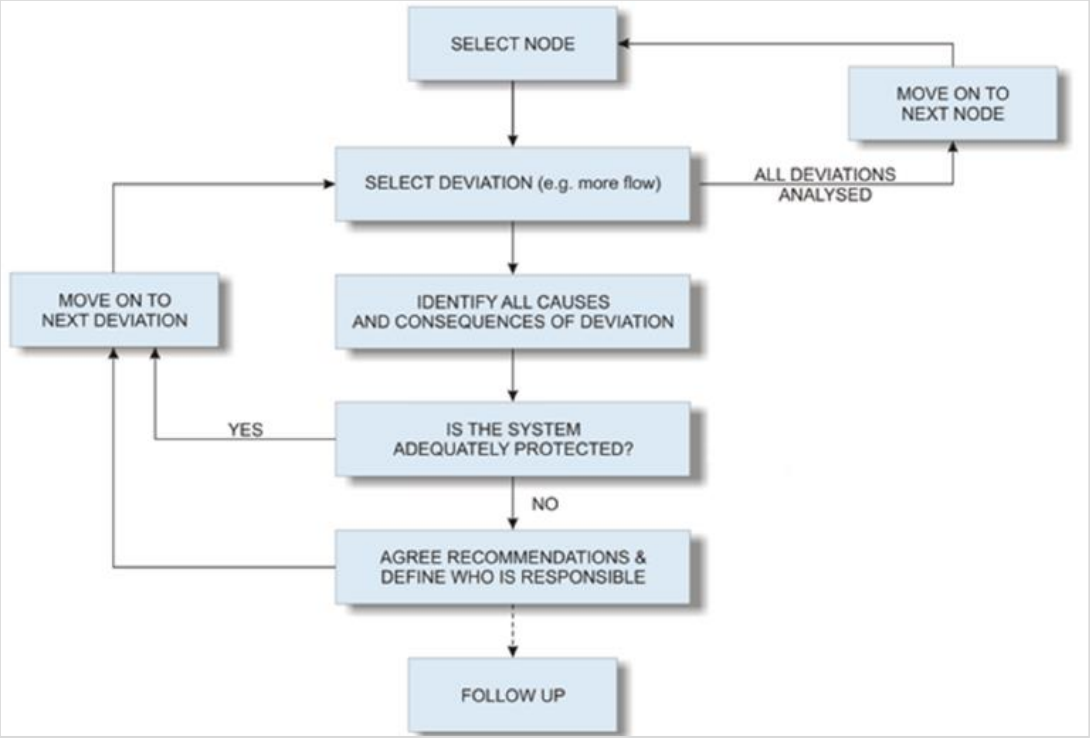

FIGURE 2: HAZOP FLOWCHART.

The first step of the analysis consists in the identification of the “nodes”. A node is a system, sub-system or portion of a system which can be analyzed by itself, together with the relevant connections to the interfaces. The totality of the nodes shall cover all the systems under analysis, without missing any portion of them, until the whole Process/Scope of Work is analyzed (identical items can be analyzed as “typical”, addressing only one of them).

Each node is reviewed by examining which deviations from normal operation can lead to undesired outcomes. All applicable deviations are examined combining appropriate guidewords to the relevant process parameters.

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The following Table 1 summarizes the main guidewords that have been applied and the typical deviations obtained combining the guidewords and the process parameters.

Table 1. HAZOP Guidewords

Parameters	Guidewords	Deviations
Flow	More	More Flow
	Less	Less Flow
Temperature	More	High temperature
	Less	Low temperature
Pressure	More	High pressure
Pressure	Less / none	Low pressure / vacuum
Utility:	No	No Utilities

For each deviation, the Review Team identifies the possible cause(s), its consequences (qualitatively) on process and operation and verifies the existence of sufficient systems of prevention, detection and correction/mitigation of the outcomes.
When deemed necessary, remedial measures have been required depending on the expected likelihood of the event and its consequences; these are recorded in the HAZOP worksheets in the form of recommendations aimed at identifying actions and at ensuring a subsequent follow-up by the project team. Each recommendation/action is assigned to a specific owner, with the Team consensus.

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3. CONCLUSIONS

RINA Consulting was appointed to perform the HAZOP (HAZard and OPerability Review) relevant to FHa and ACEA feasibility studies for replication, especially on the implementation of the full-scale plant.

In the present report, the reference methodology has been described, which has been followed during the sessions held on the 23rd of May, 2024 with both FHa and ACEA representatives.

Such sessions have identified, as a main and most significant result, that any new and/or additional risks compared to those found within the WP5 haven't been identified.

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4. REFERENCES

[1] EPSC IChemE and Chemical Industries Association, 2000, "HAZOP – Guide to best practice for the process and chemical industries";

[2] IEC 61882, 2001, Hazard and operability studies (HAZOP studies) - Application guide.

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