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608571
Project acronym:
SUCCESS
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Industrial steam generation with 100% carbon capture and insignificant efficiency penalty - scale-up of oxygen carrier for chemical-looping combustion using Environmentally sustainable materials
Collaborative project
Theme:
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Deliverable D9.8
Draft Exploitation Plan

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Table of contents

1 Introduction

Up scaling the chemical looping combustion (CLC) technology is one of the main purposes of SUCCESS. It will be demonstrated at a scale of 1 MW_{th} and research will be provided to be ready for next scale demonstration. CLC has the potential to become a major asset in the CCS technology portfolio due to the very low CO_2 avoidance costs compared to other carbon capture technologies like amine scrubbing. In the present document, exploitable foreground will be identified and planned exploitation activities will be described. Further planning beyond the project end and a structured approach of exploitation of the short- and long-term results by the project partners and stakeholders are provided in this deliverable.

2 Summary of project concept and expected impact

At the start of SUCCESS, CLC for gaseous fuels has been successfully demonstrated at small pilot scale (up to 140 kW_{th}) and for more than 1 000 hours at 10 kW_{th}. In previous EU financed projects, promising non-nickel oxygen carrier materials have been identified as potential candidates for a commercial application of the CLC process at a large scale.
The successful upscaling of chemical looping combustion mainly depends on a suitable oxygen carrier (already identified), a reactor system fulfilling the demands of end users and a competitive production process of the oxygen carrier material. The latter two are addressed in SUCCESS.
Even though CLC is a quite new process, there is a significant interest in this technology. Several organizations are planning to upscale the process to the10 MW_{th} – range mainly focusing on the reactor system. SUCCESS focuses not only on the upscaling of the CLC process on reactor design level but also on upscaling of the oxygen carrier production process, health safety and environmental implications of material handling and plant operation. Furthermore, the techno economic potential for different possible applications in industry and power production is evaluated in the project. The strength of the work done in SUCCESS is, that at the end of the project the gained knowledge is not only how to upscale the reactors, but also the commercial supply chain and the operation of large CLC systems are evaluated.

3 Estimation of market potential

Market options of carbon capture and storage (CCS) technologies are roughly estimated using CO_2 emission scenarios provided by the International Energy Agency (IEA, 2012). The predicted contribution of CCS to the total portfolio of climate mitigation options in the energy and industry sector was taken to estimate numbers for potential applications of the CLC technology.
The IEA developed three scenarios for possible CO_2 emission pathways until 2050:

- The 6 Degrees Scenario (6DS) assumes that no new policy actions addressing climate change are taken and that the energy system will continue to depend largely on fossil fuels. The 6DS predicts a global temperature rise of 6 °C.
- The 4 Degrees Scenario (4DS) assumes that there is a “concerted effort to move away from current trends and technology […] reducing both energy demand and emissions” resulting in a global temperature rise of 4 °C.
- Pursuing the 2 Degrees Scenario (2DS) results in a global temperature rise of 2 °C. Reaching this kind of goal means “cutting energy-related CO_2 emissions in half by 2050 compared to 2009”. (IPCC Fifth Assessment Report 2013, Techn. Summary Pages 35-36)

Climate research however clearly indicates that the worst consequences of climate change can with high probability only be avoided, if society succeeds to follow the 2DS scenario. Hence, this scenario will be taken as a baseline for the following discussion.

3.1 Potential in industry sector

The emissions reductions resulting from application of CCS are split about equally between power and industrial applications. The industry sector has a share about 40% of the total energy related CO_2 emissions. The total direct use of natural gas in the industry sector, including energy use, non-energy use, and gas-powered electricity, has a share of 22% of the final energy consumption (year 2009). According to the 2DS the natural gas consumption will rise until 2030 to 30% and then will stabilize, as illustrated in Figure 1. This means that it increases by 165% between 2009 and 2050. Causes are the shift from coal to natural gas in the chemicals production and in the iron and steel manufacturing, which switches away from coal-based direct reduced iron (DRI). In addition, in the aluminium production the trend to recycle material results in an increasing re-melting technology, which requires natural gas.

Besides the use as fuel, natural gas is applicable as a feedstock to produce ammonia, methanol or other hydrocarbon-based products, with a share higher than 75%. Also in the manufacturing industries like iron and steel, pulp and paper natural is included to generate heat in combustion processes.

CCS in the industrial sector mainly applies in gas processing and the production of synthetic methane.

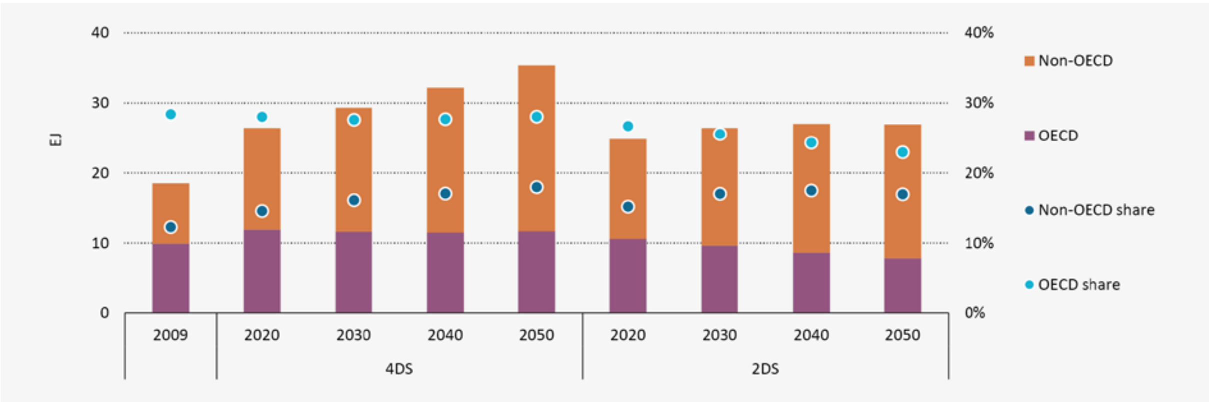

Figure 1: Final natural gas consumption in the industry sector (International Energy Agency, Energy Technology Perspective, 2012)

In Figure 2 the annual CO_2 capture rate from industrial applications of CCS is illustrated. It shows a need of over 3.5 $GtCO_2$ captured per year in the industrial sector in 2050. To reach this aim 875 CLC units would be needed to be installed with a market potential of 10 %. At the beginning of this period (2015), mainly the OECD countries capture CO_2, whereas only 10 years later the share of the non-OECD countries is much higher.

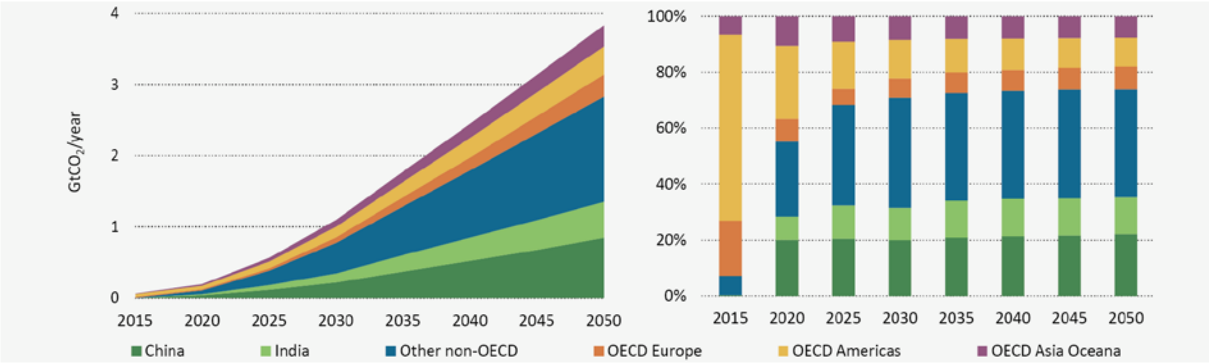

Figure 2: Annual CO_2 capture rate from industrial applications of CCS (left) and the corresponding fraction of CO_2 captured annually by region (right) (International Energy Agency, 2012)

<u>Potential of the CLC technology</u>
The CLC technology is still at research stage but has high potential as carbon capture technology. During the SUCCESS project the TRL will be raised from 4 to a solid 5.
CLC has unique potential for reducing energy and cost penalty for CO_2 capture, as it avoids the costly gas separation of other CO_2 capture technologies. Early deployment is seen in natural gas steam generation, where gas-to-steam efficiency penalty with CLC is below 1%-point compared to 15%-points with amine scrubbing and 8%-points with oxyfuel combustion, all for 95% capture rate. Reduction of the CO_2 avoidance cost of 60% compared to amine scrubbing post combustion capture results from higher efficiency.

Table 1: Model Calculation for CCS market potential in industrial sector

Industry Sector		
CO_2 to be captured in industry by 2050 in the 2DS	>3.5	$GtCO_2$/yr
Assumed market share of proposed CO_2 capture technology	10%	
Resulting number of sold CCS units with CLC	875	
Total CCS units sold	883	

Literature
International Energy Agency. (2010). World Energy Outlook.
International Energy Agency. (2012). Energy Technology Perspectives.
International Panel on Climate Change. (2013). Fifth Assessment Report, Techn. Summary.
M. Odenberger, J. K. (2013). Prospects for CCS in the EU Energy Roadmap to 2050. Energy Procedia 37.

4 SWOT-Analysis for the exploitation of SUCCESS

A SWOT analysis has been carried out (compare Table 1) to get a better understanding of possible complications during the project, with influence on the exploitation strategy. It should be a tool to call the attention to problems during the project runtime, covered in the Weaknesses and Threats section. It should allow a timely correction of the exploitation strategy. Further the SWOT analysis should also highlight the intended focus of the exploitation, covered in the Strengths and Opportunities section.

Table 1: SWOT analysis

Strenghts: - SUCCESS consortium unites major parties of the CLC community in Europe - LCA carried out during SUCCESS. - HSE study carried out and can be used as basis for future REACH approval process	Weaknesses: - First time of large scale oxygen carrier production. - No existing market for CLC process - No existing market for oxygen carriers
Opportunities: - The consortium has the chance to be first in production of large scale synthetic oxygen carrier - Development of standards for the commercial CLC process can be defined. - LOI for possible cooperation with CENOVUS.	Threats: - Interest in CCS will drop due to public concerns and economic interests - It turns out that upscaling of oxygen carrier production is not finished within SUCCESS - It turns out that CLC is not competitive with other capture technologies

5 Exploitation strategy

The exploitation of results and gained knowledge in SUCCESS is an important part of the implementation of the project to provide an ongoing process of research and foreground. It should become accessible to end-users such as (other) companies and research institutes.

On partner level mainly exploitation of results from activities in the work packages is possible. In most cases the outcome is tightly linked with the CLC process but also more general knowledge and skills have been developed. Some highlights are: optimized production methods for oxygen carrier materials and the development of a method to analyze particle attrition under hot conditions.

The main focus of SUCCESS lies on upscaling of the CLC process and the demonstration of its readiness for commercialization. Exploitation activities on project level are based on getting in touch with potential end users and the whole supply chain (raw material suppliers, particle – and boiler – manufacturers).

During the proposal phase of SUCCESS, the consortium had contact with CENOVUS, a Canadian oil company. The corporation planned to build a 10 MW gas fired CLC demo plant and issued a LOI for a possible collaboration with the SUCCESS consortium. It is planned to produce and test one oxygen carrier material in the 10 MW CLC demo plant. CENOVUS would be one recipient of the offers for the production of 50 t of oxygen carrier, issued at the end of SUCCESS.

5.1 Management of knowledge and intellectual property rights

The management of knowledge and intellectual property rights is regulated by the Consortium agreement, a contract between all parties in the SUCCESS consortium.

6 Exploitation activities

In SUCCESS not only industrial but also academic partners are involved. Both partner types have different opportunities of exploitation activities. Aim of each exploitation strategy however is to promote the created results outside the project.

Figure 3 illustrates the general structure of exploitation activities. It shows different paths for the industrial and academic project partners as another audience is addressed. Different exploitation types can be identified depending on the research results of the project and the time frame. Some use direct technical improvements having usually an immediate impact in a short period of time. On the contrary some exploitation activities have long-term effects to develop strategic guidelines. The activities can be directed internally or externally of the project partners. In contrast to the internal exploitation activities are external activities promoted to the outside the project (standardizations). Internal activities are only addressed to other project partner.

The exploitation activities will be summarized in Deliverable D9.9 at the end of the project.

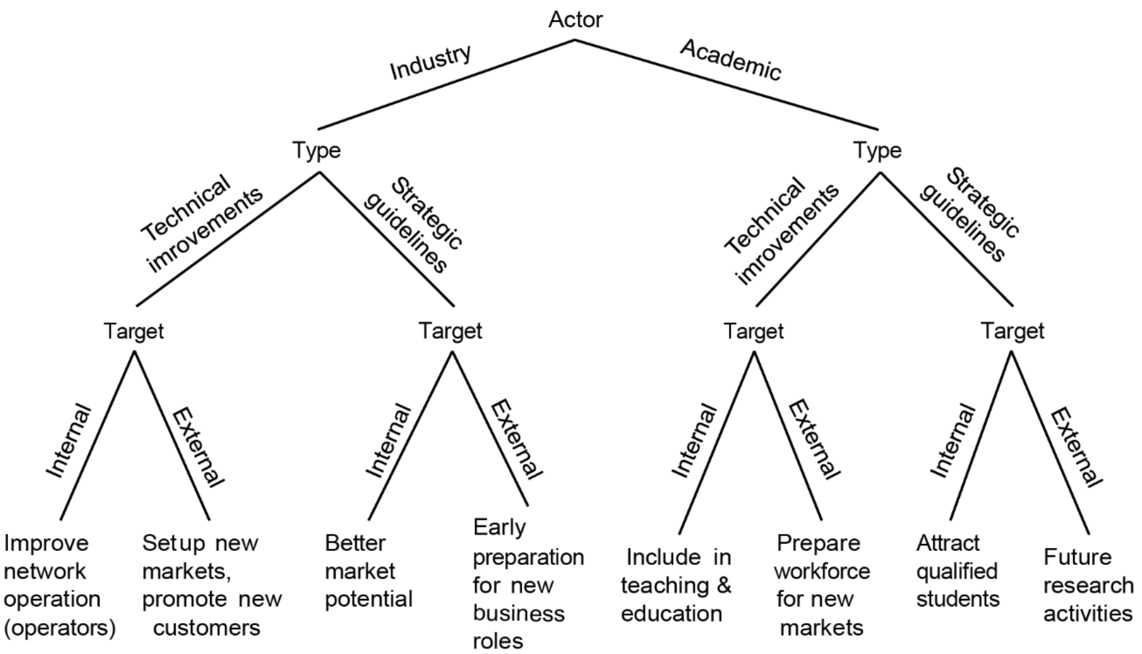

Figure 3: Exploitation activity structure