

Research and development projects on climate issues

Reykjavik Energy (OR) has been at the forefront of innovation and development on climate issues over the past decade.

Examples of projects developed in cooperation with the academia and business sector 2021:

- **Near-zero geothermal utilisation.** In 2018, OR and its partners received more than ISK 2 billion in funding from the Horizon 2020 EU Research and Innovation Program. The grant is for the GECO (Geothermal Energy and Climate Outlook) project, which is largely based on the Carbfix re-injection method. With the GECO project, the Carbfix method will be further developed into four types of bedrock to test whether it works as well there as has been shown in Icelandic basalt. The project includes preparations for the experimental capture and disposal of carbon dioxide and hydrogen sulphide at the Nesjavellir geothermal power plant, as well as the experimental operation of the 2nd step of carbon dioxide purification at the Hellisheidi geothermal power plant to support its utilization in ON Power 's geothermal garden. See more below.
- **95% clean Hellisheidi geothermal power plant.** OR aims for carbon neutrality by 2030. If this is to become a reality, almost all carbon dioxide in the production cycle of ON Power plants will have to be removed. The main purpose of the first phases of the capture and storage plant at the Hellisheidi power plant was to reduce the emission of hydrogen sulphide, but at the same time it was possible to reduce the emission of carbon dioxide from the power plant. The results of analyses, which are based on the operation of the capture and storage plant from 2014, show that the same technology can be used to further reduce carbon dioxide emissions from the power plant or up to 95%, store it permanently in rock and / or utilize it in value creation. Furthermore, it will be possible to remove almost all hydrogen sulphide and store it permanently in rock. In 2021, a grant of ISK 600 million was received for the Silferstone project (i.e., to build an air purification plant), from the Innovation Fund, a development fund under the auspices of the European Union. Subsequently, design of a pilot plant has started at the Nesjavellir geothermal power plant, which also assumes a 95% injection of carbon dioxide.
- **Direct air capture plant at Hellisheidi.** Carbfix and ON Power have partnered with the Swiss company Climeworks, which specializes in capturing carbon dioxide from the atmosphere. This is a large-scale project based on experience from a pilot project on the integration of carbon dioxide capture from the atmosphere and its binding in rock that has been going on at the Hellisheidi Geothermal Power Plant since 2017. That project was part of the Carbfix2 project funded by the H2020 research and the European Union's Innovation Program. In 2021, the first direct air capture plant of its kind in the world was commissioned in On Power's Geothermal Park. This is a ground-breaking project, as Carbfix's and Climeworks' technology solutions are now working together to tackle climate change on a commercial basis. The ongoing development and expansion of the project will weigh on the scales of keeping global warming within the bounds of the Paris Agreement.
- **Binding of carbon dioxide in rock from Sorpa's methane station.** Carbfix, Sorpa and partners have received funding from the Rannís Technology Development Fund to investigate the feasibility of disposing of up to 7,000 tonnes of carbon dioxide per year from Sorpa's methane plant using Carbfix technology. The novelty of the project lies in the adaptation of Sorpa's gas purification system to the Carbfix method and in its use independently of the operation of geothermal power plants, which is an important test for the adaptation of Carbfix to different energy and industrial processes. Furthermore, for the first time, carbon dioxide will be injected into

older and denser rocks than before. Such an injection will have an important predictive value for the feasibility of using the Carbfix method in Iceland and globally.

- **Hydrogen production at Hellisheidi** was commenced at the end of 2020 and is based on the results of a pilot project at the Hellisheidi geothermal power plant on behalf of the European Union; Hydrogen Mobility Europe (H2ME). The production was adapted to the conditions in Hellisheidi and is going well. Shell has distributed the hydrogen. There are great possibilities in hydrogen as an energy source e.g., for heavy vehicles, work machines, ships and aircrafts and energy related matters in Iceland.
- **Energy shift in transport in Iceland** is a joint project between OR and its subsidiaries ON Power, Veitur and Reykjavik Fibre Network. Part of the project involves the development of infrastructure in Reykjavík for electric car owners, advice and encouragement to the community.
- **SPARCS** (Sustainable Energy Positive & Zero Carbon Communities) is a European Union grant project H2020 and lasts for 5 years. The goals are carbon offsetting cities and building an innovative network of environmentally friendly cities. Seven European cities are participating in the project. In Iceland, the project is carried out in collaboration with the City of Reykjavík and the main emphasis is on energy exchange and energy saving in transport. OR together with Veitur and ON Power participate in the project. At Veitur, emphasis is placed on load control due to the rapid increase in the number of electric cars, and at ON Power, emphasis is placed on charging infrastructure and related solutions.
- **Deep drilling** is a project that involves drilling deeper into geothermal systems in high-temperature fields - i.e., into their roots. The aim is to develop methods to extract the heat energy from these deep hot strata and thus expand the workable geothermal system downwards. Technical challenges still need to be addressed to make this possible. ER and ON Power participate in several grant projects under the auspices of the European Union (GeoPRO, HotCase, GeConnect) and the Geothermica Fund (HEATSTORE, DEEPEN), which aims to meet these challenges. It is planned that the third deep drilling well in Iceland, IDDP-3, will be drilled in the Hengill area in the next five years in collaboration with other energy companies, and preparations for this project have begun.
- **Management of induced seismic activity.** The COSEISMIQ project aims to understand what affects induced seismic activity and how it can be controlled. The project is funded by the Geothermica Fund. An extensive measuring network is operated around Hengill and ON Power meters in the area are a good addition. So-called reserve models are used to simulate how temperature, pressure and pressure change with processing and injection and predict how it affects seismic activity. The aim is to develop a tool that can help predict seismic activity due to planned processing and injection, so that it can be dealt with before it occurs.
- **Improved resource utilization in low-temperature areas for the future.** The RESULT project, funded by the Geothermal Fund, will look at improved resource utilization in geothermal areas in urban areas. In Iceland, the focus will be on the Elliðaár area, which has long been used for hot water production, and attention will be paid to how the utilization has affected the area. Furthermore, proposals will be made on how best to utilize the area for the future in a sustainable way.
- **Water quality.** Implementation of real-time microbiological measurements is ongoing, with the aim of creating a real-time understanding of i) of the interplay of microbial pollution of water with meteorological and environmental factors, ii) to control water harnessing always according to the

best quality and thus maximizing consumption treatment, especially when meteorological events threaten water quality in water abstraction areas and iii) ensure water quality to the consumer.

- **Future vision of drinking water resources.** A future vision has been prepared for the municipalities of Reykjavik and Akranes, based on a forecast of drinking water demand until the year 2060. Future forecasts also assess the possible maximum demand that can be created on dry and sunny summer days. Climate models indicate that the frequency of extreme weather events will increase in the coming years, so it can be expected that conditions leading to maximum stress will become more frequent in the coming decades. However, more time is needed to assess how the effects materialize.
- **District heating resources:** A project in progress which aim is to map the resources for district heating in the capital area. Furthermore, a demand forecast for the future for all district heating utilities is being prepared, as well as a mapping of long-term supply resources.
- **Increased overview of collection- and distribution systems.** Number of projects are in progress which aim at an increased overview of status, supply and failures in Veitur Utilities' systems with the aid of digital meters, automatic data analysis methods and system models. The sewer has prepared a flow forecast and is working to increase flow measurements in order to be able to better assess the risk of an increase in flow due to precipitation events and respond to them. Veitur's electric utility, together with OR and ON Power, are launching the project "Better loading", which aims to examine the possibilities for controlling / shaping electric carload with the aim of reducing capacity and thus making better use of the existing infrastructure. The initiative is in control and overview of the flow of energy through the electricity distribution system. With better information, the system can be operated closer to the tolerance limit and delay or ignore certain investments, but at the same time build the system where the data shows that there is a need for. Veitur's district heating utility is working on projects aimed at a better overview of the condition, use and failures of the systems with digital meters, automatic data analysis methods and system models.
- **Future vision of the electricity distribution system.** Work is in progress on an overall vision for an electricity distribution system. A system that examines a holistic approach, compares different ways of building the system with the aim of meeting the increased load. A load due to energy exchange in a timely manner and in a way that minimizes the construction required to operate a secure distribution system.
- **Utilization of biodegradable sewage waste.** A large amount of waste is generated by Veitur from the sewage that the sewer receives from customers. Some of the waste is high in energy and can be rich in nutrients and other valuables. It has been landfilled with associated greenhouse gas emissions and waste of valuables. Veitur are in favour of reducing this landfilling, especially the part that is biodegradable and prioritize research into possible ways of utilizing biodegradable sewage waste. This emphasis resulted in the agreement on the receipt of sludge from organic treatment plants for land reclamation in 2021, but research on possible ways of utilizing fat waste has not been completed. Work is also underway to assess the feasibility of recycling sand from sewage treatment plants, a project that received funding from the Ministry of the Environment.