Grant agreement No. 764810

Science for Clean Energy

H2020-LCE-2017-RES-CCS-RIA
Competitive low-carbon energy

D9.4
Action Plan for Succession

WP 9 – Dissemination, Innovation & Exploitation

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History of the changes

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1.2	12-11-2020	Adrian Jones (UCL)	Final edits
2.0	13-11-2020	Coline Morin (UCL)	Final version

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1 Introduction

Throughout the development of a comprehensive approach towards ensuring that the future development of sustainable sub-surface energy operations in Europe may proceed with limited, if any, environmental footprint, S4CE believes to have had a direct quantifiable positive impact on European technology as well as on the support of the future skilled workforce.

S4CE has contributed to the expansion of SMEs and also supported two start-up companies during the project duration. Therefore, S4CE has supported the foundation, via concrete actions, for the European geo-energy sector to contribute reaching the Paris Agreement objectives.

As it is recognised that a 40 months project will not be sufficient to lead to sustained changes and to a sustainable energy future, S4CE set the goal of training the next generation of geo-energy scientists, which was likely to yield the most positive long-term impact. S4CE also considered the possibility of further developing the technologies and the scientific discoveries enabled by the consortium via follow-up research partnerships.

The scope of Deliverable 9.4 is to summarise the actions we undertook and those we have planned, to further the reaches of the consortium into the future.

1.1 General context

S4CE strongly committed to training the next generation of scientists, who will be in charge of the sustainable deployment of geo-energy operations in the years to come. S4CE developed and expanded programs to train the future experts in the sustainable deployment of geo-energy. Target groups of these initiatives included students of all ages, from pre-university to post-doctoral researchers.

The S4CE was convinced that multi-disciplinary collaboration is essential for reducing the environmental impact of geo-energy operations. Thus, the consortium established and maintained effective networks of collaborations across countries, across disciplines and across industrial sectors. The Exploitation and Innovation Advisory Board was instrumental for identifying new opportunities for enhancing the positive impact of S4CE along the directions of a sustainable future, and the members of the External Scientific Advisory Board were very effective at identifying possible new research directions, as well as synergistic research activities conducted elsewhere. The whole consortium benefitted from the support and dedication of the board members throughout the lifespan of the project.

The S4CE project brought together a wide group of leading experts to focus on real problems selected to identify the best ways to secure sustainable low carbon energy supply. Our R&D activities span across the traditional academic silos and allowed us to establish a transformative and refreshing experience for all involved, but especially for Early Career Researchers.

1.2 Deliverable objectives

This report seeks to document suggestions and actions we implemented for continuing the scientific operations enabled by the S4CE consortium within and beyond the scopes of Horizon 2020.

2 S4CE structure – Securing an action plan for succession

To secure long-lasting positive impact, the main tools were (1) to train the next generation of geo-energy scientists, and (2) to develop new technologies, which could be further improved and deployed in the future.

2.1 Training programme

S4CE delivered a long-lasting training program, building on the masters' program 'Global Management of Natural Resources' at the Department of Chemical Engineering at University College London (UCL)[1].

The program was launched for the 2016-2017 and started with 11 students enrolled. For the 2020-2021 academic year, 46 students are enrolled, which demonstrates the attractiveness of the program. Indeed, thanks to S4CE, this training program now includes Carbon Capture and Storage (CCS) and enhanced geothermal (EGT) among the topics covered, with expert lectures provided by the industrial partners of S4CE.

The program is now a legacy of S4CE, as it will remain an official program offered and available to students throughout Europe well beyond the end of the consortium.

The S4CE consortium developed and operated a series of Summer Schools to train post-graduate researchers across Europe. Information on the Summer Schools is provided in another Deliverable (D9.1).

In addition, the Early Career Researchers involved in the project were provided with cross-disciplinary and transferable training, including a workshop on proposal writing (enabling them to target future grant applications) and another one on career progression. These are described in Section 3.3 below.

2.2 Exploitation and Innovation Advisory Board (EIB)

Throughout the project, the EIB advised S4CE partners on how to maintain the fundamental research conducted within the consortium within the realm of practical interest. The EIB members participated to S4CE consortium meeting to monitor and evaluate the project's activities. After each consortium meetings, EIB members provided recommendations for the consortium to reach its objectives.

[1] http://www.ucl.ac.uk/chemeng/prospective-students/postgraduate-taught/msc-global-management/

The EIB also provided the opportunity to strengthen the relationships between the consortium and industry. For example, S4CE managed to invite two representatives of the North American industry, explicitly Erik Nickel (Petroleum Technology Research Centre and Fabio Ribeiro (Purdue University and CISTAR) speakers at the S4CE Forum organised at the Geological Society of London on the 4th of November 2019.

The EIB helped identify some fundamental discoveries that could provide commercial benefit in the future. For example, UCL Earth Sciences developed a technique to quantify the amount of gas that could be stored in unconventional formations. Possible applications range from unconventional hydrocarbon production to carbon sequestration. It is not up to the academic partners to take these suggestions further but could be developed with the support of UCL Business if required.

Additional practical innovations allowed S4CE's industrial partners (e.g., MIRICO, Haelixa) to improve their products, and others (e.g., TWI, Q-CON) to improve the knowhow needed to provide expert opinion when required. The fundamental research conducted in some of the field sites (e.g., Cornwall and Iceland) will likely result in more environmentally friendly operations in the future.

These are a few examples of the legacy due to the S4CE consortium, which will have positive impact for many years to come in Europe~~,~~ and beyond.

3 Activities to secure the future of clean geo-energy operations

3.1 Field sites assessment

The S4CE partners accessed the scientific field sites to further build their legacy. The practical activities are described within the deliverables of Work Package 7. Permanently instrumented field sites will ensure in particular that micro-seismicity, stray gas emissions, water quality, and local environmental impacts will be able to be monitored during ~~the~~ future operations. Data obtained before the operations will also serve as a strategic multidisciplinary baseline.

3.2 S4CE Technologies and Models

The development of new technologies as well as new models is an impressive strength of S4CE, promising to extend world-first levels of sophistication to difficult problems. The synergistic and highly transformative approach implemented by the S4CE consortium in developing new technologies is of high value to the long-term sustainable energy future of Europe. The specifics of the new technologies developed are presented within the deliverables of Work Packages WP4, WP5 and WP6. It should be pointed out that the collaboration among different groups and between different disciplines was instrumental for achieving the successful breakthroughs pioneered by this consortium.

To ensure visibility of the technologies developed, a new page has been created on the website to highlight these results[2] towards the end of the project. Additionally, an animated video "Towards sustainable geo-energy operations" explaining how the technologies operate for a sustainable future has been created and shared to the S4CE network[3].

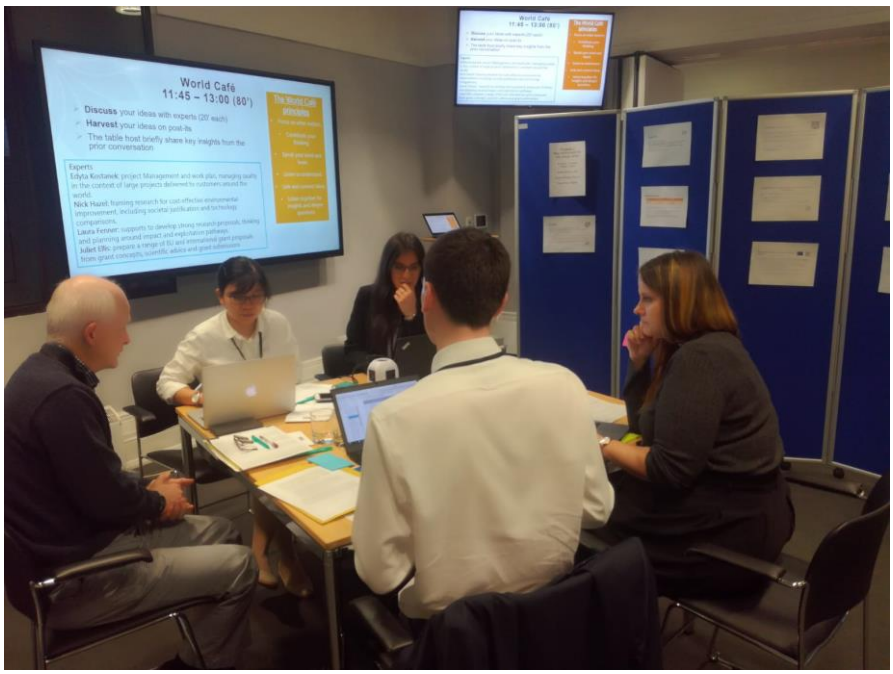
These new technologies and models are frequently featured in our dissemination material, including posters, electronic newsletters, etc. This visibility will likely result in future support for the further development and enable future deployment of such innovations.

3.3 ECRs Workshop – Proposal writing for clean energy

Specific attention was given to training and empowering the Early Career Researchers (ECRs) involved in R&D activities for the sub-surface geo-energy sector.

In line with the objectives of preparing the scientific workforce of tomorrow, S4CE put the ECRs in charge of organising a consortium meeting, in which the main goal was to empower our junior colleagues for entertaining successful careers in science. This workshop, organised in London on the 30th of January 2020 at the Wellcome Trust in London, aimed to provide the ECRs with project management and career development skills.

During this one-day workshop, fourteen participants learned about structuring and writing a grant proposal and how to develop project management competences. They also had the opportunity to learn how to promote themselves and their work, as the future generation of scientists in the geo-energy energy sector.



[2] http://science4cleanenergy.eu/about/technologies/
[3] http://science4cleanenergy.eu/new-video-towards-sustainable-geo-energy-operations-2/.

The ECRs worked together in groups, and a selection of four experts in proposal writing and geo-energy spent 20 minutes with each group on a rotating basis to discuss the proposal according to their own expertise.
The experts were UCL professionals:

- Edyta Kostanek, Teaching Fellow in Project Management, School of Management, Faculty of Engineering,
- Dr. Nick Hazel, RAEng Visiting Professor, Department of Chemical Engineering,
- Dr. Laura Fenner, Senior School Research Facilitator for the BEAMS School,
- Dr. Juliet Ellis, Proposal Manager, European Research & Innovation Office

A talented multi-disciplinary and diverse group of 14 ECRs (8 females and 6 males) took on the challenge and collaborated forming four groups to brainstorm and propose new research ideas. They were asked to go through all the main stages of proposal preparation, had the chance to discuss with the four experts, and prepared a 'sales pitch'. Each group had 20 min discussions with each expert, followed by 1-hour to prepare their presentations, and finally pitching their proposals to a panel of experts in 15 minutes.

What proposals ideas did the ECRs pitched?

- Securing societal progress while reducing environmental impact. This group proposed the project "Science for Clean Air". Carbon mineralisation is a novel technology for the permanent storage of CO2. This group aimed to identify the most suitable CO2 injection locations (with the highest impact) for the initial deployment of the technology. This project idea is actually the continuity of S4CE
- Public acceptance of geologic operations. The second group developed an educational/dissemination project, titled "Geo Education Objectives" (GEO). The ambition was to create a protocol to educate the general public regarding the perception of risks related to operations concerning the exploitation of geo-energy resources.
- New technologies for the energy sector. This group proposed a project to develop a novel state-of-the-art machine learning algorithm to optimize site operations and minimize risks, leading to an increase in technologic and economic feasibility of subsurface operations.
- The life-energy-geology nexus: what opportunities lie ahead? The final proposal pitched tackled the clean extraction of rare earth elements from geothermal wastewater by making the most of the already-existing processes in geothermal exploitation.

The proposal on "New technologies for the energy sector" gave an excellent presentation describing an ambitious, innovative and detailed project plan. The group of four ECRs were awarded the early bird registration to the Goldschmidt Conference 2020, that was part of S4CE's dissemination activities, and a travel grant to Hawaii (USA), where the conference was supposed to take place. However, due to the Covid-19 outbreak, the ECRs interested participated online. They facilitated a session on "Mitigating Environmental Impacts: Carbon Capture, Utilization, and Storage (CCUS) and Novel Approaches in the Geo-Energy Sector",

and six S4CE abstracts were submitted[4]. With 40 registered participants and over 60 people giving their time and resources to attend and contribute with outstanding work and that made our session a total success.

3.4 Action plan for the future

During the online 3rd Annual Consortium Meeting (3rd – 5th June 2020), Work Package Leaders were asked to focus on each WP achievements and results, and to share their views on an "action plan for the future". We summarise below the ideas put forward during that virtual meeting.

Work Package 2 – Ethical Oversight
Action Plan for the Future:

- Promote the methodology for a more systematic use and thus pave the way for these approaches in relation to subsurface engineering.

Work Package 3 – Instruments and tools development
Action Plan for the Future:

- Continuing the scientific operations enabled by the S4CE consortium within the scope of Horizon 2020
- Large scale application of DNA tracers in industrial facilities
- Further development of DNA particle platform (Biodegradability, Functionalization, DNA loading efficiency)
- Use of pressurized rock system to study CO2 injection reservoir
- Large spatial and temporal deployment of gas isotopic analysis for sub-surface geochemistry. Model constrain and validation. Automated monitoring of fixation process for example (CCS).
- Isotopic sniffers to discriminate atmospheric CO2 from reservoir leakage (CCS)
- Long-term continuous automated deployment of gas mapping systems
- Development of enhanced computational methods for gas emission tomography (maintenance, leakage, quantification of CCS, geothermal, O&G …)

Work Package 6 - Implementation of Novel Technologies
Action Plan for the Future:

- Study from various standpoints the development of fracture networks resulting from pressurized fluid injections at depth are a pioneer and will be continued after termination of S4CE.
- This will determine the relationships between parameters of injection and fracture network developments, allowing more accurate assessments of the hazards related to the undesired development of fluid migration pathways (either seismic or hydraulic) and their mitigation.
- This will be beneficial for the safety of people and the environment in the areas at hazard as well as for the economic viability of these projects.

[4] http://science4cleanenergy.eu/s4ce-and-goldschmidt-2020-a-successful-virtual-session/

Work Package 8 - International Cooperation and Policy Recommendations
Action Plan for the Future:

- Virtual site visits/meetings
- Failure modes, effects, and criticality analysis (FMECA), Features, events and processes (FEPs) , Fault tree
- Actively seek new relevant collaborative opportunities

Work Package 9 – Dissemination, Innovation and Exploitation
Action Plan for the Future: 4 proposals from our ECRs workshop (January 2020)

- "Securing societal progress while reducing environmental impact"
- "Public acceptance of geological operations"
- "New technologies for the energy sector"
- "The life-energy-geology nexus: what opportunities lie ahead?" The ECRs who work on this proposal presented their idea to the rest of the consortium during the Consortium Meeting, asking for advice to identify the right call, the budget needed and declaration of interest from partners.
  - Tackle the clean extraction of rare earth elements from geothermal waste water by making the most of the already-existing processes in geothermal exploitation
  - Objectives:
    - Identifying Rare Earth Elements in geothermal fluids at different sites
    - Developing an economically viable way to separate these elements from the waters
    - Understanding the fluid-rock interaction in the geothermal reservoir

These ideas could seed future research consortia. S4CE wishes best of success to the partners in pursuing these exciting opportunities.

3.5 New H2020 Proposals

Towards the end of the S4CE lifespan, the H2020 research and innovation programme has a call for proposal under the work programme LC-SC3-NZE-6-2020: Geological Storage Pilots with the call on "building a low-carbon, climate resilient future: secure, clean and efficient energy" (h2020-lc-sc3-2018-2019-2020).

The S4CE management did not think this call was consistent with all the R&D activities conducted within the consortium, and therefore a comprehensive consortium to continue the S4CE activities was not submitted. However, a few S4CE partners identified the attractiveness of the call for proposal, especially because of the urgent need of implementing geological carbon sequestration at the large scale. S4CE partners participated to at least 2 consortia, one focused on the use of nearly depleted hydrocarbon reservoirs, and the other focused on the possibility of achieving large scale carbon mineralization. We wish luck to the S4CE partners involved in these proposed consortia. It is likely that the collaborations established within the S4CE consortium will leverage future collaborations in the sub-surface geo-energy sector.

4 Future steps

S4CE is soon coming to an end. The partners will continue to consider possible collaborative projects. At the moment, the H2020 'Green Deal' initiative seems promising. In fact, the Work Package Leaders discussed the Green Deal Initiatives during their monthly meeting in October 2020. Notably, UCL's European support office is organising a series of webinars to inform the UCL academics about the Green Deal calls in Horizon 2020. Other initiatives that are aligned with the S4CE project include the Accelerated CCS Technologies, in its 3rd call, and the future Innovative Training Networks. The ability of UK scientists and institutions to participate to these, and other initiatives in the future will certainly depend on the agreements achieved between the EU and the UK in regard to Brexit. We remain cautiously optimistic in this very uncertain period.