GEORG – Geothermal Research Cluster cooperation Joint Effort in Geothermal Energy Research

Hjalti P. Ingólfsson[1], Alicja W. Stokłosa[1], Magnus T. Gudmundsson[2], Rúnar Unnthórsson[2], Einar J. Ásbjörnsson [3], Steinunn Hauksdóttir[4], Bjarni Pálsson[5], Oddur B. Björnsson[6], Ernst Huenges [7], Sigurdur M. Gardarsson[2].

[1] GEORG, Grensasvegur 9, 108 Reykjavik, Iceland

[2] University of Iceland, Sæmundargata 2, 107 Reykjavik, Iceland

[3] Reykjavik University, Menntavegur 1, 101 Reykjavik, Iceland

[4] ISOR, Grensasvegur 9, 108 Reykjavik, Iceland

[5] Landsvirkjun, Haaleitisbraut 68, 103 Reykjavik, Iceland

[6] Verkis,Ofanleiti 2, 103 Reykjavik, Iceland

[7] Helmholtz Centre Potsdam, GFZ, Telegrafenberg, 14473 Potsdam, Germany

hpi@georg.cluster.is

Keywords: Geothermal, cluster, research synergy

ABSTRACT

GEORG is a research cluster cooperation based in Iceland and consists of 22 partners. GEORG was founded early 2009 with a grant from the Science and Technology Policy Council in Iceland through their Centres of Excellence and Research Clusters – program. It combines all the main educational and research organizations, energy companies, engineering firms and start-ups in Iceland as well as their key international collaborators in the geothermal science and utilization. The cooperation creates a platform for universities, scientific institutions, geothermal power companies and engineering consultancies to join forces with the aim to strengthen research and development of innovations in the field of geothermal energy. The cooperation of GEORG is based on four operational pillars: Support for Geothermal Research Projects; Service to Cluster Participants; Grant Application Support for Participants; and Promotion and Dissemination. The long term vision of GEORG is to be a sustainable cluster with clear value addition for the cluster participants and thereby strengthening the geothermal community for the benefit of the society.

1. INTRODUCTION

In 2009 the Science and Technology Policy Council of Iceland initiated an application process for Centres of Excellence and Research Clusters program. The process was open to all fields and was in two steps. Out of roughly 70 applications in the first step, ten were selected for second round. GEORG, which is an acronym for GEOthermal Research Group, was selected as the top program and the cluster initiative was subsequently formally established in April 2009. The grant amounted to €0.5 million (70 million ISK) per year for seven years (total of €3.5 million) which is the largest grant ever awarded to a single project in Iceland. The grant period ended formally on in March 2016 and today GEORG is operated as a non-profit association built on the firm grounds of its significant accomplishments.

The selection of GEORG by the Science and Technology Policy Council of Iceland was twofold. Firstly, it acknowledges the important role the geothermal sector has provided in the progress of the Icelandic society, which is e.g. evident by the energy transition from oil and goal based society to renewable energies as is shown in Figure 1. Secondly, the decision also influenced by the great challenges from climate change that necessitates the need for further development in the geothermal field, so geothermal energy can continue to contribute to the solution to the problems created by climate change. The objectives of GEORG are to:

• Reduce worldwide GHG emission worldwide by contributing to significant increase in sustainable energy production/utilization from geothermal sources

• Make Iceland a case study for near energy independent and carbon neutral society

• Create a platform for entrepreneurship and export of geothermal energy resources and education, both for partners in the group and in the ensuing creative

environment established through its national and international operations

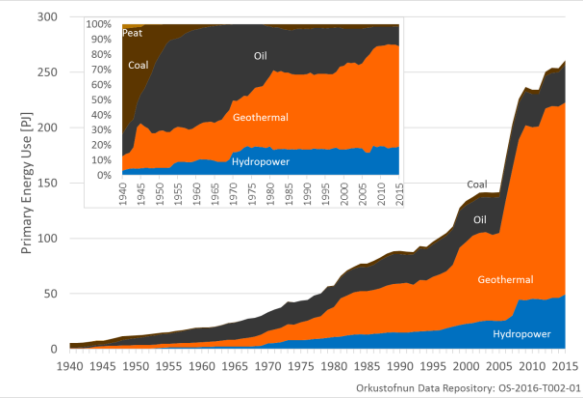

Figure 1: Energy use in Iceland by source (Orkustofnun, 2015).

GEORG is a good entry point for those who have interests in the geothermal sector in Iceland and it has made an early progress in establishing a Knowledge Hub. Within GEORG there are close interactions between academia and industry, which have contributed to better cooperation within industries as well as within the academic sector. The GEORG cooperation has focused on furthering interdisciplinary collaborations, such as with partners from socio-economic disciplines. On the international level, many well regarded foreign partners have been involved in GEORG projects, which have resulted in closer and more comprehensive collaborations.

GEORG is an excellent forum for stimulating R&D in the geothermal sector. It brings together key researchers from academia and members of industry. GEORG has supported and initiated many industries driven project which have provided support for a large number of graduate students. In addition, GEORG has provided several conference travel funds for graduate students, including for the annual European Geothermal PhD day.

One of GEORG‘s goals is to create a platform for entrepreneurship. In that spirit GEORG is a proud founder of the business accelerator program Startup Energy Reykjavik (SER), together with Landsvirkjun (National Power Company of Iceland), Arion Bank and Innovation Centre Iceland. Startup Energy Reykjavik is a mentorship-driven seed stage investment program with focus on energy related business ideas. In the program selected teams receive up to USD 40,000 in seed funding, outstanding working facility, ten weeks of intensive top-notch mentorship and the chance to pitch to angel investors and venture capitalists at the end of the program.

The partnership of GEORG creates a critical mass of joint resources and efforts to break through existing scientific and technical barriers to innovation in the field of geothermal. GEORG aims to significantly increase the number of qualified experts in geothermal research, engineering, design and technical exploitation of the resource with. This is done by emphasizing strongly on supporting young scientists and by that bridge the emerging generation gap in this area. GEORG creates synergy effects by combining different research aims of academic and industry partners and by joining relevant activities where operational effectiveness is enhanced.

GEORG strongly promotes international research collaboration by taking active part in promoting geothermal research within the European research agenda through its partnership in the European Commission’s Energy Committees and other policy related activities.

The GEORG group conducts research actions and projects, linking them in a managed manner with international or national groups capable of exploiting results through innovation and business development, to maximize possible return on investment in research in joint programmes of the partners.

1.2 Operational Structure

GEORG operation is based on four key focus areas as shown in Figure 2. These four key areas are further defined as:

Support for Geothermal Research Projects. GEORG assigned most of its funding budget to support and lubricate cooperation on research projects related to geothermal energy.

Figure 2: Operational structure of GEORG.

Service to Cluster Participants. The most important service of GEORG is to provide a platform to link different disciplines and between academia and industry. This is done through match-making, contact sharing, knowledge sharing among partners, training organisations, seminars and workshops.

Grant Application Support for Participants. GEORG offers expertise in applying for grants at the European and international level. It growths the potential and significantly improve the success rate for research grant application and influence the force of the geothermal cluster for the benefits of the participants.

Promotion and Dissemination. GEORG operations form a platform to promote knowledge on the

geothermal energy resource, its utilization potential, sustainability and environmental issues. This is accomplished through training and information sharing through courses, workshops, seminars and conferences. Promotion of the geothermal energy resource at the European and international level increases the awareness of the opportunities the renewable energy source offers.

1.3 GEORG members

The group behind GEORG is highly multidisciplinary and consists of all the main educational and research organisations, energy companies, engineering firms, and start-ups in Iceland, as well as their key international collaborators in the geothermal sciences and energy resources utilisation. Figure 3 shows the members of GEORG grouped be their role. The figure shows clearly that the members span nicely all the roles needed to form a research cluster that has the aim of bridging between academia and industry. The main University and research institutes in Iceland are all members, the three largest energy companies as well as the main players in the engineering consulting field.

Figure 3: Members of GEORG grouped by operation.

2. ACHIVEMENTS

2.1 Research projects by cluster members

GEORG has supported 26 research projects that were coordinated by the cluster members. The projects range from the geothermal reservoir upstream, the midstream technology, including borehole construction and equipment, downstream waste streams, environmental impacts, and geothermal management and data. The titles of these projects, indicating the research topics undertaken, is shown in Figure 4. Many of these research projects were worked on in collaboration with members within the cluster and in some cases additional partners were recruited when and if needed. The collaboration net is shown in Figure 5, where the dotted circle indicates the division between cluster members and additional partners. The figure also shows the strong connections that have been established through the projects between Universities, research institutes and the industry, both energy companies and consulting companies. This demonstrated clearly that GEORG has been able to fulfil one of the main objectives of bringing together the main players in the field of geothermal energy.

GEORG has supported the research project with about €2,3 million with matching co-fund from other sources of about €9,1 million, yielding total turnover of the projects of about €11,4 million.

2.2 Research projects synergy

The research projects were executed during the first years of GEORG. The research created synergy by the cooperation between the players which the cluster was able to harness by creating two super projects that build on the research project success.

The first is a project named Deep Roots of Geothermal System (DRG) and utilities the results from the upstream and midstream research projects, marked as DRG in Figure 4. The aim of DRG, which is ongoing, is to understand the relationship of water and magma in the roots of volcanoes and how heat is transferred into geothermal systems to maintain their energy. The design of wells and well heads for high temperatures is a focus area as well as methods for utilizing superheated steam from great depths. The research work is divided into six tasks, each lead by a Principal Investigator and includes participants from universities, research institutes, engineering

consultancies and energy companies. The latest technology will be applied in surveying, resistance measurements and seismic measurements, petrology and geochemistry. In addition, new simulation models will be developed. These models will be used to simulate heat transfer and operation of geothermal boreholes for high temperature steam. One of the key aspects of the DRG project is to foster and encourage cooperation with other international project in the same field such as the Swiss/IPGT-COTHERM project, the IDDP & EU-DEEPEGS projects, EU-IMAGE project, and the EU-FUTUREVOLC project.

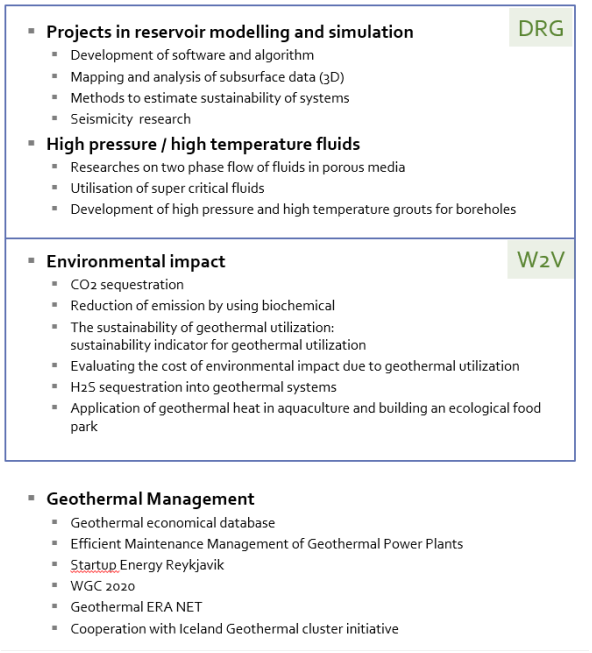

Figure 4: Research project titles supported by GEORG. The boxes indicate the synergy grouping of the research projects.

The second synergy project is named Waste to Value (W2V) and is based on the research projects that focused on downstream waste streams. These include waste streams like warm water for Aquaponics, or utilization of gases, such as CO_2 for energy production. Both the DRG and the W2V projects are ongoing.

2.3 Innovation and start-ups

GEORG has supported innovation in the geothermal field and has in particular encouraged strongly a creation of start-up companies to bring to market the fruits of research in the geothermal field. This has mainly been accomplished by partnering with Arion Bank, Landsvirkjun and Innovation Center of Iceland through the Startup Energy Reykjavik business accelerator. The program selects seven energy startups, following a rigorous application process, to participate in a 10-week business accelerator. The startups get a cash infusion from the four partners in exchange for equity position and access to expert mentors during the 10-week program as well as a follow-up advice. The program has been executed two times, resulting in 14 startups being formed. Of the 14 about 5 are in the geothermal field but the others in various renewable energies. The name and the logos of the startups are shown in Figure 6. All are still operational, and few have gotten additional investors and have made promising progress.

2.4 Dissemination and student support

The research projects have already been published in 46 journal articles, in 49 conference papers, and in 135 other miscellaneous publications. As some of the projects are ongoing or have recently finished this numbers will probably increase.

GEORG has actively focused on supporting students through the research projects. About 36 doctoral students have been partly or completely funded through GEORG grants, about 35 MSc students and 4 postdocs.

GEORG has also explicitly supported conference participation by students in conferences through separated grant application process. To date GEORG has provided 66 grants to students to present papers at various geothermal conferences.

2.5 Cluster Cooperation

GEORG has cooperated successful with the Icelandic Geothermal Cluster initiative (IG) which is a more industry focused geothermal cluster. Many of the same institutions and companies are members of both clusters and members from each cluster are board observers in the other cluster board. GEORG and IG have successfully worked together on some projects that benefit both, including securing that the World Geothermal Congress that will be held in Iceland in 2020.

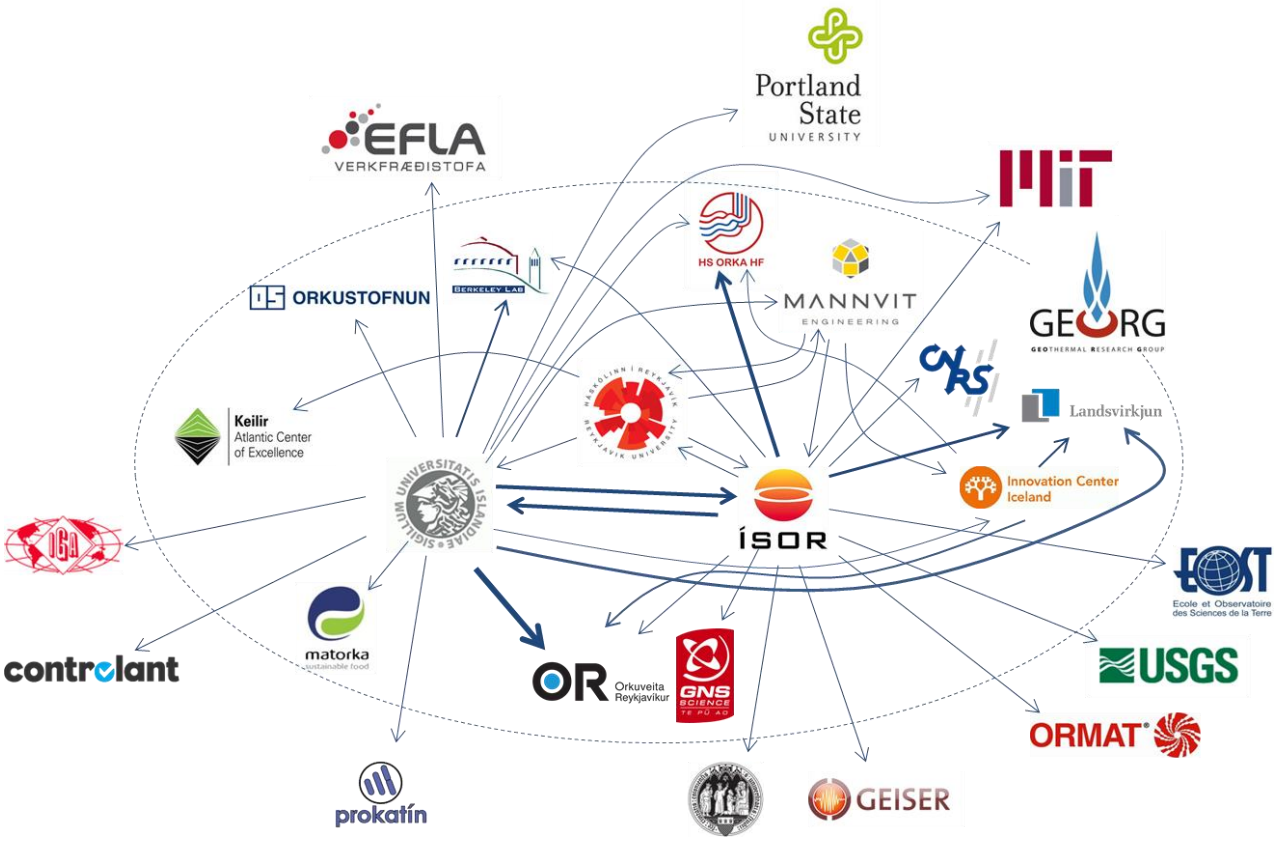

Figure 5: Cooperation net of GEORG research projects. The GEORG members are inside the dotted circle and additional partners recruited for individual research projects are shown outside of the circle.

3 EUROPEAN PROJECTS

GEORG has focused on participating in European projects in the field of geothermal energy. This includes participating in FP7 and Horizon 2020 program committees to be able to influence the European geothermal policies. Support to geothermal Energy has increased significantly in Horizon 2020 framework compared to the framework programmes before as Figure 7 shows.

GEORG was a key player in establishing the Geothermal ERA-NET. It was launched in 2012 supported by a EUR 2 million grant of the European Commission. Its principal aim is to deepen European cooperation on geothermal research at national and administrative levels and enable the integration of national research programs. This first four-year phase (2012-2016) is led by Orkustofnun, Iceland's National Energy Authority, and is a cooperation of research and innovation programme owners and managers (funding agents) from France, Germany, Hungary, Iceland, Italy, the Netherlands, Portugal, Slovakia, Slovenia, Switzerland and Turkey.

Figure 6: The 14 startup companies that were selected for participation in the Startup Energy Reykjavik business accelerator.

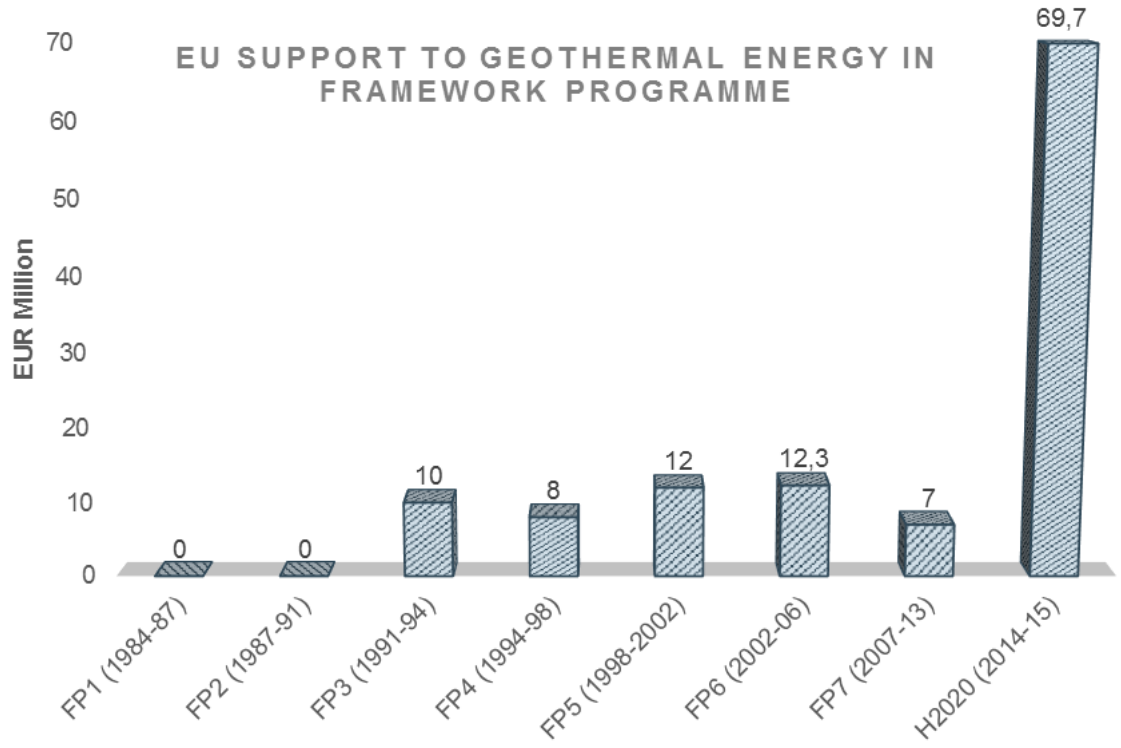

Figure 7: EU R&I support for Geothermal Energy (Data: European Commission).

Through its actions, the Geothermal ERA NET aims to increase the uptake of geothermal energy; not only to contribute to an increased share of renewables in the energy mix, but also to improve security of supply and increase energy savings in Europe, and thus ultimately having a strong positive impact on Europe's economy and competitiveness. By doing so, the Geothermal ERA-NET's activities correspond to the delivery of a strategic contribution to the European Action Plan "Energy Policy for Europe".

The Geothermal ERA-NET has provided a strong platform for continued collaboration among Europe's geothermal research and innovation program owners and managers. Four years of intensive exchange and collaboration on research policies, programming, funding instruments and frequent interpersonal exchange have enabled the formation of strong relationships among participants. So much so, that the Geothermal ERA-NET member countries intend to move to a subsequent stage in coordination of national research and innovation programme. Building on joint activities and prioritization of trans-European common research and innovation topics and themes, and the continued support and facilitation of the European Commission to enhance and strengthen cooperation and coordination of national research and innovation programmes, a large number of GEOTHERMAL ERA-NET countries and new European partners have teamed up to launch an ERA-NET Cofund Action.

GEORG participates in the €44 million DEEPEGS project which was funded recently by almost €20 million from Horizon 2020. It is coordinated by the Icelandic energy company HS-ORKA with participation from five countries. The project duration is 4 years and GEORG is among other things responsible for running the project office. The main objectives of DEEPEGS is testing of stimulating technologies for EGS in deep wells in different geologies that will deliver new innovative solutions and models for wider deployments of EGS reservoirs with sufficient permeability. This will be done by drilling three deep holes in Iceland and France as is shown in Figure 8.

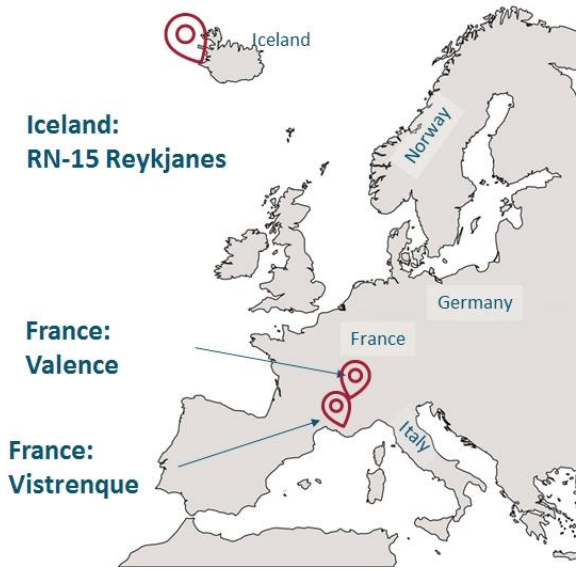

Figure 8: DEEPEGS demonstration sites in Iceland and France.

GEORG takes part in the preparation of European Technology and Innovation Platform (ETIP) for deep geothermal. The overarching objective of the new ETIP-"Deep Geothermal" it to enable deep geothermal technology, in particular Enhanced Geothermal Systems (EGS), to move from the current European R&D and pilot-sites, proliferating in other European countries and different geological situations. The primary objective is overall cost reduction, including social, environmental, and technological costs.

The ETIP-GT will be an open stakeholder group, including representatives from industry, academia, research centres, and sectoral associations. It will cover the entire deep geothermal energy exploration, production and utilisation value chain.

The European dimension has always been important for the operation of GEORG and will continue to remain one of the main focus areas.

4. GEORG FUTURE STRATEGY

The formal grant period for Centres of Excellence and Research Clusters program finished at the end of March 2016. The operation of GEORG has been formalized in a non-profit association and will be operated as such in the future. The main focus will remain the same as is shown in Figure 2, with emphasis on grant application support at the European level and service for the cluster participants and promotion of the geothermal issues, especially on the European and international stage. Funding for the operations of the cluster for the next four years has been secured and further development of the cluster initiative is under way.

5. CONCLUSIONS

The geothermal cluster initiative GEORG has operated for the last seven years bringing together players in the geothermal field, both nationally and internationally. The members of the cluster have accomplished significant research goals and the cluster has been able to use the synergy of the projects for further research development. The innovation focus of GEORG has resulted in small equity stake fourteen startups which have promising future. The European connection is strong, reflected in participation in several European commission funded projects. The funding of GEORG is secured for the next four years and the cluster initiative is continuing its development for the benefit of its members.

REFERENCES

Orkustofnun, Frumorkunotkun á Íslandi 1940-2015, Identifier: OS-2016-T002-01. Retrieved from: http://os.is/media/talnaefni/OS-2016-T002-01.xlsx

Stoklosa, A.W., Ingolfsson, H.P., Garðarsson, S.M.: GEORG Newsletter, (February 2016) Retrieved from: http://georg.hi.is/files/newsletter%20FEB016%20FINAL.pdf

Ingolfsson, H.P., Stoklosa, A.W. Garðarsson, S.M. GEORG Annual Report 2015, GEORG (May 2015) Orkustonun. Retrieved from: http://georg.hi.is/files/GEORG%20Annual%20Report%20Y6%20final%20AWS.pdf

European Technology & Innovation Platform, Terms of Reference (May 2016): Retrieved from: http://www.geoelec.eu/wp-content/uploads/2016/05/Terms-of-Reference-ETIP-DG-Final.pdf

Acknowledgements

GEORG is supported by the Science and Technology Policy Council in Iceland through their Centers of Excellence and Research Clusters – program (Grant number: RAN090326-1303).