14th International Conference on Greenhouse Gas Control Technologies, GHGT-14

21st -25th October 2018, Melbourne, Australia

Profiting from CCS innovations:
A study to measure potential value creation from CCS research and development

Sigmund Ø. Størset[a,*], Grethe Tangen[b]

[a] *SINTEF Energy Research, Box 4761 Torgarden, 7465 Trondheim, Norway*
[b] *SINTEF Industry, Box 4760 Torgarden, 7465 Trondheim, Norway*

Extended abstract

Summary

Globally, large private and public budgets are invested into carbon capture and storage (CCS) research to provide the knowledge and technology required to mitigate CO_2 emissions below a sustainable level. A pertinent question to ask is whether this is the best way of spending limited funds? This paper presents an ongoing study aiming to document the potential value creation from selected CCS innovations created in the international research centre BIGCCS and its successor NCCS. The results indicate that the potential profits by far exceed the investment.

Introduction

Over time, it has been shown that companies collaborating with academic institutions have a superior output of new innovations, compared to those operating only within their own organisation [1], [2]. However, to release the full potential of university-industry cooperation it is important to identify how the scope of research is adapted to meet the industries' future needs, how the research is kept relevant despite changing and uncertain conditions, and how the research results can be transferred to the industries for them to utilize the takeaways [3]. These aspects are highly relevant for research within CCS technologies, as much of the research efforts currently are performed under collaborative schemes such as EU's framework programme for research and innovation, Horizon2020, and national funding schemes for research centres. For many business areas, effects of research can be documented based on assessment of actual commercial value and profits from implementation of technology. Furthermore, future potentials can be predicted based on known reference and business scenarios. The lack of a commercial market for CCS makes it more challenging to predict upcoming business opportunities and thus assess the value of scientific and technological progress. Nevertheless, to motivate continued investments in research critical for future sustainable energy solutions, it is essential to document the anticipated commercial value of future deployment of CCS technology.

* *Corresponding author. Tel.: +47 98611167*
E-mail address: Sigmund.Storset@sintef.no

In this study, we are investigating the potential value creation from application of innovations created in a major CCS research centre; The BIGCCS International CCS Research Centre [4]. BIGCCS was mainly funded by the Research Council of Norway and participating industry partners. It was led by the Norwegian research institute SINTEF. The centre operated between 2009 and 2017 and had a cumulated budget of more than 500 kNOK (or about 50 kEUR). During the centre lifetime 46 new innovations emerged [5], and several of them are further developed in the research centre succeeding BIGCCS; the Norwegian CCS Research Centre NCCS [6]. If large scale deployment of CCS becomes a reality the innovations are anticipated to represent a significant value creation potential for the centre's industry partners, as well as other commercial CCS actors. By addressing value creation from specific technologies, the presented work complements another study addressing industrial opportunities and employment prospects in large scale CO_2 management in Norway [7].

Measuring value creation

An overall ambition of the study is to illustrate the impact of BIGCCS research and innovations by as far as possible quantifying the potential value creation, in terms of actual Euros or Dollars. Given the nature of the task the calculations must be based on a set of assumptions such as future deployment of CCS and implementation of the technologies in question. It is therefore essential that the reasoning is transparent, and all assumptions are explicit.

After screening the 46 reported innovations, six were selected to be included in the study. These innovations comprise technologies and methods covering the whole chain, and the potential for value creation is being assessed for each innovation. For a power producer or energy intensive industry actor, CCS is first and foremost an enabler of more sustainable products (i.e. with a lower carbon footprint), and CCS comes with a certain investment and operational cost. However, these investments are expected to be necessary for maintaining a competitive industry. When estimating the potential value creation for innovations within CCS technologies, it is usually more relevant to consider *reduced investment or operational expenses*, rather than increased revenues. Consequently, for the six innovations, we established the value creation potential using one or several of the following principles:

- Lower investment costs compared to reference because of new or improved technology.
- New technologies or methods making investment obsolete (i.e. enabling reuse of existing technologies)
- Lower heat or electricity consumption compared to reference because of new or improved technology.
- New technologies or methods drastically reducing other operational costs compared to reference.

The six innovations included in the study are:

1. **Capture and liquefaction of CO_2 for ship transport**: A new concept for low temperature liquefaction and separation of CO_2 for producing H_2 from natural gas is developed. If successfully implemented it is anticipated that the innovation has a potential for reducing energy cost by 30-40%.
2. **Chemical looping combustion (CLC) for cost efficient CO_2 capture from biorefineries**: CLC research has focused on advancing and validating chemical looping combustion for CO_2 capture at industry scale. The purpose it to bring down capture costs, which represent a major cost component of the CCS chain. Used in biorefineries globally, CLC can enable negative emissions, i.e. net reduction of CO_2 in the carbon budget.
3. **Preventing running ductile fractures in CO_2 pipelines:** Advanced simulation models to predict whether a pipeline crack or damage can develop to a running fracture are developed. Such tools make it possible to avoid costs due to fracture event. It also allows more cost-efficient design. E.g. preliminary calculations indicate that reduced design margins could save 250 million NOK (25 million €) for 500 km pipelines due to reduced steel for production. Finally, new methods enable the qualification of existing natural gas pipelines for CO_2 transport. By converting natural gas pipelines to CO_2 infrastructure large investments are avoided.
4. **Cost-efficient methods for geophysical monitoring:** The innovation comprises results from longstanding research on integrated methods for accurate monitoring at lowest possible cost to underpin operational decisions for safe CO_2 injection and storage. Initial assessments indicate that new methods can reduced the

need for collecting geophysical data over the site lifetime by 50 % and enable up to 30 % reduced costs related to unforeseen events.

5. **Improved integrity over the lifetime for CO_2 wells:** Improved cementing, optimal placement of well and safe plugging and abandonment will reduce leakage risks and ensure longer operating time for wells. A portfolio of research activities has resulted in knowledge and methods that makes is possible to avoid a significant share of maintenance costs and to reduce investments, enabling more safe and cost-efficient CCS.
6. **Smart design of CCS chains:** A new tool is developed for transparent, consistent and holistic optimisation of CCS chain design, taking technology, economy and environment into account. Initial analysis conducted by the research team indicates that optimal design may reduce overall costs of a CCS chain by 10%.

By using a simplified approach, a value of Euros saved or earned per unit of CO_2, per reservoir, per CO_2 well, per CCS chain etc. can be estimated. These values can then be applied in a conservative scenario for CCS deployment in Europe, in a time perspective from today and until 2050. The scenario for this study is constructed based on IEA's 2-degree scenario in which there is a 50% probability of limiting global warming to 2 degrees. The scenario implies annual capture and storage of 320 million tonnes CO_2 from European industry and power sources. For each innovation, assumed *applicability* (e.g. the innovation is applicable for 10% of emission sources in Europe) and *deployment* (e.g. the innovation is used for 10% of the emission sources it is applicable for) within the scenario are estimated.

The paper will present the main scientific contributions of the selected BIGCCS innovations, clarify key assumptions and discuss the value creation potential based on the estimated earned or saved value. Also, the paper will show how successful large-scale deployment of the new methods and technologies within the frames of the 2050 scenario contributes to overall potential commercial value. Additional qualitative effects such as improved storage safety and spill-over effects to other business areas are not included. Nevertheless, the preliminary analysis shows that the estimated potential value creation by far exceeds the 50 million € investments in the research leading to the innovations. Therefore, the conclusion so far is that if the international community maintains the ambitions to significantly reduce the global CO_2 emissions, CCS research and development is a valuable investment that can enable sustainable power and energy intensive industry while securing the profitability of the businesses.

Acknowledgements

This publication has been produced with support from the NCCS Centre, performed under the Norwegian research program Centres for Environment-friendly Energy Research (FME). The authors acknowledge the following partners for their contributions: Aker Solutions, ANSALDO Energia, CoorsTek Membrane Sciences, Gassco, KROHNE, Larvik Shipping, Norcem, Norwegian Oil and Gas, Quad Geometrics, Shell, Statoil, TOTAL, and the Research Council of Norway (257579/E20).

References

[1] Nieto, M. J. & Santamaría, L. (2007). The importance of diverse collaborative networks for the novelty of product innovation. Technovation, 27(6), 367-377.

[2] Fabrizio, K. R. (2009). Absorptive capacity and the search for innovation. Research Policy, 38(2), 255-267.

[3] Adler, N., Elmquist, M. & Norrgren, F. (2009). The challenge of managing boundary-spanning research activities: Experiences from the Swedish context. Research Policy, 38(7), 1136-1149.

[4] Mølnvik, M. J., Aarlien, R., Henriksen, P. P., Munkejord, S. T., Tangen, G. & Jakobsen, J. P. (2016). BIGCCS Innovations – Measures to Accelerate CCS Deployment. Energy Procedia, 86, 79-89.

[5] BIGCCS Final Report, 2017. Available from *https://434113txicu25pflj3lqxy8nen-wpengine.netdna-ssl.com/wp-content/uploads/2017/12/bigccs-final-report_16_11_hr.pdf*

[6] NCCS - Norwegian CCS Research Centre. Official web page *https://www.sintef.no/nccs*

[7] Størset, S.Ø., Tangen, G., Wolfgang, O., Sand, G. (2018). Industrial opportunities and employment prospects in large-scale CO2 management in Norway. SINTEF Report 2018:0594. ISBN 78-82-14-6865-8.